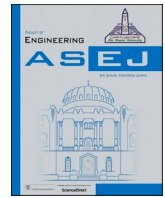




Contents lists available at ScienceDirect

Ain Shams Engineering Journal

journal homepage: www.sciencedirect.com

Coping with skill shortage within the UK construction industry: Scaling up training and development systems

Rashid Maqbool^{a,*}, Yahya Rashid^b, Ayman Altuwaim^c, Muhammad Tariq Shafiq^d, Luke Oldfield^a

^a Faculty of Engineering and Environment, Northumbria University, Newcastle upon Tyne NE1 8ST, UK

^b Bob Gaglardi School of Business & Economics, Thompson Rivers University, Kamloops, BC, Canada

^c Department of Civil Engineering, College of Engineering, King Saud University, Riyadh 4545, Saudi Arabia

^d Architectural Engineering Department, United Arab Emirates University, Al Ain, United Arab Emirates

ARTICLE INFO

Keywords:

Skill shortage
Quality management
Covid-19
Brexit
Ageing workforce
Training and development

ABSTRACT

A skilled workforce is essential for producing high quality construction work, efficiently and effectively. This paper is formulated to improve the understanding and knowledge surrounding the skill shortage currently being faced within the UK, and the significant impact it is having on quality management. It surrounds around each main area, and the impacts of recent years: Brexit, Covid-19 and ageing workforce. A mixed method approach was applied to collect data from the quantitative and qualitative sources. The quantitative survey data was collected through snowball sampling from the 130 construction professionals working the UK construction industry. Moreover, a case study has been conducted on a large-scale construction project located in the Northeast of England where the outcome of these issues can be seen in all aspects of the work. Training and development are the fundamental issues highlighted during the literature review and then subsequently expressed by participants of the surveys. In addition, the moderation analysis also provides the important role of training and development in reducing the negative impacts of COVID-19 and Brexit towards quality management. However, it was also revealed that the training and development are not useful for the aging workforce in combating the skilled shortage challenges towards quality management system in the construction industry. This research will allow the industry to understand the need for a skilled workforce and how it benefits the quality management elements of a construction project.

1. Introduction

Unemployment is on the rise in the United Kingdom (UK) due to the impact of the Covid-19 pandemic. The easing of restrictions has led to increased recruitment across all sectors as the economy is picking up the pace since people begin to spend the money they saved during the pandemic. Even though the UK Government's job retention scheme has helped preserve jobs in the country across all sectors, post-pandemic economic uplift resulted in higher demand for staff and labor [64].

The Covid-19 pandemic has severely impacted the construction industry in the UK, which resulted in firms shutting their projects across the country contributing to project delays and a shortage of skilled workers who sought employment opportunities elsewhere. Furthermore, Brexit led to a historic shortfall in the labor market of the UK

which further contributed to the lack of skilled workers in the construction sector [44].

The shortage of skilled workers has put contractors in a tough position in terms of the availability of the necessary skills in the labor market. This resulted in a significant investment of time and resources within their workforce by choosing a few select competent individuals for required training to address the problem of skilled labor shortage. This approach may fall short in the long run as labor costs increase and the need for adaptation becomes more significant even though investing in the current workforce through additional training and rewards can resolve the problem for the time being [39].

Another glaring issue is the inclination of young people towards pursuing secondary and higher education rather than apprenticeships to train for the special skills required by the construction industry. This

* Corresponding author.

E-mail addresses: rashid.maqbool@northumbria.ac.uk (R. Maqbool), yrashid@tru.ca (Y. Rashid), aaltuwaim@ksu.edu.sa (A. Altuwaim), Muhhammad.tariq@uaeu.ae (M.T. Shafiq), luke.oldfield@northumbria.ac.uk (L. Oldfield).

<https://doi.org/10.1016/j.asej.2023.102396>

Received 26 August 2022; Received in revised form 10 June 2023; Accepted 9 July 2023

2090-4479/© 2023 THE AUTHORS. Published by Elsevier BV on behalf of Faculty of Engineering, Ain Shams University. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

resulted in the reduced intake of students in the vital trades required for the construction sites potentially impacting the long-term quality of buildings. This declining result is also why the construction industry is struggling to attract young people, therefore, to address this problem, recent legislation in the UK now mandates schools to promote various forms of training necessary to address the shortage of skilled workers in the construction industry [14].

Quality management has numerous definitions, and each project is often assessed differently as it is affected by distinct factors such as execution time and quality of the personnel [32]. "In the construction and management of work, people are the main part." The quality management of a construction project can only be optimized with improvement in all aspects: from design to the optimization of personnel and systems [21]. However, one of the main challenges is maintaining staff motivation for conducting quality control, given that each aspect of quality management differs between businesses [29].

This research study aims at investigating the impact of skill shortages on quality management systems in the UK construction sector. The specific objectives of this study are as follows:

1. To determine the key contributors to skill shortages within the construction sector and how they are affecting the overall quality of the construction.
2. To determine to what extent the skill shortages impact quality management in the construction sector
3. To determine the role of legislation and other steps taken by the government and the industry as a whole in coping with the skill shortage in the construction sector

The research methodology involves the anonymous distribution of a survey questionnaire among construction industry professionals who are either working in the industry or pursuing further education in a similar domain. The snowball sampling technique was used to collect data, primarily focusing on quantitative information to capture a wide range of perspectives. A systematic approach was employed to collect data and ensure that the survey reached the appropriate participants since key questions were designed to explore domain-specific knowledge about the skills shortage in the UK construction industry. Furthermore, to confirm the findings of the survey, a case study was employed to examine the direct impact on the industry and gain further insight into the requirements for taking necessary action [57].

2. Literature review

The UK Construction Sector has expressed significant concerns in recent years regarding the shortage of skilled labour and the impact that this will have on the need for traditional and new skills on current projects. It has been observed that the practice of "poaching" high skilled labour amongst companies has become more commonplace. This has led to an increase in the cost for construction, which further leads to "extreme fluctuations in construction output" [40].

Following on from this; the damaging effects a skill shortage can cause within construction have made an impact on Quality Management Systems (QMS) which are in place. High quality tradespeople are becoming more difficult to acquire due to the increased cost for their skills. This is not only for their performance, but for the knowledge they have of the industry as whole, i.e., safety and environmental awareness. Construction managers spend more time focusing on trying to enable their current workforce to produce and therefore the QMS falters [26].

2.1. The skill shortage within the UK construction industry

Since 2015 the UK has seen a significant increase in recruitment across England, Scotland, and Northern Ireland with minor changes in Wales [4]. Whether it be tradespeople or managers, it has been more difficult to hire out of education than ever before. In the 2017 skills

survey the UK reported that a third of available job vacancies were considered "hard to fill" with a further 8% increase in skill shortage vacancies compared to 2015, with candidates simply lacking the requirements specified by employers [62]. In the same report it was stipulated by the Department of Education that "vacancies were highest in construction" where 36% of vacancies were related to skill shortages.

It is necessary to investigate certain areas relating to the shortage of skills within the UK. In a report from the University of Cambridge, Dr Kwadwo Oti-Sarpong [54] highlighted the well known issues within the construction industry, describing the main concern being a "labour crisis" stemming from the skill shortage, an ageing workforce, Brexit and apprenticeship attendance. These key areas have the potential to be explored further to determine a root cause.

2.2. Quality management in UK construction projects

Management System integration is something that businesses are adopting as it makes them more appealing to the clients offering work. These mainly consist of but are not limited to: Quality Management (ISO 9001), Health and Safety Management (OHSAS 18001) and Environmental Management (ISO 14001) [51]. ISO 9001 is a quality management system that organisations often introduce to improve "internal and external effectiveness" where improvements can be seen in management, leading to an enhanced workforce [15].

Quality Management Systems are a standardised framework which allow for "quality assurance in design, development, installation and servicing." Most contractors adopt this framework to achieve customer satisfaction and quality requirements for the project client [26]. However, when quality management systems are introduced into businesses they are to be maintained by middle management within the company, because of this there can often be disruption between teams as "conflicts often arise upon integration" [10]. It is important that these systems are maintained to ensure quality work is produced.

Quality Management within the UK is a necessary process for projects as it improves the performance of the workforce as well as establishing a framework which each construction project within the business must follow to achieve the high standards required by clients and the construction sector. Maslow's Hierarchy of needs indicates that the basic psychological need of a person is fundamental for achieving their best possible performance; "This concept of benefits is the most important and key to the achievement of quality", therefore the impact of quality management can play an important role in UK construction projects [30].

2.3. The impact of the skill shortage on quality management in construction

The impact on Quality Management can be related to the effects from the skill shortage within the UK. Covid-19, Brexit and an ageing workforce have all influenced the performance of construction projects and quality management, especially within the last few years due to the issues that the UK has faced. Quality has suffered because of impacts relating to cost and time burdens.

2.3.1. The impact of Brexit on quality management

Brexit has impacted quality management within the UK construction industry in numerous ways, with the "resource limitations" having a significant impact on the desired quality of the project [44]. Further data gathered from a survey conducted by Mohamed, Pärn, & Edwards [44] led to 51 responses, where 30 participants agreed that the quality of projects would be reduced due to the impact of Brexit.

A "no-deal Brexit" was a huge uncertainty which affected most trade passing between the UK and the rest of Europe. Trade is considered one of the most crucial elements of Brexit which needed to be agreed before Britain withdrew from the EU as international agreement needed to be established to ensure the UK was getting a fair deal [7]. There were

concerns for the increasing cost associated with the trade between the UK and the EU, as an independent nation with no land borders it was important to make sure that the UK could still get the goods and materials that it would require [6].

High transaction costs are a limiting factor which could impact the quality of materials that the UK suppliers are willing to pay for as the increased cost will in turn limit spending [35]. Furthermore, construction companies are paying extra for materials due to new import costs and cannot complete work to the highest standard. It is well known between tradespeople that using inexpensive materials impacts reputation, durability, aesthetics and variation in costs [55].

2.3.2. The impact of Covid-19 on quality management

During the height of the Covid-19 Pandemic it was determined that tradespeople within the construction industry were not “essential/key workers” [42,49] and because of this it meant 25.8% of construction personnel were not in work between April and June in 2020 [59]. Covid-19 impacted the construction industry as a whole but the impact on quality is determined by the quality of tradespeople [1]. Given that there was a limited number of tradespeople on sites, it is to be expected that overall quality would fall during the pandemic. However, research carried out by Ogunnusi et al., [52] determined that the time off provided by the lockdowns across the world could lead to “Improved productivity” with the additional time allowing for critical decision making, leading to better quality and progress overall [52].

Guidance offered by the Government was to avoid face to face contact which meant quality checks on site could not be completed in as much detail [43]. The role of Building Control in the industry is essential to ensuring education around the materials used and improving the overall quality achieved from the tradespeople [46].

2.3.3. The impact of the ageing workforce on quality management

Quality workmanship comes from years of training and developing an understanding of a specific trade. For this reason, it is commonly seen within different industries that higher quality work is achieved across projects with a mature workforce. The benefits they offer are often overlooked, with the older generation naturally teaching the younger generation as well as having a strong work ethic and retention of business knowledge and networks [20,11].

Despite all the advantages, an ageing workforce comes with issues as the impact of being older in an active and fast paced environment can often increase duration of work. Quality can be maintained but at the risk of increasing duration [20].

The importance of ageing workforce on quality is often overlooked but it can provide many benefits. However, the delays and issues relating to an ageing workforce can often have major effects on a project and it is a risky position for management to put themselves in to accept older generations onto projects if time is a limiting factor. Reduced motivation and a slower pace are fundamental downfalls for an ageing workforce on projects.

2.4. The role of training and development in UK construction sector

To have a skilled workforce it is important that the level of teaching is high quality and consistent to allow for specific skills to be developed and maintained. Research conducted in India determined that the structure of their training was one of the factors leading to the downfall of most training as sites simply did not have the infrastructure to allow for on-site training [31]. Similarly, this can be seen within the UK: “Investment into training is low in comparison to other sectors” with only 7% of school leavers under the age of 25 being employed in the construction industry. Therefore, training infrastructure in the UK is not attracting school leavers as well as other sectors [8].

Women within the construction industry is an important topic of conversation and it could be another limiting factor as to why the shortage of skills within the industry is on the rise. Worrall, et al. [63]

explained that women are less common in senior positions within construction, this is thought to be because of the culture which the construction industry has been connected to in its earlier years. They go on to further develop the need for change in training and advertisement within the industry as the process for women to get involved in a male dominated industry is daunting and may be unappealing.

The appeal to be a part of the industry is an area which needs improvement. Parents and guardians have a significant impact on young school leavers and the focus is on getting students into university. This could be due to a lack of understanding that the influencing parents and guardians have regarding the “earning power” of being part of a skilled workforce [33].

Statistics gathered from the UK Government highlight the fluctuation in apprenticeship start-ups from each available year. Between 2019 and 2020, research shows that the apprentice starters are down by 6.9%, showing a significant decline in the number of people starting apprenticeships [50]. This decreasing statistic could be due to Covid-19 as recruitment for apprenticeships was reduced by most employers to focus on their fulltime and fully qualified staff [34]. Additionally, it was difficult to encourage a training labourer to work from home when work needs to take place in a practical environment [17].

Building Information Modelling (BIM) is a collaborative network which allows consultants and professionals within the industry to share and work simultaneously on a model to reduce time, improve collaboration and achieve better quality results first time [53]. The use of more detailed and intricate modelling and measuring techniques has increased over the last decade with their use becoming more prominent across the construction industry [45]. However, the development of an innovative technology means changes within the industry, and with change comes challenge. “A significant amount of education we had to do with the FM (facilities managers) team, even to bring them up to a basic awareness of what could be done with BIM...” [58].

Additional training is necessary for most “technical innovation” that comes into the industry. Whether it is a new type of material or tool, there will always be a requirement to ensure the knowledge is passed from developer to producer [23]. Quality assurance techniques have been simplified using BIM as it allows for easier recognition of the issues and therefore allows for professionals to ensure these areas are addressed before the project is handed over [9]. Without BIM the quality assurance process involves copious amounts of documentation and record keeping which can all be simplified by completing it electronically [5]. Training in BIM is necessary for businesses as it means development can take place and it ensures the entire process is streamlined, saving on time, costs and an overall improvement in quality [56].

2.5. Research framework

Though there are some earlier researches conducted on the skills shortage, however, the scope of most such researches was not specifically on construction industry [41,18] or on UK’s construction industry [60,28], or on the policy and strategic level of the overall construction industry [40]. Whereas the UK’s construction industry’s issues are way ahead than other contexts or industries considering the Brexit, and high amount of Elderly work force as well as recent threats posed by the COVID-19. That’s why it was important to have detailed research, covering both the qualitative and quantitative views to understand the overall issues caused by these factors (Brexit, Elderly work force, COVID-19), and proposing the possible solutions based on the respective training and development to meet the currents and upcoming needs for this industry.

Throughout the literature it is evident that there are areas in the research which need to be further understood and highlighted. There are gaps in the literature surrounding the impact that Brexit and Covid-19 have had on the training/development in education as well as slowing down the technical innovation provided by BIM. This highlights the point that skilled workers may be let down by lack of training/education

and the additional destruction caused by Covid-19 and Brexit (Fig. 1 – Research Framework).

To summarise, the literature covers the understanding that the number of skilled workers within the industry are expected to fluctuate over time. Further literature which delves into the history of the skill shortage within UK determined that the source could be lack of training, Brexit, Covid-19 and an ageing workforce, each of which directly impacted the number of skilled workers. Additionally, the literature explores quality management within the industry and how each element impacting the skill shortage has similarly influenced the quality management of projects. Past and present impacts on the industry show that a skilled workforce and quality take place hand in hand and barriers will need to be broken to determine a way to establish an effective solution to the skill shortage that the UK is facing. From the research we expect to see a clear representation of how the lack of skill within the industry has an overall impact on the quality management of a project. It gives us a strong lead of moderating role of training and development in between Skill Worker Shortage Factors (i.e., Covid-19, Brexit, and Aging workforce) and Quality Management (i.e., Time, Cost, and Productivity) in the construction industry. Owing to this discussion a framework is developed to test in this research, highlighted in the Fig. 1.

3. Methodology

The Mixed methods are used to gather information relevant to the hypothesis, quantitative and qualitative methods give a variation of detail in the data. Quantitative techniques focus on *surveys*, where numerical data is gathered, and trends are visualised through graphs and charts to determine trends. Qualitative techniques allow for greater gathering of more detailed information from the research, looking at the quality of the data which is being received; usually gathered through *interviews* and *expert opinions* [19]. The mixed method data collection was used to gather the information in this research, by using the quantitative as well as qualitative methods.

Data collection comes under a combination of questionnaire survey and a case study of XYZ Development Site (name is anonymised) which is currently under construction by principal contractor, ABC Construction Ltd. This data gathered will contain information from individuals from the industry as well as a direct review of the impacts on the case study by using information gathered from the site.

3.1. Quantitative

“The quantitative methodology seeks to obtain accurate and reliable measurements that allow a statistical analysis” [57]. By using quantitative methods of data collection within the research a greater

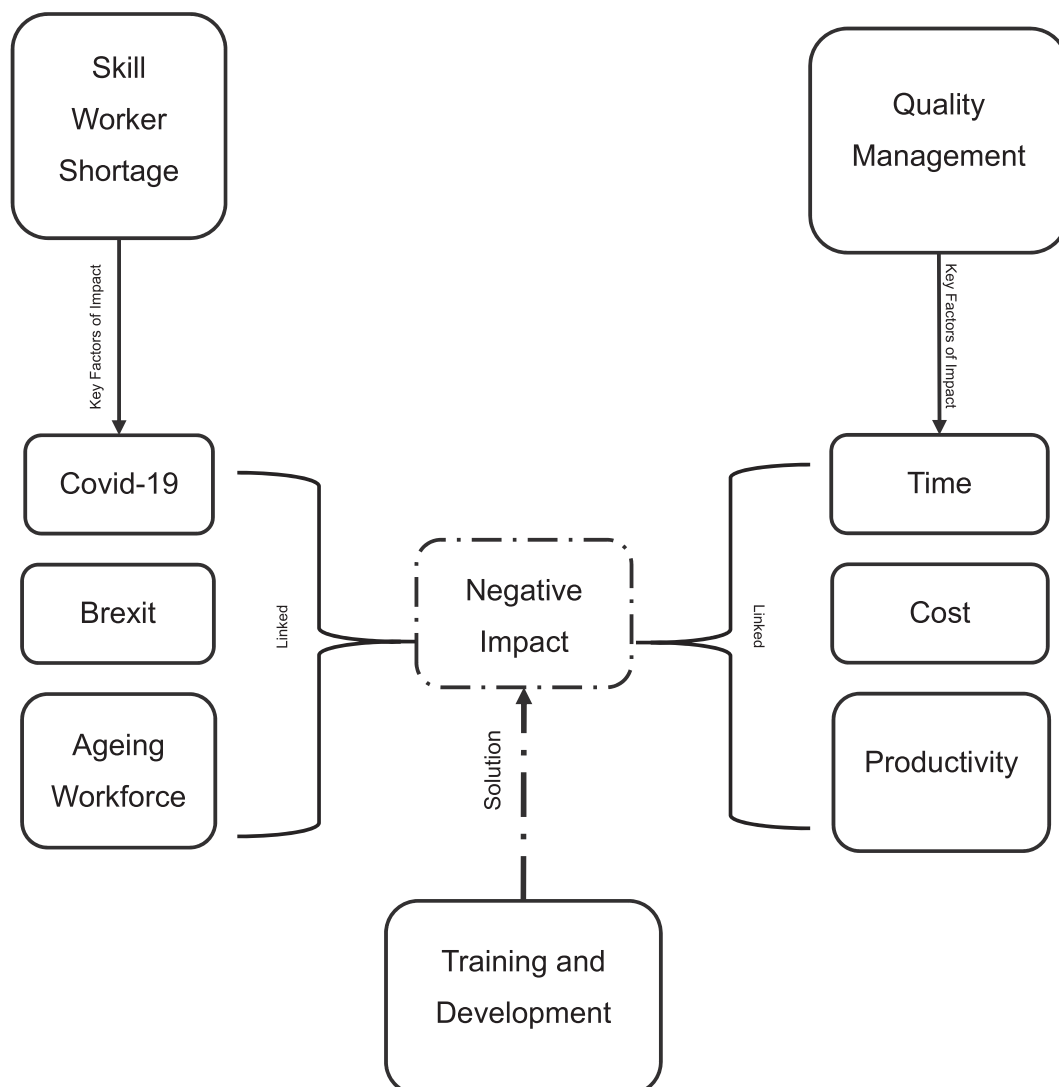


Fig. 1. Research Framework.

understanding can be gained of the impact that people within the construction industry think the skill shortage have had on the overall quality of the construction projects. This will be determined by gathering data surrounding the impact of events from Covid-19, Brexit, an ageing workforce and lack of training, which can then be analysed against primary data.

3.1.1. Questionnaire survey

In this research, questionnaires are used to extract data from 130 professionals through Snowball sampling within the construction industry and gather quantitative information surrounding the causes of skill shortages. The questions are centred around gathering opinions relating to Covid-19, Brexit and training. The responses were taken from the industry's professionals based on their overall construction experiences, rather than any specific projects. This way the chance to any potential biased feedback is also minimized. The trends discovered are analysed alongside the anomalous results which stray from the hypothesis.

The use of the questionnaire allows for better analysis of information gathered from people who are actively working within the industry and will provide a more present representation of what effects the skills shortage within the UK is having upon the quality of construction projects.

3.1.2. Questionnaire contents

The questionnaire contents are drawn from a variety of sources to assist in formulating appropriate questions to determine the best results from the participants. Questions have been gathered from Mohamed, et al., [44], Gamil & Alhagar, [22] and Guillemard, et al., [24]. The questions are structured on a five-points Likert Scale system which provides the participants to answer from strongly agree (5) to strongly disagree (1) on how much they agree with the statement presented to them. The major reason of using the five-points Likert scale is its enhanced response rate, effectiveness towards quality response, as well as respondents' better satisfaction as compared to seven-points and

Table 1
Measurement and Instrumentation.

No.	Factors	Description	Items	Source(s)
1	Brexit	Labour from Europe, quality suffered due to Brexit, impact on construction projects, negative impact on supply chain, project delays.	6	Mohamed, et al., [44]
2	Covid19	Impact on labour attendace, impact on workmanship, difficulty in managing workforce, impact on project duraion, impact on supply chain, impacted quality of workforce, increase in project spending.	7	Gamil & Alhagar, [22], Maqbool & Patil [37]
3	Aging workforce	Decreased productivity, decreases workmanship closer to retirement, age impacts, importance of age and experience while hiring.	6	Guillemard, et al., [24]
4	T&D	Improved quality, improved productivity, better workmanship, skilled workforce.	5	Maqbool et al., [38]
5	QMS	Cost and time, skilled workforce and productivity, quality management.	5	Maqbool et al., [38], Maqbool & Amaechi, [36]

nine-points Likert scales [3,16,27]. The details of the measurement of the questionnaire items are presented in the Table 1.

3.1.3. Distribution of questionnaire

The questionnaire is formulated on an online software called Google Forms as it allows for easy distribution. Electronic distribution offers a higher chance of receiving a response from participants, this is due to the ease of access that technology currently offers as well as the increased response rate due to the lack of failures in other methods such as letters via post. Sending questionnaires by letter poses a range of difficulties, i. e.: acquiring addresses for participants, failure of receipt, failure of response and security of responses from participants [47].

3.2. Qualitative methodology

"The qualitative methodology intends to understand a complex reality and the meaning of actions in a given context" [57]. The use of qualitative methods of data collection within this research will increase the depth of knowledge and information surrounding the primary data as interviews and expert opinions should offer comparable results gained during the primary data collection stage.

The second stage of data that investigated in this research is qualitative case study as it is taking direct information from an individual case and then using that to analyse the effects that these factors have had. Quantitative elements may be present within the case study; however, the analysis of data will be reliant on the quality of information provided and how it impacts the research [61].

A case study is an investigation into a particular situation that is or has previously taken place, meaning that the views of the researcher play a vital part in the data collection. Case studies are widely used in practise orientated fields such as: education, management, public administration, and social work [61]. This research method has been considered between researchers for a while as they cannot determine whether it is a qualitative or quantitative method.

The case study used for this research is an active construction site in Durham City Centre. The XYZ Development (name is anonymised) is currently under construction by ABC Construction Limited (name is anonymised), and it offers a vast amount of data relating to quality implications because of a lack in skilled labour; as a result of Covid-19, Brexit, ageing workforce and lack of education.

Using information from the case study, this research will show where the effects of Covid-19 affecting labour attendance to site has had an impact; Brexit delaying the import of goods and materials across the border, and the impact from lack of training during this difficult period. This can all be deduced from information which is readily available on site.

Information has been gathered from the case study by looking into elements that have been affected by Covid-19, Brexit, ageing workforce; whilst also looking into productivity, time and cost elements of the project. The XYZ Development (name is anonymised) in Durham was selected as the key case study due to the ability to assess each element separately. As the large-scale project started during the Brexit negotiations, took place throughout the Covid-19 pandemic and has seen every element of trade working within the industry it was a clear candidate to assess each element of the research.

4. Analysis

4.1. Quantitative analysis

The quantitative analysis was conducted using a software called SPSS. Prior to performing a specific analysis for finding the causal relationships between the independent, dependent and moderating variables, the initial data screening, reliability, and validity checks were performed.

4.1.1. Data Screening, reliability and validity

The quantitative data analysis was initiated with the initial data screening, which was conducting by performing the missing value analysis and screening about the outlier values. It was observed that the none of the missing value reported in the whole data sheet, Moreover, there were few outlier values which were excluded from the data sheet before moving for the data analysis.

After performing the initial data screening, the reliability of the data was observed through Alpha coefficient approach, commonly know as the Cronbach’s alpha [12]. The causal research analysis relies mostly on the Alpha coefficient approach, because of its important and extensive quantification [13]. The range of the Cronbach’s alpha values were reported between 0.695 and 0.817, which represents a fairly reliable data to proceed for the further analysis. According to Amirrudin et al., [2], the Cronbach’s alpha values between 0.6 and 0.7 are considered acceptable whereas values over the 0.7 are deemed as good. The details of the Alpha coefficient values (Cronbach’s alpha) are presented in the Table 2.

In the next step, the normality of the data was measured by determining the skewness and kurtosis values of the data. The acceptable range of kurtosis values are -7 and 7 and for the skewness these value range is from -2 to 2 [65]. In the current data, the skewness and Kurtosis values fall well within the prescribed limits, which depicts the normality of the data. The details of the skewness and Kurtosis values are presented in the Table 2.

The Kaiser-Meyer-Olkin (KMO) test was also performed, which reflects on the suitability the data for the further analysis. The KMO test for the current data was also adequate. Further, Bartlett’s Test of Sphericity was also attempted to understand whether the correlation matrix is spherical for the current data. It was also observed that the values for the Bartlett’s test (see Table 3) are well within the recommended guidelines [48].

4.1.2. Bivariate correlation analysis

In order to understand the dependence of a single factor over the multiple other factors, correlation analysis is considered to be important [25]. In the current research this link between the independent, dependent and moderating variables is determined through the bivariate correlation analysis. It was observed that most of variables have strong association in between each other except only few which do not show any strong correlation (see Table 4).

The Table 4 presents the values of the correlation analysis, where the highest correlation is observed in between Covid19 and Brexit, whereas no correlation was observed in between QMS, and Brexit, Covid19 and Aging_workforce. Similarly, the Aging_workforce was also found to be not associate with the T&D.

4.1.3. Moderation analysis

Using hierarchical regression analysis in three steps, the moderation effect of training and development on the relationship between skilled worker shortage and quality management was investigated. Based on VIF (0.10) thresholds per Hair et al. (2010), no multicollinearity was found. Training and development were observed to exhibit significant moderation for Brexit and COVID-19. However, no significant moderation was seen in the ageing workforce. The moderation results are

Table 2
Analysis of screening, reliability and validity of data.

Factor	Items	Cronbach’s alpha	Mean	Std. Deviation	Skewness	Kurtosis		
			Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Brexit	6	0.817	3.5436	0.74610	-0.332	0.297	-0.427	0.586
Covid19	7	0.764	4.3868	0.55139	-0.862	0.297	0.303	0.586
Aging_workforce	6	0.695	3.0359	0.62465	0.282	0.297	0.125	0.586
T&D	5	0.753	4.4308	0.45309	-0.812	0.297	1.167	0.586
QMS	5	0.816	4.0031	0.80272	-0.816	0.297	0.141	0.586

Table 3
KMO and Bartlett’s test.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.889
Bartlett’s Test of Sphericity	Approx. Chi-Square	2295.589
	df	36
	Sig.	0.000

Table 4
Correlation Analysis.

	Brexit	Covid19	Aging_workforce	T&D	QMS
Brexit	1				
Covid19	0.522**	1			
Aging_workforce	0.496**	0.359**	1		
T&D	0.315*	0.334**	0.112	1	
QMS	0.116	0.072	-0.019	0.426**	1

** Correlation is significant at the 0.01 level (2-tailed).

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

summarised in Table 5.

The regression equations’ information was used to illustrate the relationships between the skilled worker shortage variables and quality management at low and high levels of training and development (TD). Low skilled worker shortages factors are associated with being -1 SD below their means. High skilled worker shortages, on the other hand, refer to +1 SD above their means (see Fig. 2, Fig. 3 and Fig. 4).

The plot analysis provided the Figs. 2-4 clearly highlights the importance of the Training and Development for the Construction industry in the UK. It can be observed that with the high involvement of the Training and Development the impacts of the Brexit and COVID-19 can be minimised towards poor Quality Management in the industry.

Table 5
Findings of Moderation Analysis.

Regression Models	Quality Management		
	β-value	t-value	R ²
Model 1			0.040
Brexit	0.145***	1.583	
Covid-19	0.122**	1.489	
Ageing Workforce	-0.184*	-1.003	
Model 2			0.229
Brexit	2.033**	3.397	
Covid-19	-1.058*	-2.740	
Ageing Workforce	-1.050*	-2.664	
Training and Development	0.497***	6.978	
Model 3			0.244
Brexit	-1.471*	-2.227	
Covid-19	1.513*	2.644	
Ageing Workforce	1.450*	2.519	
Training and Development	1.371**	3.001	
(Brexit × Training and Development)	1.919*	1.791	
(Covid-19 × Training and Development)	-2.474*	-1.723	
(Ageing Workforce × Training and Development)	-0.633	-0.612	

* p <.10.

** p <.05.

*** p <.01.

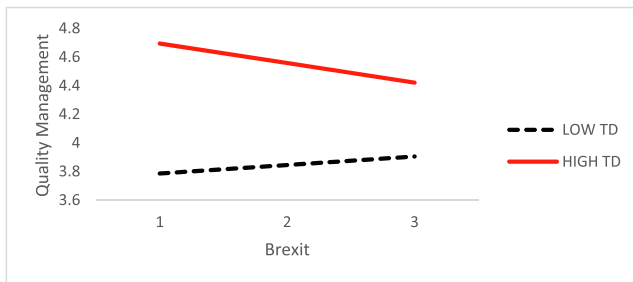


Fig. 2. Plot Analysis on the role of Training and Development Towards Brexit Impacts.

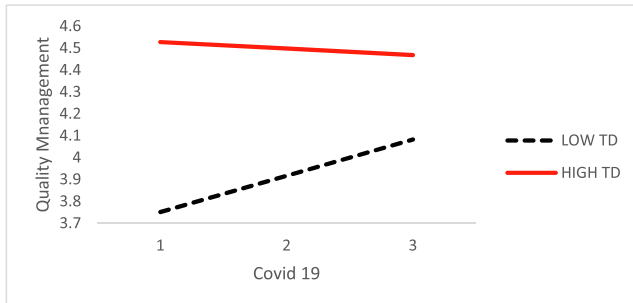


Fig. 3. Plot Analysis on the role of Training and Development Towards COVID-19 Impacts.

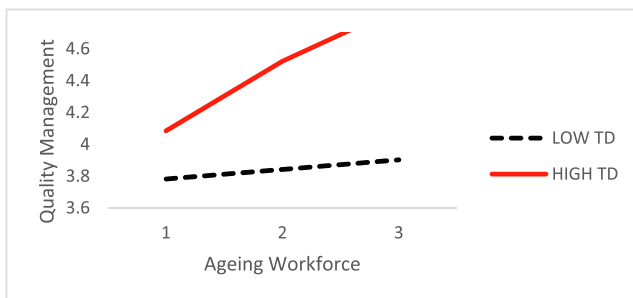


Fig. 4. Plot Analysis on the role of Training and Development Towards Aging Workforce.

Whereas it was also shocking to see that the impacts of the Aging Workforce towards poor Quality Management of the construction industry cannot be controlled. It shows the importance of the younger work force for the industry through multiple such training and development programmes.

It was observed that training and development can largely impact on reducing the negative impacts of COVID-19 and Brexit towards quality management in construction industry in UK. Which means in order to have better construction quality the role of training and development in the critical factor to focus on. However, it was also observed that training and development failed to mediate in between the aging workforce and quality management. In simple words it can be analysed that the better quality construction is linked with the young and energetic workforce and that's why more and more such training and development opportunities should be provided to the young employees working in this industry. Training and development opportunities would help in shaping the new starters abilities in right direction towards their career in construction as well putting an overall impact on the quality management activities in the construction industry in the UK.

4.2. Qualitative findings of case study – XYZ development (name is anonymised), Durham 2019 – 2022

The XYZ Development (name is anonymised) was a project which started on site in the spring of 2019 where ABC (name is anonymised) won the contract for the brownfield site and started enabling works. During the last 3 years this construction project and staff have experienced the impacts caused by Brexit (January 2020), Covid-19 (December 2019 to 2022) and the effects of an ageing workforce. Therefore, it makes it a perfect “candidate” to be used as a case study for this research.

The XYZ Development (name is anonymised) consists of a variety of units and buildings all offering their own challenges and constraints; The project is split up into a Premier Inn Hotel, three Private Rented Sector Apartment blocks, a nine floor “open plan” office space, three story car park, four cinemas, and a selection of retail and leisure units, amounting to £85,000,000.

4.2.1. Time delays on site

When ABC tendered (name is anonymised) for the project the initial handover date was set at November 2021, giving just over 2 years to complete the project. As of March 2022, the project is still under construction and is expected to hand over in May 2022.

Due to time delays from the Covid-19 Pandemic, ABC (name is anonymised) appealed to the client for extensions of time to allow them to complete the project. A six-month extension was granted because of the delay caused by Covid-19. The time lost during the project was down to a substantial number of the skilled workforce being out of work and isolating from Covid-19. The reduced labour on site led to significant delays and there was a rush to get works completed on time. ABC (name is anonymised) staff focused on productivity rather than quality during Covid-19, therefore inadequate quality was missed early in the project which means that the quality later was not as high as it could have been. Now that the impacts of Covid-19 are getting easier to manage it means that quality is improving across the site and ABC (name is anonymised) staff can focus more on the performance of each trade.

Brexit has led to significant delay in getting required materials to sites across the UK, this also applied to the XYZ Development site (name is anonymised). The setbacks caused by Brexit meant that importing materials for the façade, including glass and stone were exhaustive. This setback has meant that the workforce on site is limited in the materials that they can use. Consequently, a large majority of the works inside the building were delayed due to the need for the external façade to be finished before internal works can be complete. The time delay caused by Brexit has meant that temporary materials were required during the waiting period, which needed to then be replaced further into the project to meet the clients specification. Staff had to focus more on improving the quality of temporary measures rather than installing the high-quality material/product first time, leading to an increase in costs and time spent “double-handling”.

4.2.2. Training and development

The effects of Covid-19 meant that a significant amount of training courses were suspended during the pandemic and it meant that ABC (name is anonymised) could not train their own staff and labour. This was seen throughout the subcontractors as well, expired or close to expiration CSCS cards were being shown at induction, however nothing could be done as the courses were not running. ABC (name is anonymised) experienced a lack of skilled labour, for example the groundwork subcontractor struggled to provide more shuttering joiners due to the lack of interest in joinery apprenticeships.

Subcontractors on site had significant issues trying to source labour as it was more difficult to come by. It was often seen that labour that was employed through agencies would be “passed around” the contractors on site. In some cases, labour that was employed at the start of the project with the groundwork subcontractor, was seen towards the end of

the project with the partition contractors. The reason for this labour shortage was suggested by many on site to be the effects of Brexit and Covid-19.

4.2.3. Quality on site

The XYZ Development (name is anonymised) has seen that maintaining high quality due to the effects of the Covid-19 Pandemic and Brexit was challenging. Monitoring quality site-wide with reduced management staff as well as labour on-site, keeping on top of quality became demanding and was often overlooked in favour of production.

As the site developed and finishing trades started commencing work on site it meant that completing areas of work was made difficult with the sheer scale of the project. For example, delays caused by the glazing contractor meant that the perimeter of the building could not be sealed, therefore the mechanical and electrical trades could not commence work inside of the building. The glazing contractor expressed that the delay was not their fault and Brexit, and Covid-19 had a significant impact, however the other trades needed to start so temporary measures were put in place to continue production. Long delays and higher costs caused by Brexit, Covid-19 and other supply chain issues meant that there was little room for error as lead times were increased on top of the project already being off schedule.

5. Conclusion and recommendations

To conclude, the review on the skill shortage within the UK construction industry, and the impact on quality management, it has been made apparent from the literature and the survey that change will be required to the training and development areas of the industry to improve on the skill shortage seen as an effect of the aforementioned impacts. The hierarchical multiple regression analysis was conducted on the quantitative data. The results highlighted the major reasons of the negative impacts on the quality management system (i.e., Time, Cost, and Productivity) in the construction are the Skill Shortage Factors, namely, Covid-19, Brexit and the ageing workforce. These negative impacts of Skill Shortage Factors are also reported in the case study of the XYZ Development (name is anonymised), Durham 2019 – 2022.

It was also observed that whether the Training and Development can moderate these negative impacts of Skill Shortage Factors or not. The findings revealed that Training and Development plays a moderating role in between the Covid-19, Brexit, and Quality Management Systems of Construction. It means the with the enhanced Training and Development opportunities, the negative impacts of the Covid-19 and Brexit can be minimized on the construction industry of UK. Whereas the moderating role of Training and Development was not observed as statistically significant for the Aging Workforce towards Quality Management Systems on the Construction. The moderating influence of the Training and Development was also explained with the help of plot analysis at the low and high levels of Training and Development opportunities on the Quality Management System while tackling the negative impacts of the Skill Shortage Factors.

The findings reveals that though Training and Development is good for the industry, still it cannot cope with the negative impacts of the Aging Workforce. So, the construction organisations should focus on the Training and Development of the younger professionals rather than hiring and training the aged workers. Employers have the ability and time to encourage training within their businesses and improving the knowledge of their staff is something that can be easily achieved with correct planning and time considerations put in place. Furthermore, skills need to be honed and developed, for the younger generation this needs to be established to set the standard for what companies want and expect to achieve. Apprenticeships, volunteers and taking on school leavers with little to no skill is a risk to a business, however the risk can be minimised if the right level of investment is considered. The results from the survey highlighted this massively, there is understanding among industry professionals that work needs to take place with young

people, yet little to no investment takes place.

A future research might be useful to understand the comparison between the effectiveness of usual training and development programmes and apprenticeship programmes, on how different these are in term of providing timely solution with effective financial constraints and effective skillset. This would help in better planning for government, industry and overall, the key stakeholders for formulating the respective strategies in better way.

Data Availability Statement

Some or all data, models, or code that support the findings of this study are available from the corresponding author upon reasonable request.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

- [1] Afkhamiagh AM, Elwakil E. Preliminary modeling of Coronavirus (COVID-19) spread in construction industry. *J Emergency Manage (Weston, Mass)* 2020;18(7): 9–17.
- [2] Amirrudin M, Nasution K, Supahar S. Effect of variability on Cronbach alpha reliability in research practice. *Jurnal Matematika, Statistika dan Komputasi* 2021; 17(2):223–30.
- [3] Babakus E, Mangold WG. Adapting the SERVQUAL scale to hospital services: an empirical investigation. *Health Serv Res* 1992;26(6):767–86.
- [4] Ball C. Skill shortages in the UK: an insight into occupational shortages in the UK labour market. Bristol: Prospects Illuminate; 2019.
- [5] Bassioni HA, Price ADF, Hassan TM. Performance Measurement in Construction. *J Manag Eng* 2004;20(2):42–50.
- [6] Belke A, Gros D. The Economic Impact of Brexit: Evidence from Modelling Free Trade Agreements. *Atl Econ J* 2017;45(3):317–31.
- [7] Brautzsch HU, Holtemöller O. International trade barriers and regional employment: the case of a no-deal Brexit. *J Econ Struct* 2021;10(11):1–25.
- [8] Brooks T, McIlwaine S. Why does anyone want to work within the UK Construction Industry? *37th Annual Association of Researchers in Construction Management (ARCOM) Conference: Proceedings*; 2021. p. 330-339.
- [9] Burgess G, Jones M, Muir K. BIM in the UK house building industry: opportunities and barrier to adoption. Cambridge: University of Cambridge; 2018.
- [10] Chountalas PT, Tepaskoualos FA. Selective integration of management systems: a case study in the construction industry. *TQM J* 2021;33(8):13–27.
- [11] Ciutiene R, Railaite R. Challenges of Managing an Ageing Workforce. *19th International Scientific Conference; Economics and Management 2014*, vol. 156, p. 69-73.
- [12] Cronbach LJ. Coefficient alpha and the internal structure of tests. *Psychometrika* 1951;16(3):297–334.
- [13] Cronbach LJ, Shavelson RJ. My current thoughts on coefficient alpha and successor procedures. *Educ Psychol Meas* 2004;64(3):391–418.
- [14] Daniel E, Oshodi AM, Henjewe C, Haywood K. Strategies for improving construction craftspeople apprenticeship training programme: Evidence from the UK. *J Clean Prod* 2020:266.
- [15] Demir A, Budur T, Omer HM, Heshmati A. Links between knowledge management and organisational sustainability: does ISO 9001 certification have an effect? *Knowl Manag Res Pract* 2021:1–14.
- [16] Devlin SJ, Dong HK, Brown M. Selecting a scale for measuring quality. *Mark Res* 2003;15(3):12–7.
- [17] Doherty K, Cullinane C. COVID-19 and Social Mobility Impact Brief #3: Apprenticeships. London: The Sutton Trust; 2020.
- [18] Duan Y, Mullins R, Hamblin D, Stanek S, Sroka H, Machado V, et al. Addressing ICTs skill challenges in SMEs: insights from three country investigations. *J Eur Ind Train* 2002;26(9):430–41.
- [19] Dźwigol H. Virtual Economics. *Research methods and techniques in new management trends: Research Results* 2019;2(1):31-48.
- [20] Finkelstein R, Block D, Butler NR. 10 Advantages of Retaining and Hiring Older Workers. s.l.: Columbia University; 2021.
- [21] Fu D. Problems and Countermeasures in Construction Engineering Quality Management. *J Soc Sci Stud* 2019;3:865–9.
- [22] Gamil Y, Alhagar A. The Impact of Pandemic Crisis on the Survival of Construction Industry: A case of Covid-19. *Mediterr J Soc Sci* 2020;11(4):122–8.
- [23] Gann D, Senker P. Construction Skills training for the next Millennium. *Construct Manage Econ* 1998;16(5):569–80.
- [24] Guillemand A, Taylor P, Walker A. Managing an Ageing Workforce in Britain and France. *Geneva Papers Risk Insurance Issues Practice* 1996;21(81):478–501.

- [25] Hall MA, Holmes G. Benchmarking attribute selection techniques for discrete class data mining. *IEEE Trans Knowl Data Eng* 2003;15(6):1437–47.
- [26] Harris F, McCaffer R, Baldwin A, Edum-Fotwe F. *Modern Construction Management*. 8 ed. Oxford: Wiley Blackwell; 2021.
- [27] Hayes BE. *Measurement customer satisfaction: Development and use of questionnaire*. Milwaukee, WI: ASQC Quality Press; 1992.
- [28] Ho PH. Labour and skill shortages in Hong Kong's construction industry. *Eng Constr Archit Manag* 2016;23(4):533–50.
- [29] Howarth T, Greenwood D. *Construction Quality Management*. 2nd ed. New York: Taylor & Francis Group; 2017.
- [30] Hoyle D. *Quality Management Essentials*. 1st ed. New York: Routledge; 2007.
- [31] Johari S, Neeraj Jha K. Challenges of attracting construction workers to skill development and training programmes. *Eng Constr Archit Manag* 2019;27(2): 321–40.
- [32] Keenan M, Rostami A. The impact of quality management systems on construction performance in the North West of England. *Int J Construct Manag* 2021;21(9): 871–83.
- [33] Lawani K, et al. Skill shortage of bricklayers in Scotland. *J Eng, Design Technol* 2021.
- [34] Mahmoudi A, Abbasi M, Deng X. A novel project portfolio selection framework towards organizational resilience: robust ordinal priority approach. *Expert Syst Appl* 2022;188:116067.
- [35] Malik A, Adekoya OD, Ajonbadi HA, Jimoh I. Investigating the Potential Economic Impact of Brexit Decisions on Business Performance in the United Kingdom: A Case Study of the UK Construction Industry. *Int J Manage, Account Econ* 2019;6(4): 347–67.
- [36] Maqbool R, Amaechi IE. A systematic managerial perspective on the environmentally sustainable construction practices of UK. *Environ Sci Pollut Res* 2022. <https://doi.org/10.1007/s11356-022-20255-5>.
- [37] Maqbool R, Patil K. In pressing COVID-19's era, where is the UK construction industry standing, understanding the impacts on projects. *J Urban Plann Dev* 2023. <https://doi.org/10.1061/JUPDDM/UPENG-4093>.
- [38] Maqbool R, Sudong Y, Manzoor N, Rashid Y. The Impact of Emotional Intelligence, Project Managers' Competencies, and Transformational Leadership on Project Success: An Empirical Perspective. *Proj Manag J* 2017;48(3):58–75.
- [39] Matthias B, Laszig L. Productivity development in the construction industry and human capital: a literature review. *Civ Eng Urban Plann: Int J* 2021;8(1):1–15.
- [40] Mackenzie S, Kilpatrick AR, Akintoye A. UK construction skills shortage response strategies and an analysis of industry perceptions. *Constr Manag Econ* 2000;18(7): 853–62.
- [41] Mason G, Constable S. Product strategies, skills shortages and skill updating needs in England: New evidence from the National Employer Skills Survey, 2009; 2011.
- [42] McSweeney R. *Office for National Statistics*; 2020. [Online] Available at: <https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/earningsandworkinghours/articles/coronavirusandkeyworkersintheuk/2020-05-15> [accessed 04 January 2022].
- [43] Ministry of Housing, Communities & Local Government. *Application of the Building Regulations during the coronavirus (COVID-19) outbreak (Guidance)*; 2020. [Online] Available at: <https://www.gov.uk/guidance/application-of-the-building-regulations-during-the-coronavirus-covid-19-outbreak> [accessed 4 January 2022].
- [44] Mohamed M, Pärn AE, Edwards JD. Brexit: measuring the impact upon skilled labour in the UK construction industry. *Int J Build Pathol Adapt* 2017;35(3): 264–79.
- [45] Moreno C, Olbina S, Issa RR. BIM Use by Architecture, Engineering, and Construction (AEC) Industry in Educational Facility Projects. *Adv Civ Eng* 2019: 1–19.
- [46] Murtagh N, Loulwa A, Roberts A. The role of building control surveyors and their power in promoting sustainable construction. *Constr Manag Econ* 2018;36(7): 363–74.
- [47] Naoum SG. *Dissertation Research and Writing for Construction Students*. 3rd ed. s. l.: Routledge; 2013.
- [48] Napitupulu D, Kadar JA, Jati RK. Validity testing of technology acceptance model based on factor analysis approach. *Indonesian J Electr Eng Comput Sci* 2017;5(3): 697–704.
- [49] Nguyen BN, Nguyen TQ, Dinh HT, Chu AT. The Impact of the COVID-19 on the Construction Industry in Vietnam. *Int J Built Environ Sustainability* 2021;8(3): 47–61.
- [50] Office for National Statistics. *GOV.UK*; 2021. [Online] Available at: <https://explore-education-statistics.service.gov.uk/find-statistics/apprenticeships-and-traineeships/2020-21#dataDownloads-1> [accessed 5 November 2021].
- [51] Ofori G, Gang G, Briffett C. Implementing environmental management systems in construction: lessons from quality systems. *Int J Build Environ* 2002;37(12): 1397–407.
- [52] Ogunnusi M et al. *Journal of engineering, design and technology. Lessons learned from the impact of COVID-19 on the global construction industry*; 2021. p. 1-27.
- [53] Oraee MM, et al. Collaboration barriers in BIM-based construction networks: A conceptual model. *Int J Proj Manag* 2019;37(6):839–54.
- [54] Oti-Sarpong K. Offsite manufacturing, construction and digitalisation in the UK construction industry - state of the nation report. Cambridge: Cambridge Centre for Housing and Planning Research; 2019.
- [55] Ozinga. *Ozinga*; 2021. [Online] Available at: <https://ozinga.com/blog/4-problems-that-arise-with-poor-quality-materials/> [accessed 02 January 2022].
- [56] Pollack J, Helm J, Adler D. What is the iron triangle and how has it changed. *Int J Manag Proj Bus* 2018;11(2):527–47.
- [57] Queiros A, Faria D, Almeida F. Strengths and Limitations of Qualitative and Quantitative Research Methods. *Europ J Ed Stud* 2017;3(9):369–87.
- [58] Rae D, Gledson B, Littlemore M. BIM and its impact upon project success outcomes from a Facilities Management perspective. Newcastle Upon Tyne: Northumbria University; 2019.
- [59] Russ B, Nigg W. *People temporarily away from paid work in the UK (Dataset)*; 2020. [Online] Available at: <https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/datasets/peopletemporarilyawayfrompaidworkintheuk>.
- [60] Silva GASK, Warnakulasuriya BNF, Arachchige BJH. A review of the skill shortage challenge in construction industry in Sri Lanka. *Int J Econ, Business Manage Res* 2018;2(1):75–89.
- [61] Starman AB. The case study as a type of qualitative research. *J Contemp Ed Stud* 2013;1:28–43.
- [62] Winterbotham M, et al. *Employer Skills Survey 2017*. London: IFF Research Ltd; 2017.
- [63] Worrall L et al. Barriers to women in the UK construction industry; 2010, p. 17(3).
- [64] Wylie E. The Impact of Covid-19 and the Lockdown on the UK Economy. Orlando, Florida: Rollins Scholarship Online; 2021.
- [65] Yen WM, Fitzpatrick AR. Item response theory. In: Brennan RL, editor. *Educational Measurement*. 4th ed. Westport, CT: American Council on Education and Praeger; 2006. p. 111–53.