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Investigating Digital Technological Competencies amongst Black Asian Minority Ethnic Construction students in the UK.

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List of Tables and Titles

Table Ⅰ Individual mean values of selected DT

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
Sending and receiving emails	35	1	5	4.60	.847	.718
Excel	35	3	5	4.57	.655	.429
Word	35	2	5	4.54	.780	.608
Computer literacy/basic IT skills	35	2	5	4.49	.781	.610
Proficiency Browsing searching materials	35	1	5	4.49	.887	.787
PowerPoint	35	2	5	4.31	.718	.516
Specialist IT skills	35	3	5	4.26	.780	.608
Mobile Devices	35	2	5	4.26	.817	.667
Tablet	35	1	5	4.00	1.000	1.000
Social media handles	35	1	5	3.80	.901	.812
Valid N (listwise)	35					

Table Ⅱ Individual mean values of Awareness of New Digital Technologies

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
Lidar survey scanner	35	1	5	2.74	1.197	1.432
Digital Twin	35	1	5	2.51	1.314	1.728
Blockchain	35	1	5	2.49	1.292	1.669
Design for Manufacture and Assembly (DfMA)	35	1	5	2.31	1.132	1.281
IoT	35	1	5	2.29	1.274	1.622
Productivity planning apps	35	1	5	2.17	1.224	1.499
Machine Learning (ML)	35	1	5	2.17	1.150	1.323
Mixed Reality (MR), Augmented Reality (AR), Virtual Reality (VR)	35	1	5	2.11	1.231	1.516
Autonomous Vehicles	35	1	5	2.11	1.051	1.104
Big data	35	1	5	2.06	1.083	1.173
Smart wearables Wearable tech	35	1	5	2.03	1.200	1.440
Data analytics	35	1	5	2.00	1.188	1.412

Robotics	35	1	5	1.89	1.078	1.163
Artificial Intelligence (AI)	35	1	5	1.89	1.183	1.398
Smart Sensors	35	1	5	1.86	1.061	1.126
Drones Unmanned Aerial Vehicles (UAVs)	35	1	5	1.86	1.167	1.361
Laser Scanning	35	1	4	1.83	1.098	1.205
Cloud computing and collaboration	35	1	5	1.77	1.140	1.299
3D printing	35	1	5	1.77	1.114	1.240
Offsite construction and manufacturing	35	1	5	1.54	1.039	1.079
BIM	35	1	5	1.49	.981	.963
Valid N (listwise)	35					

Table Ⅲ Individual mean values of Training Awareness of New Digital Technologies

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
Blockchain	35	1	5	3.69	1.388	1.928
Autonomous vehicles	35	1	5	3.63	1.395	1.946
ML	35	1	5	3.60	1.439	2.071
Lidar survey scanner	35	1	5	3.51	1.463	2.139
3D printing	35	1	5	3.40	1.479	2.188
AI	35	1	5	3.37	1.477	2.182
Robotics	35	1	5	3.31	1.491	2.222
IoT	35	1	5	3.31	1.409	1.987
Laser scanning	35	1	5	3.29	1.467	2.151
Data analytics	35	1	5	3.29	1.506	2.269
Digital twin	35	1	5	3.29	1.526	2.328
Smart wearables Wearable	35	1	5	3.26	1.482	2.197
Smart sensors	35	1	5	3.26	1.482	2.197
Big data	35	1	5	3.26	1.559	2.432
Drones UAVs	35	1	5	3.20	1.530	2.341
DfMA	35	1	5	3.14	1.517	2.303
Productivity planning apps	35	1	5	3.00	1.475	2.176
MR AR VR	35	1	5	3.00	1.372	1.882
Cloud computing and collaboration	35	1	5	2.89	1.430	2.045
Off-site construction and manufacturing	35	1	5	2.71	1.545	2.387

BIM	35	1	5	2.46	1.559	2.432
Valid N (listwise)	35					

Table Ⅳ Individual mean values of Competencies in the use of new Digital Technologies

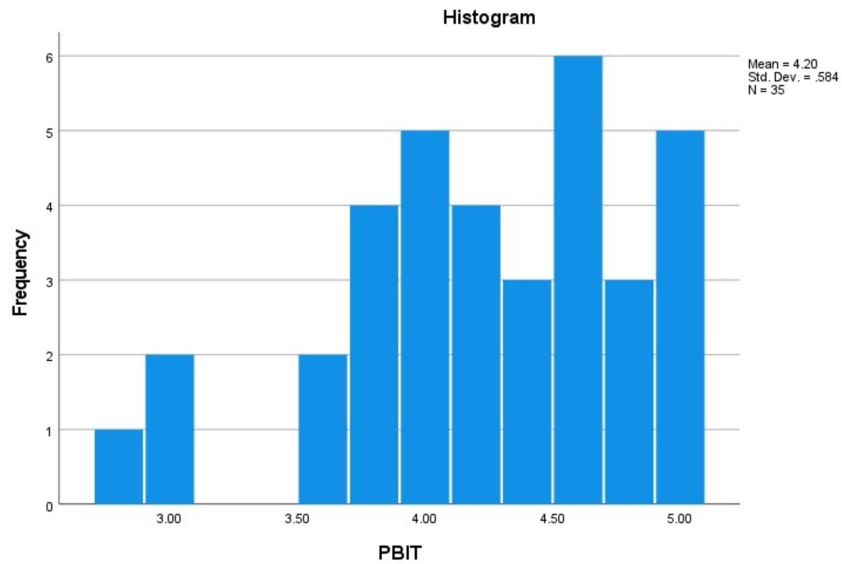
Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
BIM	35	1	5	3.09	1.292	1.669
Cloud computing and collaboration	35	1	5	3.06	1.454	2.114
Productivity planning	35	1	5	3.00	1.515	2.294
Off-site construction and manufacturing	35	1	5	2.66	1.259	1.585
Data analytics	35	1	5	2.57	1.378	1.899
IoT	35	1	5	2.40	1.499	2.247
Smart wearables	35	1	5	2.37	1.330	1.770
Big data	35	1	5	2.34	1.392	1.938
Smart sensors	35	1	5	2.31	1.231	1.516
DfMA	35	1	5	2.17	1.294	1.676
MR AR VR	35	1	5	2.11	1.278	1.634
Drones UAVs	35	1	4	2.09	1.245	1.551
Digital twin	35	1	5	2.09	1.337	1.787
ML	35	1	5	2.06	1.327	1.761
3D printing	35	1	5	1.97	1.071	1.146
AI	35	1	5	1.91	1.222	1.492
Robotics	35	1	5	1.77	1.060	1.123
Laser scanning	35	1	5	1.77	1.140	1.299
Blockchain	35	1	4	1.71	1.045	1.092
Autonomous vehicles	35	1	5	1.69	1.051	1.104
Lidar survey scanner	35	1	4	1.60	.946	.894
Valid N (listwise)	35					

Table V Individual mean values of whether the new digital technologies are well captured in the current teaching and learning

Descriptive Statistics

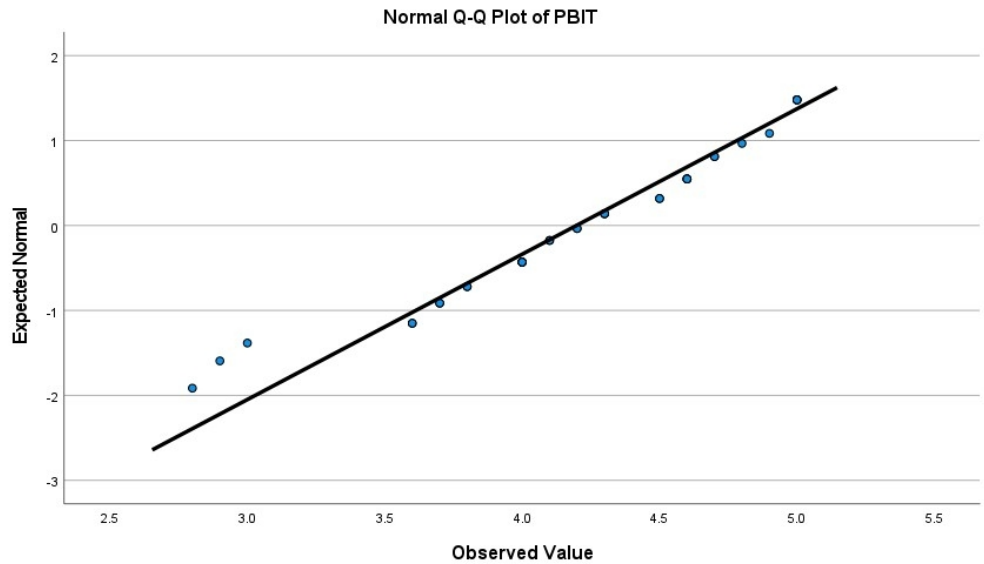
	N	Minimum	Maximum	Mean	Std. Deviation	Variance
BIM	35	1	5	4.06	1.211	1.467
Off-site construction manufacturing	35	1	5	3.97	1.043	1.087
Productivity planning	35	1	5	3.11	1.132	1.281
Cloud computing and collaboration	35	1	5	3.09	1.095	1.198
MR AR VR	35	1	5	2.97	1.098	1.205
Smart sensors	35	1	5	2.94	1.211	1.467
3D printing	35	1	5	2.91	1.040	1.081
DfMA	35	1	5	2.86	1.192	1.420
Laser scanning	35	1	5	2.80	1.132	1.282
Big data	35	1	5	2.71	1.178	1.387
IOT	35	1	5	2.71	1.045	1.092
Smart wearables Wearable tech	35	1	5	2.69	1.231	1.516
Digital twin	35	1	5	2.69	1.051	1.104
Drones UAVs	35	1	5	2.66	1.027	1.055
Data analytics	35	1	5	2.63	1.087	1.182
Lidar survey scanner	35	1	5	2.57	1.092	1.193
Robotics	35	1	4	2.49	.887	.787
Autonomous vehicles	35	1	5	2.46	1.010	1.020
AI	35	1	4	2.43	.850	.723
ML	35	1	5	2.40	.881	.776
Blockchain	35	1	5	2.34	.998	.997
Valid N (listwise)	35					



[redacted]

Figure 3 – A Histogram showcasing the mean distribution of the proficiency level of BAME CUGS in basic Digital Technologies

224x146mm (96 x 96 DPI)



[redacted]

Figure 4 – Expected normal vs Observed plot of the proficiency level of BAME CUGS in basic Digital Technologies

224x146mm (96 x 96 DPI)

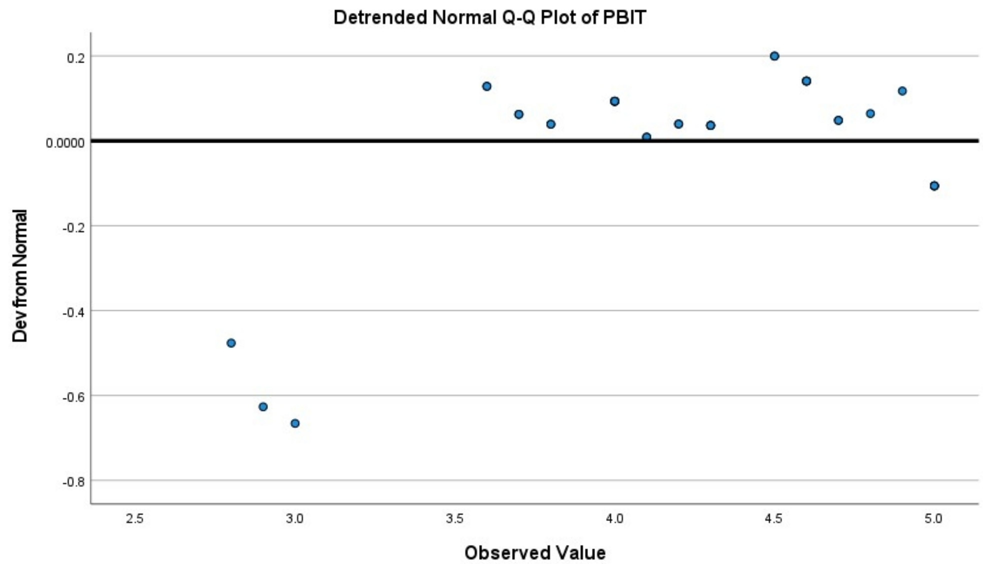


Figure 5 – Observed vs Deviation from normal plot of the proficiency level of BAME CUGS in basic Digital Technologies

224x132mm (96 x 96 DPI)

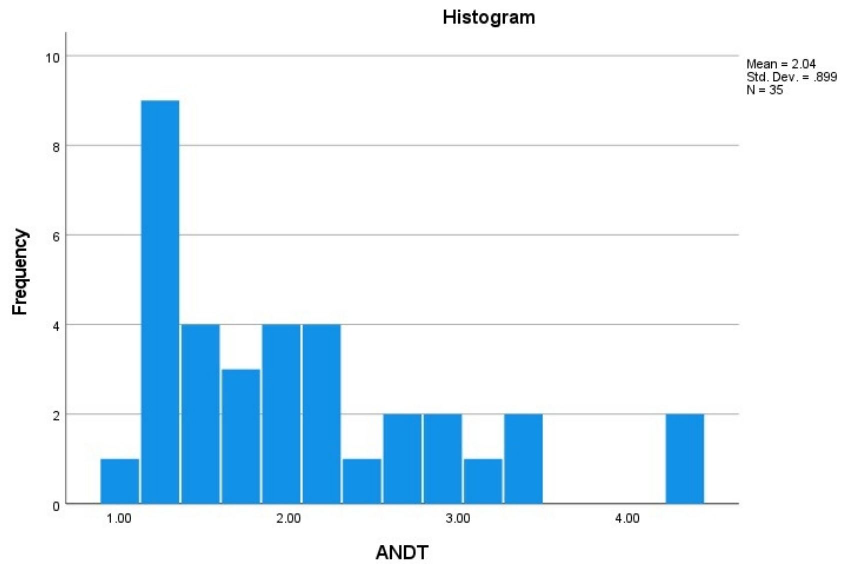


Figure 6 – A Histogram showcasing the mean distribution of respondent’s awareness of new Digital Technologies

224x132mm (96 x 96 DPI)

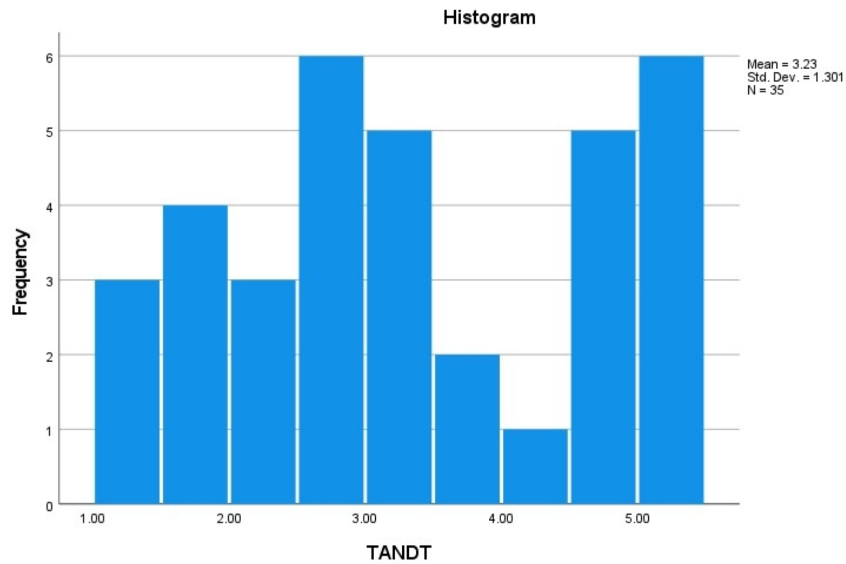


Figure 7 – A Histogram showcasing the mean distribution of respondent’s awareness of Training relevant new Digital Technologies

224x132mm (96 x 96 DPI)

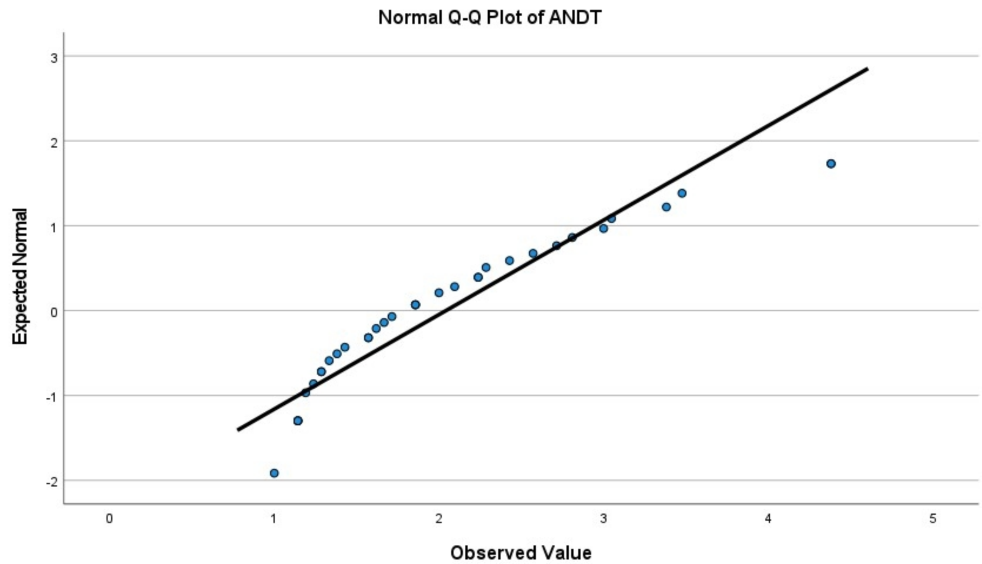


Figure 8 – Expected normal vs Observed plot for Awareness of new Digital Technologies

224x132mm (96 x 96 DPI)

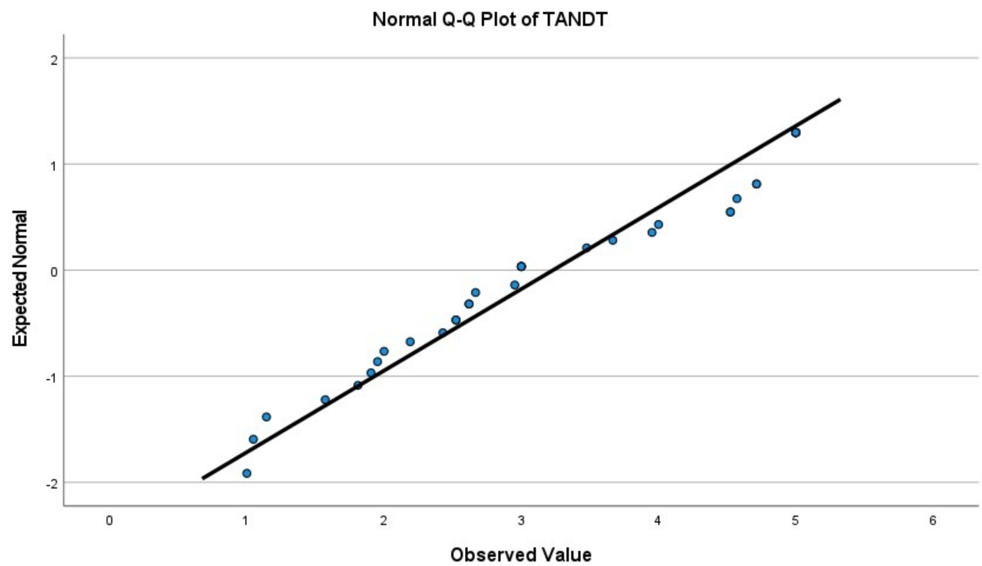


Figure 9 – Expected normal vs Observed plot for Training awareness of new Digital Technologies

224x132mm (96 x 96 DPI)

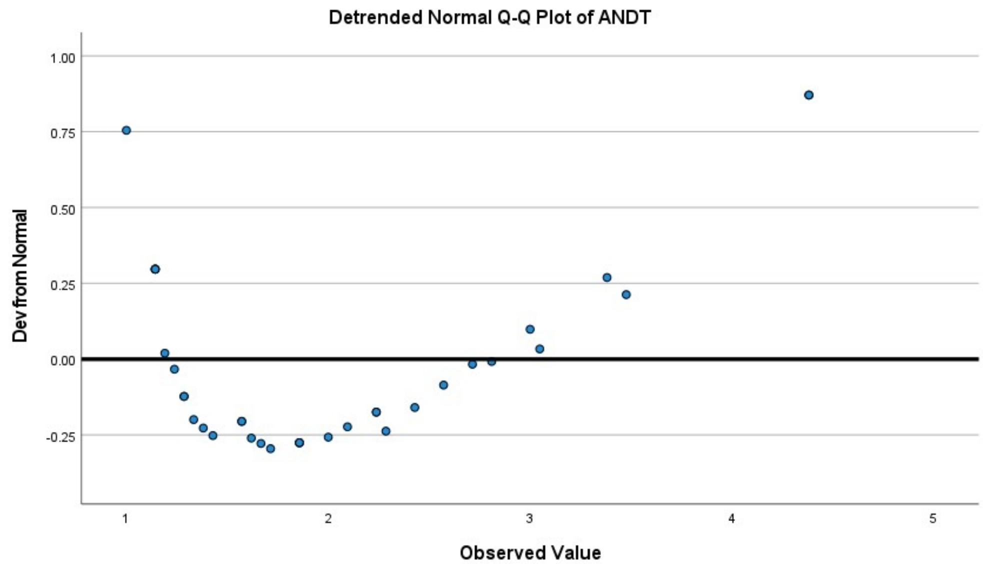


Figure 10 – Observed vs Deviation from normal plot for Awareness of new Digital Technologies

224x132mm (96 x 96 DPI)

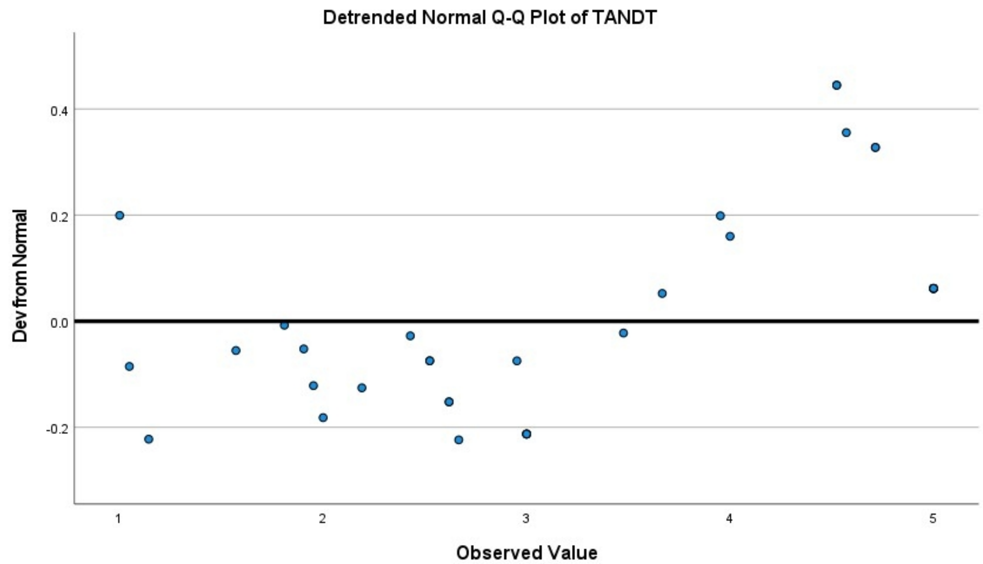


Figure 11 – Observed vs Deviation from normal plot for Training awareness of new Digital Technologies

224x132mm (96 x 96 DPI)

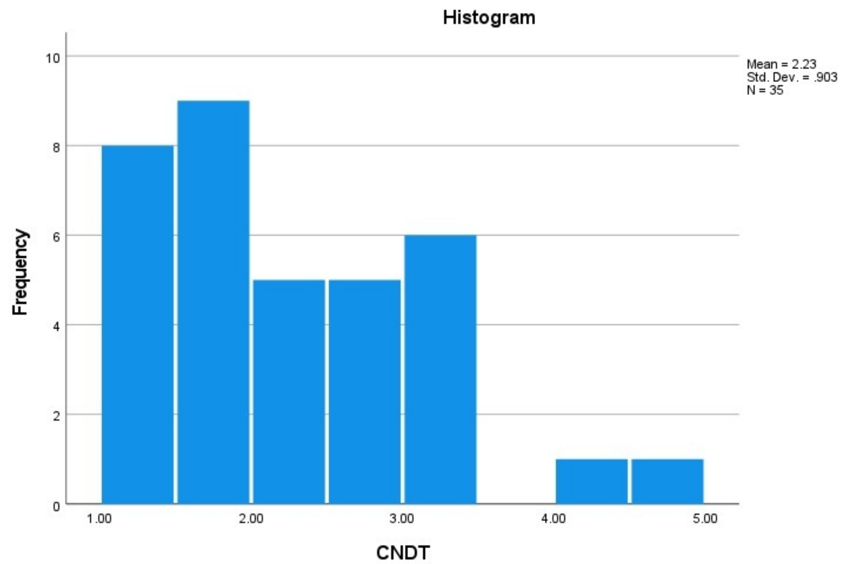


Figure 12 – A Histogram showcasing the mean distribution of respondent's competencies in the use of new Digital Technologies

224x132mm (96 x 96 DPI)

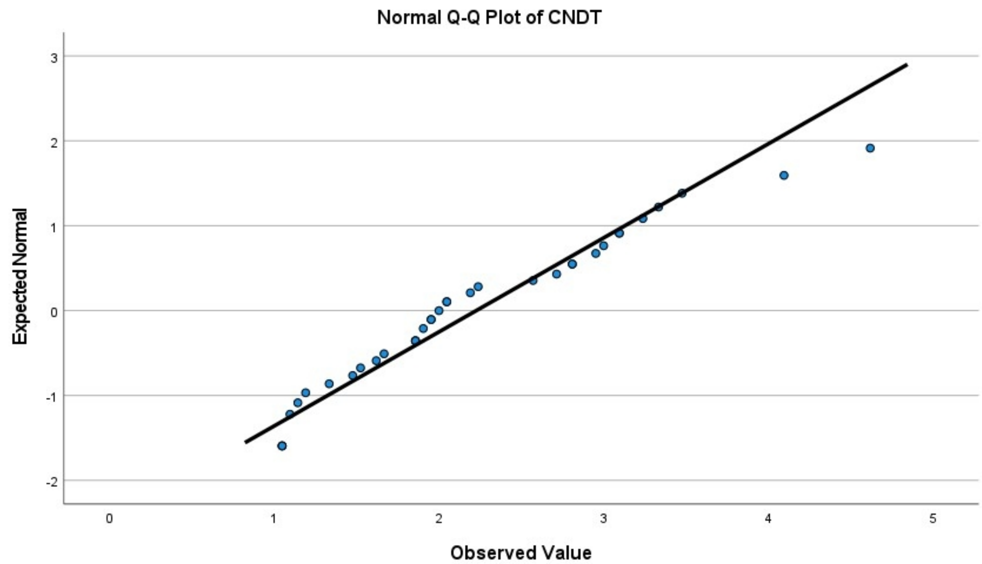


Figure 13 – Expected normal vs Observed plot for Competencies in the use of new Digital Technologies

224x132mm (96 x 96 DPI)

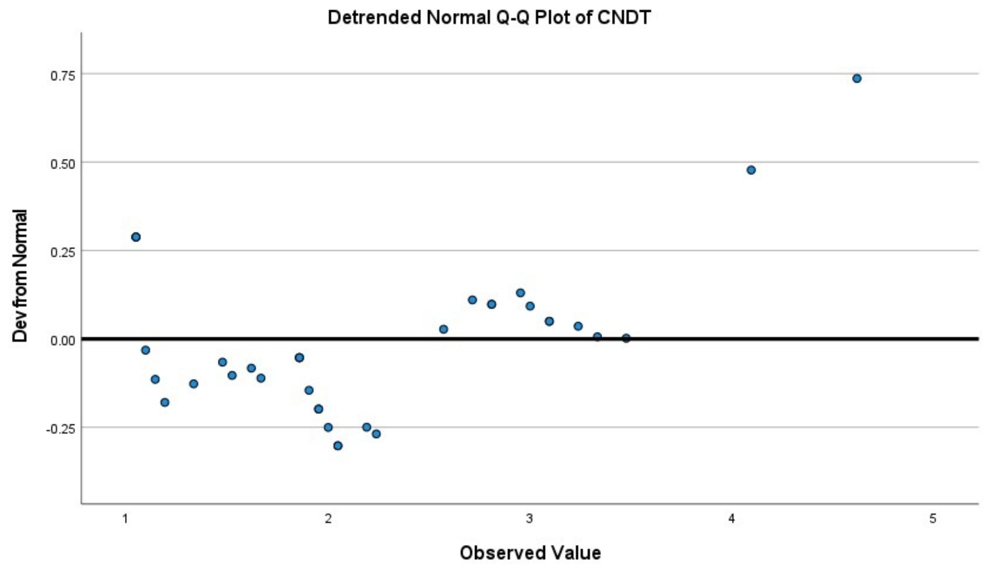


Figure 14 – Observed vs Deviation from normal plot for Competencies in the use of new Digital Technologies

224x132mm (96 x 96 DPI)

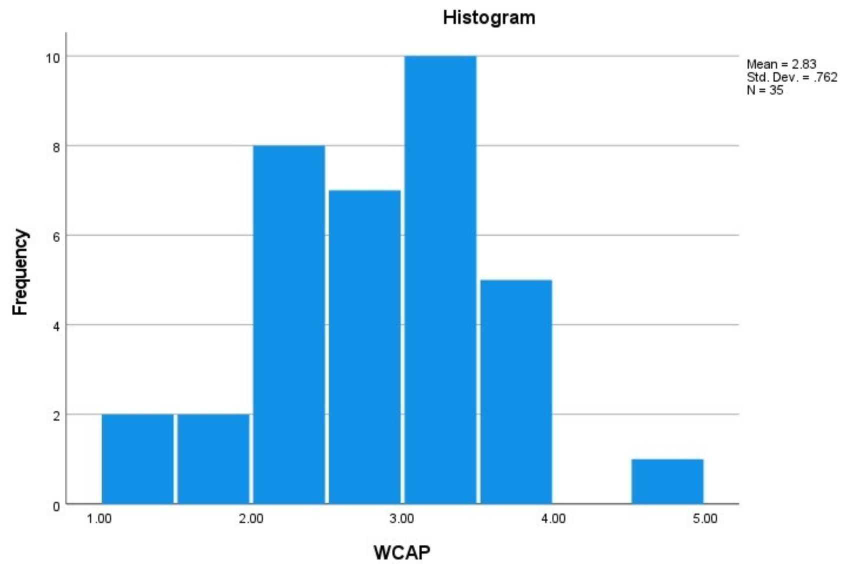


Figure 15 – A Histogram showcasing the mean distribution of respondent's response to whether the new digital technologies are well captured in the current teaching and learning

224x132mm (96 x 96 DPI)

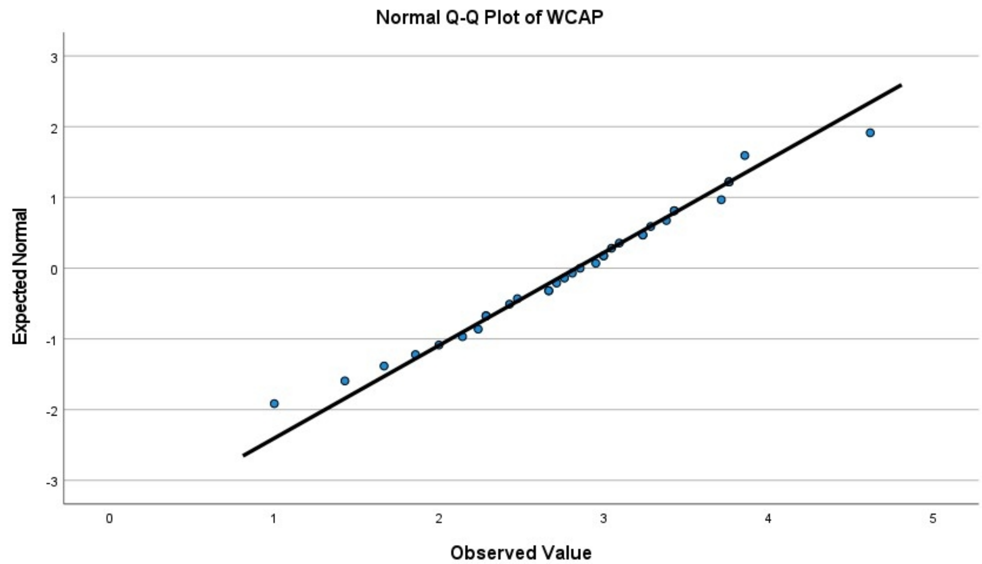


Figure 16 – Expected normal vs Observed plot for whether the new digital technologies are well captured in the current teaching and learning

224x132mm (96 x 96 DPI)

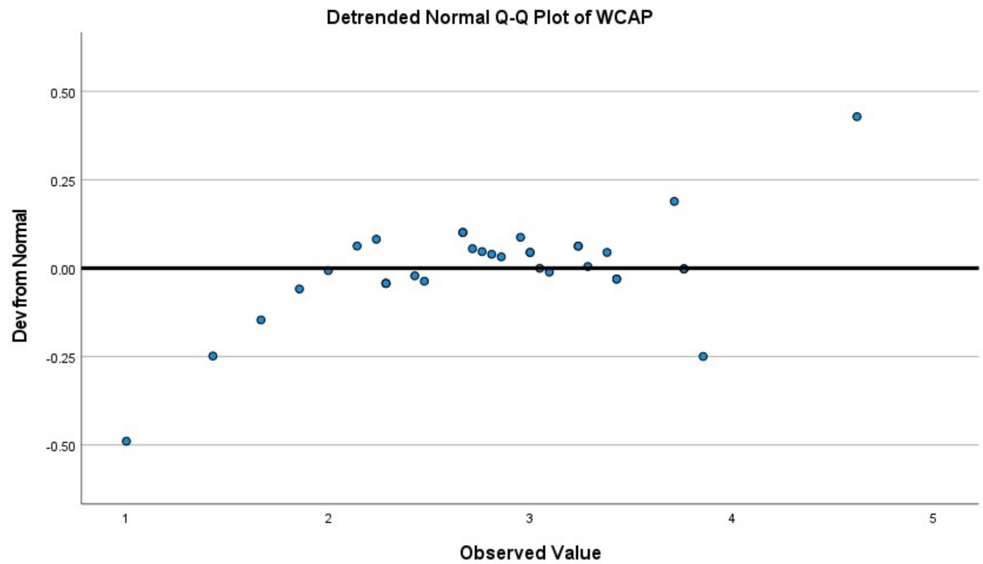


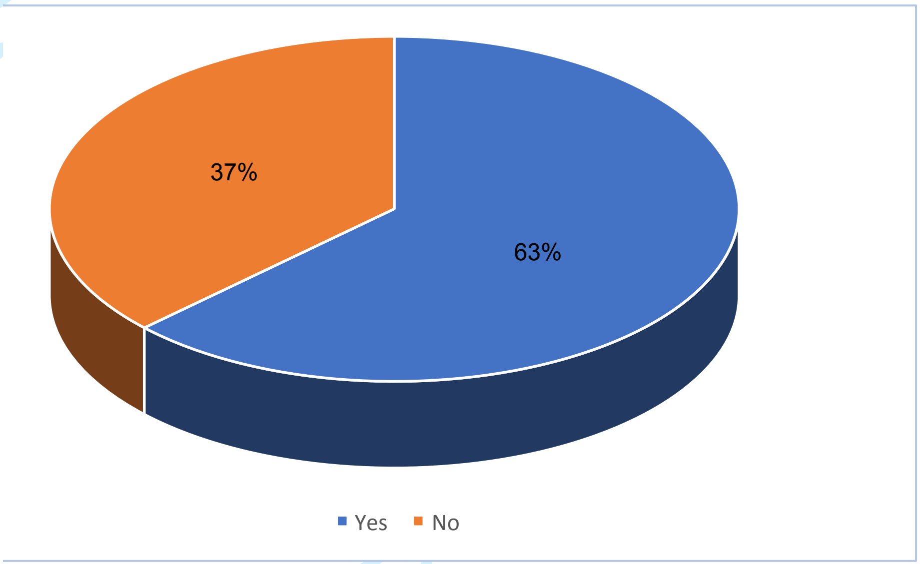
Figure 17 – Observed vs Deviation from normal plot for whether the new digital technologies are well captured in the current teaching and learning

224x132mm (96 x 96 DPI)

Yes	62.9
No	37.1

Figure 1

Figure 1 – Is there a problem of low digital technol



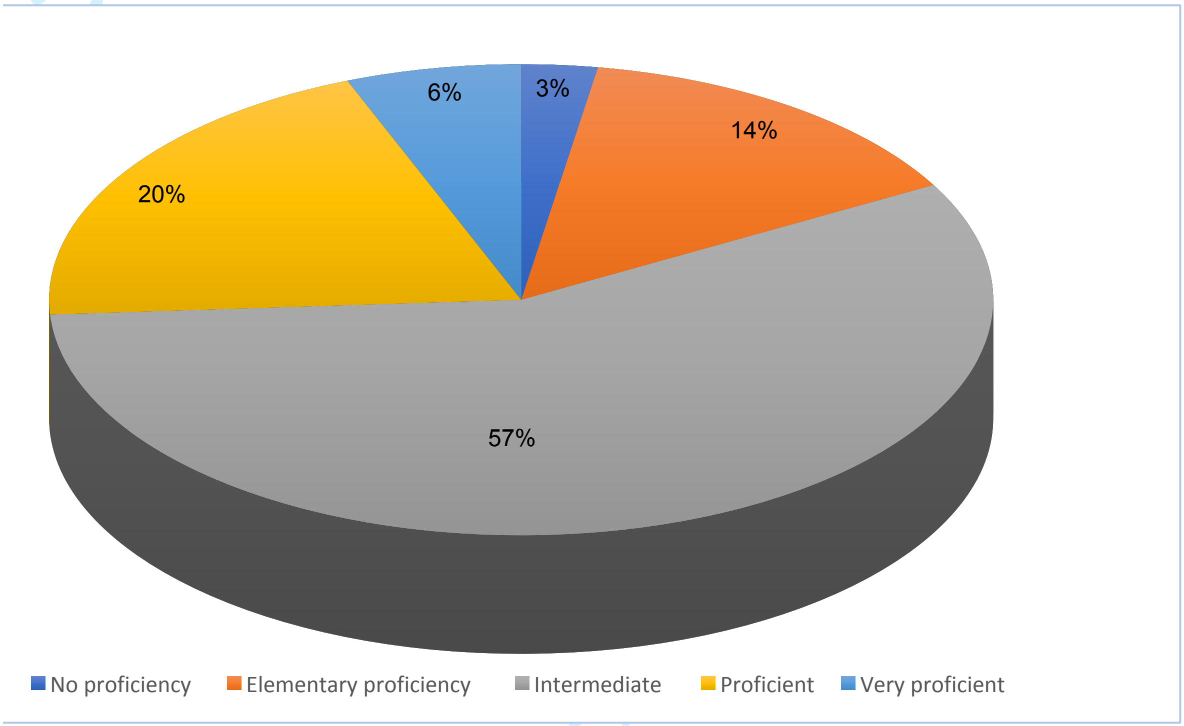
ogical competencies? Reveals whether there is a problem of in ability to use digital technologies amon

ıgst BAME CUGS

No proficiency	2.6
Elementary proficiency	14.3
Intermediate	57.1
Proficient	20
Very proficient	6

Figure 2

Figure 2 – Respondent's p



erception on the proficiency level of BAME CUGS with using Digital Technologies.

Investigating Digital Technological Competencies amongst Black Asian Minority Ethnic Construction students in the UK.

Purpose – This study aims to investigate Digital Technology (DT) competencies, training and awareness amongst Black Asian Minority Ethnic (BAME) construction student in the UK.

Design/methodology/approach – This study uses a quantitative online survey to investigate both BAME Construction Undergraduates Graduate Students (CUGS) and staff studying on and teaching on Construction programmes. The investigation examined their opinions as to their own awareness of their competencies and training regarding DT.

Findings – Findings indicate that BAME CUGS were mostly "very proficient" in the use of basic DT, such as required to complete an authentic assessment that typifies a real-life scenario. For example, sending and receiving emails, excel, word, computer literacy/basic IT skills, browsing searching materials, Powerpoint, specialist IT skills, mobile devices, tablet and social media handles. However, findings revealed that training awareness and competencies in new DT is shallow, and BAME CUGS are probably not ready for the digitalised construction world. Respondents were mainly within the "probably aware" range, and very few were within the "definitely aware" range, on the Likert scale adopted. New DTs that fell within the "definitely aware" range are BIM, offsite construction and manufacturing, 3D printing, cloud computing and collaboration.

Originality/value – The study provides valuable recommendations useful for Higher Education (HE) institutions, industry, and government. Recommendations provided include a need to review and update the current curriculum, robust partnership between academia and industry, increase government funding, upskilling and training staff in the new DT.

Research limitations/implications – It is acknowledged that expanding the sample size to other universities and exploring BAME industry professionals' narratives could further enrich the discussion. However, these limitations did not impact the robust practical and theoretical implications provided to CUGS, HE sectors, University staff, and industry emerging from the analysis and findings achieved in the study. Still, it is being recommended for future work to consider.

Keywords Built environment research, Curriculum development, Education, Alternative and new technologies, Cooperation between academia and industry, Building technology

Paper type Research paper

1. Introduction and Background

The UK Employer Skills Survey (2017) revealed over 36% and 42% vacancies in construction and trades professionals, indicating a significant skill shortage in the construction sector (Department for Education, 2018). Similarly, many construction employers are dissatisfied with the proficiency level of their workforce, emerging from either; being new to the role, partial or no adequate training received, or low motivation for the work (House of Common, 2020). Proficiency or competency level and skills are two sides of the same coin, and sometimes are used interchangeably or confused all together. For instance, the knowledge for executing a task and the competency required in performing the same task with the same quota of knowledge are two different things. Meanwhile there is a perceived line of thinking that knowledge plus competency and behavioural skills equal employability skills (Oyegoke, *et al*., 2009). Arguably, the distinction between this three i.e., knowledge, competence and behavioural skills is yet to be fully understood in the construction sector and all seem to be classified as skill gaps or shortages. According to Government the Office for Science (2016), the concept of skills and the use of the word “skill” vary across disciplines, and knowledge, skills, and competence can mean different things or the same thing depending on the discipline. Similarly, within the context of this paper the terms competency and skills are used interchangeably and refer to the knowledge and proficiency required to function within a discipline. Simultaneously there is lack of clarity between the current skills demanded by the industry and what university graduates are equipped with or possess at graduation. Findings of skills gaps is recurring, and it is important to know the specific skills that are lacking to proffer specific solutions (Government Office for Science, 2016). For instance, Perera *et al*. (2017) noted the unrealistic expectations of the industry of Quantity Surveying (QS) graduates, suggesting that they should have achieved high-level competency in mandatory, core and optional areas of the RICS competency requirements, which the students found dissatisfying and indicates a perception gap between academia and industry. Zaheer *et al*. (2021) second this perspective, unveiling the employers' view of the competencies of market-ready building surveying graduates, which does not match what the students currently possesses. The skills mismatch perhaps stems from the disparity between the skills required to complete a coursework and learning outcome in higher education versus those required or essential in the workplace (Times Higher Education, 2017). However, researchers in this domain have dwelled mostly on discipline-specific skills such as Quantity Surveying (QS), Building Surveying (BS), Real Estate Surveying (RES), etc., in an attempt to bridge the gap between the skills required in the workplace (i.e., work-ready and employability skills) and those the students attain in school. Very little attention is paid towards digital skills, which cut across all of these disciplines but have remained in short supply for the last three years (Department of Education 2018; 2020). Neither is the subject of digital skills within the minority groups explored for the UK construction industry to leverage this resource. There is huge BAME under-representation in the construction industry (GMB Union, 2019), and very little is done to explore the problem, nor is the subject of digital technology skills considered a cause for the gap. Meanwhile, the industry is encouraged to tap into a diverse skills pool to bridge the skills gap and facilitate digitalisation. **As such, the research sets to investigate digital** technological skills, competency, or proficiency level amongst the minority groups as many with such skills are required in the digitalised economy, but currently in short supply. **Section two below expands on the layers of problems associated with skills shortages in the UK.**

2. Problem definition

The UK construction sector is experiencing a skills gap and attracting new entrants has not been very successful. Besides, technology is disrupting the construction sector, impacting processes and activities yet integral to the attainment of sustainable construction, net-zero carbon reduction and the UK's build back better strategy (CLC, 2020; HM treasury, 2021). However, the goal to build back better is weakened by skills shortages, particularly digital skills (CLC, 2020). It is forecast that by 2030 many traditional skills will be outdated or unnecessary, stemming from automation and robotics onsite activities (Industrial Strategy Councill, 2021). Already, the emergence of Virtual Reality (VR) and Mixed Reality (MR), Artificial Intelligence (AI), and Internet of Things (IoT) is changing the paradigm and shifting the traditional onsite culture and placing different skills demands on the industry and implies that new competencies will be required. Whether these technologies will drastically replace the traditional approach is still debatable (CLC, 2019). However, employers are still keen to get onboard people with relevant digital skills in preparation for the future skill demand (Bakhshi, Downing, Osborne, Schneider, 2017; Learning and Work Institute; 2021).

The current construction workforce is ageing and the impact of Brexit and Covid 19 pandemic further compounds the problem (Watkins and Hochlaf, 2021). However, there are increasing recommendations for the sector to tap into the wealth of a more diverse pool as it is expected that there will be a surge and increase in demand during the recovery process (Watkins and Hochlaf, 2021). The UK construction industry for a long time has not been able to unlock the diverse skills available in the migrant community despite their higher skill level, which is further threatened by Brexit and the introduction of the points-based immigration system (Buckley, *et al.*, 2016). Even so, the sector has not been too appealing to the BAME community or has not managed to retain and advance people of BAME background such that they only represent 5.4% of the 2.1 million workforce in the UK (Department for Business, Energy & Industrial Strategy, 2019; GMB, 2019), and 12% of the 808,891 workforce in the US (Engineering News Record ENR, 2020; Zippia, 2021). This under representation is alarming and worthy of investigation. Apart from the limitation of not benefiting from a diverse skill pool it is important to understand if the industry is not guilty of discrimination, stereotyping or conscious or un-conscious bias (Autodesk University, 2020; ENR, 2020).

According to ENR (2020), people of colour have not been given a fair opportunity in leadership or admitted into higher technical roles requiring more technical abilities, decision making and strategic thinking which is perhaps why the sector has not been too attractive. A recent study highlights that 76% of Black and 77% of Asian employees in the construction industry experience limited career progression due to their race and protected characteristics, and organisations are not making a conscious effort to develop underrepresented groups, specifically into leadership roles (Pathmajothy 2020). In fact, only 3.4% of all construction managers in the UK are from ethnic minorities (Construction Manager Staff, 25 February 2020). Meanwhile organisations should be hiring and promoting based on skill and experience regardless of ethnicity, gender, race, nationality, religion or sexual orientation (ENR, 2020; Construction Manager Staff, 2020). Even so, the recently published government report of the Commission on Race and Ethnic Disparities has not been helpful and considered unacceptable, failing to recognise the fundamental challenges facing ethnic minority group in the UK (Gumble, 2021). More so, there is limited training opportunities for the BAME group to leverage (ENR, 2020).

Therefore, it is critical to investigate if the poor representation of the BAME community within the UK construction sector is linked to not possessing the required digital technological skills or whether stereotyping or unconscious bias is responsible for the shortfall. To narrow the focus, the research explores DT skills amongst BAME construction students and gauges their readiness for employment in the envisaged digitalised world. It explores if the current construction programs and curricula allow learners (with a focus on BAME students) to be aware of or equipped to use and apply new DT. Because primarily whoever has the right skill, competence and expertise should be employed and promoted regardless of background. The research is unique as having zeroed in on the minority groups and though a slightly controversial area it can unlock significant findings. For example, unveiling lagging DT skills and highlighting specific training and competencies required to attract new entrants and making it possible to tap from a more diverse pool.

3. Research questions

Emerging from the problem definition above are four research questions used to structure the research and informed the analysis conducted in section eight.

1. Is the under-representation of BAME employees in the UK construction sector linked to a lack of digital technological skills?
2. What level of digital technological competencies currently exist amongst the BAME construction students
3. Is the awareness of new digital technological tools, competencies, and training popular amongst the BAME construction student?
4. Are BAME construction undergraduates equipped with new DT skills for progression and employability opportunities?

4. Research Aim

To provide insights and recommendations for enhancing DT competencies, training and awareness amongst BAME construction student in the UK.

5. Research Objectives

In line with the research questions, the research objectives are:

1. To understand if the under-representation of BAME in the UK construction is linked to digital technological skills.
2. To understand the existing levels of digital technological competencies amongst the BAME construction student in the UK.
3. To investigate and evaluate the awareness of new digital technologies, competencies, and training amongst the BAME construction students in the UK.
4. To explore the extent to which the current construction curriculum equips the BAME students with new digital technological skills.
5. To make recommendations for improving DT competencies and training opportunities amongst the BAME construction students in the UK.

6. Review on Skills Demand

Skill is defined as ''the ability to competently perform a particular task assigned'' (United Kingdom Commission Employer Skills, 2010) or to perform ''a specified task at a certain level of expertise''

(Shah and Burke, 2003; Trendle, 2008). Similarly, a ‘skill ‘can be described as ‘’ the capability to carry out a job assigned to a level of competence and this can be built upon through learning’’ (OECD, 2012). Within the construction industry, skill therefore is an activity involving knowledge, judgement, accuracy and mastery, all of which are acquired as a result of long training and practice in a workplace (Odusami, 2002). The concept of skill has been defined differently by writers in different sectors. Skills could also be looked into from another perspective as being expert in an area of specialisation (Wood, 1988), having competence (Boyatzis, *et al*., 2002; Olaitan, *et al*., 2000), dexterity and knowledge of the workforce (Mangham and Silver, 1986). In a similar vein, according to some schools of knowledge, a skill is a special ability to perform specific duties that are usually acquired through some type of formal or informal training (Tether, *et al*., 2005). Definition of skill according to some schools of thought should entail the ability of the skilled artisan to work in various sections of the industry or the workplace independently (Spenner, 1983; Olaitan *et al.,* 2000). It could be termed as capability to carry out jobs perfectly without supervision.

Overwhelmingly, a skill, and various types of skills identified within the literature are linked to an activity or a job (Clarke and Winch, 2006). As skill is linked with a particular task, a person who does not have skill is unlikely to be able to carry out a given job or will be less productive than somebody who possesses the skill. Skills are often linked and have some alliance with qualifications (Cappelli, 2014) and their acquisition through formal education and training which is adequate in quality and quantity. Construction skills and training needs are continually changing, and these, alongside with the introduction of new business processes, organizing production and technical and vocational innovation require the construction workforce to be more highly skilled in their various areas of expertise (Mackenzie *et al*., 2000; Forde and MacKenzie 2004; Aliu and Aigbavboa 2020).

Technology is driving most industries, and schools yet to advance and update their curricular in latest technologies cannot equip students with the technological skills in demand (Zadok, 2020). More so, the pandemic has impacted how organisations invest in talents, particularly with having to work remotely requiring one form of digital skills or the other suggest the need to strengthen partnerships between educators and industry so that training can mirror the industry’s technological developments (Findlay, 2021). HM Treasury (2021) eluded that the UK’s skill system is less competitive internationally in technical skills, and the most persistent technical skill shortage is in the construction and manufacturing sector. Within the construction sector, the digital skills shortage is most prevalent (Department of Education, 2020). The emergence of DT such as Big data, data analytics, Internet of Things (IoT), 3D printing, Autonomous Vehicles (AV), robotics, offsite construction and manufacturing, smart sensors, digital twin, Building Information Modelling (BIM) etc., further reveals the extent of the gap. For instance, the introduction of new technology represents 19% of causes of the skills gap in the UK, whilst being unable to recruit staff with the required skill or staff not receiving the appropriate training represents 28% and 25%, respectively (Department of Education, 2018). The UK construction industry, in particular, had a total of 14,000 skills-shortage vacancies in 2017 (36%) and 35% of all the skill-shortage vacancies were attributed to or partly linked to lack of digital skills and got worse in 2019 (39%) (Department of Education, 2018; 2020). Many jobs have a digital element, and it is predicted that within 20 years, 90% of all jobs will require some element of digital skills, and as the digital economy grows, there will be even greater demand for people with specialist digital skills (CITB, 2018; 2019). It therefore implies that the construction sector will require people who are digitally literate and collaborative to meet the industry's expectations and as such it is relevant to investigate how much of this skill is prevalent within BAME construction students to estimate their readiness for the near future. More so, a report presented by the House of Lords in 2017 revealed that more research is required to uncover the difference between ethnic groups as far as digital skills is concerned (House of Lords, 2017). Hence why it was important to target only the BAME CUGS for the research and subsequently compare findings with non-BAME student in the near future.

7. Research Methodology and Design

Positivism was selected to underpin the philosophical orientation of the research based on the nature and scope of the research questions and objectives. Positivism, however, is the philosophical orientation underpinning a quantitative approach adopted for the research and involved an online questionnaire survey with BAME construction students and academics of a UK university. **Aliu and Aigbavboa (2020; 2021) adopted a quantitative questionnaire survey whilst conducting similar research in Africa. Thus, the approach can be employed for this research that falls within a similar context.**

A purposive sampling strategy was adopted, and only students from BAME backgrounds and academics teaching on the QS, BS, CPM, and RES construction programmes were targeted for the exercise. The sample size was restricted to one university to narrow the focus. Aside from this, engaging other universities will involve the lengthy ethical application procedures and risk assessments that vary across universities and could impact the timely execution of the project. According to Rose et al. (2015), inter-university research can be challenging to secure the necessary ethical approval, and the data set required. With the selected university, it was possible to extract BAME student's statistical data held for QS, BS, CPM, and RES construction programmes from level 3 to level 7, from the university's QlikView system (a robust database system) and a link

to the survey was sent to their university student email. The ease of assessing these data could not be guaranteed with the involvement of other universities in addition to the intricacies of securing timely ethical approvals and conducting the relevant risk assessments. As such, it was best to narrow the sample size to the selected university where the ethical approval and the dataset required are accessible and secured to facilitate timely execution.

Similarly, lecturers teaching on the QS, BS, CPM, and RES construction programmes were identified via the university outlook mailing list, and a link to the survey was sent to their staff email. An email group containing potential participants was created in Microsoft Outlook for the email to be sent in one go. A total of 430 students and 25 staff received the email containing the questionnaire. The Microsoft Outlook insight feature has the capacity to reveal the percentage of those who opened the email from the group email that was sent and indicated that only 43% had opened the email following two separate reminders meaning that only 196 realistically saw the survey. This is not unusual in ethnic and minority type of research as people sometimes find it offensive to single out a group for research and would rather not get involved (Autodesk University, 2020). This has been a major challenge for many years and one of several reasons for the limited data to showcase racial abuse and ethnic bias as well as skills gaps because many are not willing to undertake the needed research and the lack of participation can be discouraging (Autodesk, 2020). For instance, the Government Commission on Race and Ethnic Disparities report suggests 6% of the Construction workforce is from an ethnic minority background whereas CIOB members from a minority background suggest the figure is less (Gumble, 2021). However, there appears to be no evidence to support the claim and as such many problems are yet to be unveiled because not many research projects have been conducted (or data available) to validate claims and clarify the extent of the problem. Aside from this, many students or staff choose not to access their university email during the summer due to summer holidays and annual leaves when the research was conducted, and as such only 35 responses was received (i.e., 5 staff and 30 students) to achieve an 18% response rate. There is inconsistency with acceptable or appropriate response rate for a research (Gray, 2004; Robson, 2011; Christley, 2015), and acceptable response rate cannot be generalised, as it depends on the study and what is being investigated (Sheikh and Mattingly, 1981). Keeping this in view, the 18% response rate is adequate for this study, considering the fact that the survey was focused on a minority group and restricted to one university. **Moreover, the small sample size allows a benchmark series of findings to be determined that will allow accuracy and analysis to be improved by later UK wide research specific to ethnic minority group**. The study employed a descriptive statistical analysis using transformed mean values and conducted a Normality test to check the normality of the mean distribution. A 95% confidence interval was set for the mean distribution to ascertain the adequacy of the sample size and ensure it was statistically significant and Shapiro-wilk, was used to test the model fit. An ordinal Regression analysis was performed on mean variables that failed the normality test involving model fitting, goodness of fit and test of parallel lines to test whether the model is a good fit and statistically significant. Lastly, Spearman's correlation was used to determine the correlation of the non-normally distributed mean variables which further strengthens the confidence level of the analysis.

8. Results, findings and discussion

Results, finding and discussion are presented based on the research questions.

8.1 Research Question One *(Is the under-representation of BAME in the UK construction sector linked to lack of DT skills?)?*

The earlier review of literature revealed that the UK construction industry is yet to unlock the diverse skills available in the migrant community, and there is the problem of under-presentation of the BAME community. However, whether the under-presentation is linked to lack of DT skills is yet to be explored. Towards this, Figure 1 shows that 63% of the respondents agreed there is a *problem of low level* of DT competencies amongst BAME CUGS, and only 37% suggest otherwise. Whilst Buckley et al. (2016), argued that the migrant community possess a higher skill level yet to be tapped into, Figure 1 suggests that perhaps it is not in the area of DT. Figure 2 further reveals respondents' perception of the digital proficiency level of BAME CUGS without any specific tool in mind and indicates that 20% and 6% suggest they were at "proficient" and "very proficient" levels, respectively. In comparison, 57% and 14% indicates they were at an "intermediate" and "elementary" levels, respectively. Whilst Figure 1 affirms that there is a problem, Figure 2 reveals the scale of the problem showcasing that many were at "intermediate" and "elementary" levels. However employers will mostly opt for candidates with either "very proficient" or "proficient" competencies during recruitment assessment and selection process with little commitment to intermediate competencies, let alone those at the elementary level. The future implication may be that only a small amount of BAME CUGS will secure a high-level digital position in the future if nothing is done to change the narrative. With the literature confirming that digitalisation and automation are changing the UK construction industry paradigm, employers are keen to secure candidates with appropriate digital proficiency to support their effort towards actualising the industry goal.

The results revealed in Figures 1 and 2 suggest that low BAME representation in the UK construction sector could be linked to low DT competencies. However, it would be useful to obtain industry perspective on the subject to achieve a balanced and holistic view.

[Insert Figures 1 and 2]

8.2 Research question 2 *(What digital technological competencies currently exist amongst the BAME construction students)*

Figures 1 and 2 reveals the general perception and proficiency level of BAME CUGS with no specific DT considered. Whereas, Figure 3 histogram provides the mean distribution of the proficiency level of BAME CUGS in specific DTs such as Microsoft word, excel, PowerPoint, mobile devices, sending and receiving emails, browsing/searching materials online, tablet, computer literacy/basic IT skills, specialist IT skills and social media handles (e.g., WhatsApp, Instagram, Twitter and Facebook). Selected DT are essential technology required to complete a well-designed authentic assignment that mirrors the real-life work environment so learners can develop technical and employability skills on the CPM, QS, BS, RES and HNC programmes. This is particularly useful for group assessment because most students struggle with other students' inability to use technology, such as Excel, PowerPoint, or CAD. Those with better proficiencies in using these technologies have to work extra, and imbalance delegation is unfair, especially if marks are awarded equally. Likewise, group members with less proficiency feel undermined or out of place for not having the right skill to contribute to the assessment. Generally, group assessment comes with its problems (Race, 2020). Nevertheless, group members with high DT proficiency level increases the success rate as members can delegate tasks equally without overloading one another.

Figures 4 and 5 showcase the observed value versus the expected normal value and observed value versus deviation from the normal value to further reveal the characteristics of the mean distribution and particularly useful for unveiling outliers. Figures 4 and 5 show outliers in the distribution. A normality test was conducted to check the normality of the mean distribution, considering the presence of outliers. The Shapiro-wilk value from the normality test equals 0.055, which is greater than 0.05, indicating that the null hypothesis that Figure 3 was normally distributed can be accepted. Furthermore, the mean value of each of the selected DTs is revealed in Table 1. It shows that most respondents were within the "very proficient = 4.2 – 5" range, and only a few were within the "proficient 3.4 – 4.2" range and explains the outliers in Figures 4 and 5.

The outliers are traceable to tablet and social media handles DTs with mean values of 4.00 and 3.80. This is good news because most construction site activities have integrated tablets and social handles in their communication, feedback, planning, organisation, and project execution activities, and a CUGS could easily fit into the operational process (CITB, 2019). Thus, although the earlier perceived level of DT competencies was not encouraging, the result gets better when specific technologies are applied, suggesting a contradiction between perception and reality.

[Insert Figures 3 - 5]
[Insert Table Ⅰ]

8.3 Research question 3 *Are the awareness of new digital technological tools, competencies, and training popular amongst the BAME construction student?*

Literature sources such as CITB (2020), Farmer (2016); Department of Education 2018; 2019, and House of Common (2019) revealed limited competencies and training opportunities and general skill shortage in DT in the construction industry. However, very little information is known of BAME UGGCS awareness, competencies and training opportunities with new DT. The variables considered are awareness of new DT (ANDT), competencies in using new DT (CNDT) and training awareness of new DT (TANDT). The Normality test conducted revealed that variables ANDT and TANDT were not normally distributed considering the Shapiro-wilk values of .001 and .015, which is less than 0.05, and the null hypothesis for normal distribution cannot be accepted. Figures 6 and 7 show the mean distribution of ANDT and TANDT. Figures 8 to 11 showcase the observed value versus the expected normal value and observed value versus deviation from the normal value for the two variables. The unevenness of Figures 10 and 11 further indicates that the means are not normally distributed (Normality Test results is available in the supplementary list).

[Insert Figures 6 – 11]

According to Field (2013) an ordinal regression can be performed to test for model fit if the data set is not normally distributed. As such an ordinal regression was performed putting TANDT as dependent variable and ANDT has covariant. The model fitting information gave a significant value of .025 which is less than 0.05 and indicates that the model is statistically significant. The goodness of fit test gave a Pearson and Deviance values of .353 and 1.000 respectively and indicates that the observed model data is a good fit being greater than 0.05. The Nagelkerke R-square value gave a value of .134 and indicates that 13% change in TANDT is dependent on ANDT and critical to making recommendations. However, another school of thought suggest that if the Nagelkerke values is less than 0.7 it means that more independent variables could have been selected to explain dependent variable but this does not affect our result or findings. Furthermore, the Parameter estimates is .802 and being a high and positive value indicates that ANDT does have an impact on TANDT and for every 1 percent increase in TANDT is 8% increase in ANDT and the significant value of .027 indicates that the model is statistically significant being less than 0.05. Finally, a test of parallel lines resulted in a value of .851 and implies that the location parameter is the same across all responses categories being greater than 0.05, and we can rely on the significance of the data set (Ordinal Regression analysis result is in the supplementary list).

Spearman's correlation can be conducted to complement the result of the ordinal regression analysis (Field 2013). The Spearman's correlation analysis conducted for TANDT and ANDT gave a value of .354 which indicates that the two variables were strongly correlated (Spearman's correlation result Table is in the supplementary list).

Table 2 presents the mean values of respondent's awareness of each new DT, and revealed that respondents were mostly within the "probably aware = 1.8 – 2.6" range and only few were within the "definitely aware 1 – 1.8" range. Technologies that fell within the "definitely aware" range include BIM 1.49, offsite construction and manufacturing 1.54, 3D printing 1.77 and cloud computing and collaboration 1.77. The only outlier was Lidar survey scanner which fell within the range of "unsure= 2.6 – 3.4". Meanwhile higher mean values imply less awareness and vice versa.

It is interesting to learn that 3D printing fell within the range of "definitely aware" despite been one of the latest technologies in the industry. **However, 3D printing was cited at 22% and the least popular technology in the recently conducted construction manager BIM survey, and many do not yet see its benefit to their operation (Mann, 2021). It is conflicting however that though the technology is popular amongst the students but not so much in use within the industry. This observation is true has the 2021 construction manager BIM survey cited that only a fifth or 21% respondents felt the industry is adopting digital technologies rapidly or fairly rapidly and 47% felt the industry is low (Mann, 2021)**.

Similarly, it was exciting to see a good level of awareness of BIM and offsite construction being a hot topic within the industry and the UK government is keen for the sector to increase their usage as a major pathway towards green construction, build back better, net zero and cardon reduction targets. Particularly, for BIM, the construction manager BIM survey revealed that only 36% use BIM on their projects and 49% fairly or rarely use it compared to 52% in 2020 (Mann, 2021). Though it suggest that more people are using it still the rate of adoption need improvement (Babatunde *et al*., 2020).

[Insert Table Ⅱ]

Table 3 presents the mean values of training awareness of each new DT, and revealed that respondents were mostly "unsure, 2.6 – 3.4" of any training awareness relevant to the new DT. 3D printing, Lidar survey, ML, Autonomous vehicles and blockchain technologies sat within the "probably unaware, 3.4 - 4.2" range. It implies that even though offsite construction and manufacturing, 3D printing, cloud computing, and collaboration have good awareness (as revealed in Table 2), many are unsure how to receive relevant training. Meanwhile, the spearman's correlation results suggest that more people will undertake training when they are aware of the new DT. But awareness does not mean people know how to undertake training and presents an entirely different problem. However, it is crucial to determine if the lack of training awareness is attributed to the previously cited slow rate of adoption of new technologies in the sector because training and upskilling are most relevant when usage increases. The development broadly demonstrates a lack of training awareness for most of the new technologies, and the CUGS are perhaps not ready for the DT shift driving the industry as very little has been done to mitigate the circumstance.

[Insert Table Ⅲ]

Meanwhile, being aware of the new DTs and relevant training are two different things and not the same as being proficient or competent in their usage. Figure 12, 13 and 14 reveals the histogram mean distribution, the observed value versus the expected normal value and observed value versus deviation from the normal value of the competency level of respondents in the use of new the DT. A normality test was conducted, and the Shapiro wilk gave a value of 0.056, which is greater than 0.05, indicating that the null hypothesis that the mean distribution is normally distributed can be accepted. Table 4 reveals individual means and indicates that a couple of people have never used some of these new technologies, for instance, the Lidar survey scanner, Autonomous vehicles, blockchain, laser scanning and robotics, having mean values between 1 and 1.8. The result agrees with the training and awareness results in Tables 2 and 3 above as people had very little awareness of these technologies and have received little or no training in their usage. Other technologies such as AI, 3D, Drones for UAVs, MR, AR,VR, DMfa, Smart sensors, Big Data, smart wearables, IoT, and data analytics, had mean values between 1.8 and 2.6, indicating that most respondents have only used them a bit but not competent in their usage. **The result obtained is similar to that of the construction manager BIM and digital survey, where virtual and augmented reality was cited at 40%, drones 37%, AI 30%, wearable technology 29%, robots and autonomous equipment 23%, benefits (Mann, 2021). However, according to the survey, these DT have not been very operational or provided many benefits compared to videoconferencing 74%, tablets, and smartphones 70%. It, therefore, made sense when the current study revealed that most people have only used them a bit and therefore not competent in their usage – at least from the student's perspective**.

The offsite construction and manufacturing, productivity and planning, cloud computing and collaboration, and BIM had mean values between 2.66 and 3.09, indicating that respondents were neither competent nor incompetent with these technologies. The result shows that even though these technologies had more awareness, there is little or no competency which is not surprising as very little training awareness was indicated with the same technologies. **The result agrees with the findings from the construction manager that lack of skill represents 61% barrier to adoption of digital technology ahead of 48% clients not interested, and 47% limited funds to invest in new technology**.

Most researchers have focused on discipline-specific competencies that a CPM, QS, RES and BS student should have, but not many have measured the competency level whether it is at an elementary or very proficient level, particularly with DT skill as demonstrated in this study. It was suggested earlier that training awareness may be impinged by the slow rate of technological adoption. Meanwhile, spearman's correlation revealed a correlation between training and awareness but does not guarantee competence. If these variables are stringed together, it will imply that the rate of adoption, training and awareness and competency level are explicit and essential variables to be considered to achieve a thriving digitalised construction industry and should be carefully crafted into teaching and learning. As such, the next research question explores whether the new DTs are well captured in the current teaching and learning curriculum.

[Insert Figures 12 – 14]

[Insert Table Ⅳ]

8.4 Research question 4 *Are the BAME construction undergrads equipped with the new digital technological skills for progression and employability opportunities and competing powers.*

Figure 15 reveals the mean distribution of respondent's responses on whether the new DT is well captured in their learning and teaching curriculum depicted as "WCAP". Similarly, a normality test was conducted to confirm the normality of the distribution, and the Sharipo wilk gave a value of 0.981, indicating that the mean distribution was normally distributed, and no further test is required. Figure 16 and 17 shows the observed value versus the expected normal value and observed value versus deviation from the normal value and supports the fact that the distribution was normal.

[Insert Figures 15 – 17]

Table 5 reveals the mean values of each DT and values between 2.34 and 2.63 indicates that the technology is not well captured as it fell within the range of "disagree". Meanwhile technologies with mean values between 2.66 and 3.11 were at borderline indicating that respondent neither agreed or disagreed with the fact that the technologies were well captured in their teaching and learning curriculum. Only offsite construction and manufacturing and BIM had the mean values between 3.4 and 4.2 and fell within the range of "Agree" indicating that respondents agreed that these two technologies are well captured. **However, when compared with construction manager's BIM and Digital survey, DfMA for instance was cited at 49% benefit, but have not been well captured within the learning and teaching curriculum. Likewise, technologies such as virtual and augmented reality, drones, AI and wearable technology had some decent percentage of benefits (according to the construction manager survey) but have not been well captured in the teaching and learning curriculum. The result thus suggests that most new digital technologies are largely not well captured in the current teaching and learning curriculum and it appears that there is a dealignment between what is beneficial to the industry and what the student actual get equipped with and indicates that most students are not ready for the real-life and the digital technological shift shaping the construction sector**. There is an urgent need therefore to review existing teaching and learning curriculum to integrate new DT to allow graduate to be work ready. Otherwise, we will be teaching obsolete and analogue skills in a new world of digital advancement. Education providers and funding bodies need to step up and create more industry partnerships, as recently suggested by Aliu and Aigbavboa (2021). With the expectation that this will help support the training and equipping of UGGCS in the use of new digital technology, so they are work-ready.

[Insert Table V]

9. Conclusion and Recommendation

As shown in the results, BAME CUGS are very proficient with basic digital technology even though there were low proficiency perceptions according to Figure 2. However, it became more clear that the low proficiency initially identified was linked to new technologies (not the basic DT) and could perhaps be linked to the under-representation of BAME in the UK construction sector. However, considering that BAME under-representation has been around for a while, the emergence of the new technologies may not be an actual cause but a contributory factor in the nearest future. Findings show that BAME CUGS are not ready for the DT shift, having demonstrated little or no competence in using the new DT. Neither does the current teaching and learning curriculum provide them with sufficient training as shown in the findings.

New DTs are a significant driver and will influence the future skill demands in the digital world. In other words, even the most relevant discipline-specific competencies will not thrive outside digital technology. If so, the broader implication of the findings suggests that there is an urgent need to embed more DT within our teaching and learning curriculum, as inadequate training and low competence in using relevant DT could lead to unemployment and redundancy in the new digital economy. For instance, the pandemic experience has shown that it is possible to suspend physical lectures, and employers can switch to remote working by relying on one form of technology or the other. Currently, online learning is different, and possibly the future of teaching and learning in the long run, and remote working has come to stay. Therefore, it would be useful to see how the new DTs can be simulated into online learning, perhaps through games, storytelling and scenario-based learning to enhance student learning and engagement and increase usability. However, the truth is, embedding technology in teaching and learning can be challenging. The issue of resources, space, and funds can limit the access given to each student for engaging with these technologies. If so, a simulated version of these new DTs embedded within the teaching and learning curriculum can accelerate the understanding of technologies across all levels. To achieve this, higher education needs to work in synergy with the industry and government to enhance next-generation learning using modernised technologies for institutions to produce the workforce the industry needs in the days to come.

In line with the research aim, the following recommendations are made, which ties together practical and theoretical implications of the study.

9.1 Practical implications

1. From the BAME CUGS perspective, DT is unlikely to be the reason for low BAME representation. However, it is recommended that tailored training and upskilling of BAME CUGS in the use of new DT is achieved, as there are indications that this is currently lacking amongst the group. Doing so will enhance their employability and ensure progression as they will possess the much-needed skills in the emerging digitalised construction world.

2. Higher Education sectors will have to review and update their current teaching and learning curriculum to integrate new DTs, potentially by game simulations technologies, storytelling and scenario-based learning. In doing so, more students can gain access to these

technologies either remotely or otherwise and increase practice, usage and familiarity, leading to higher competencies and employability in the long run.

3. University staff teaching on construction-related programs will require upskilling in the new DTs either via CPD or relevant training, which ties into the earlier recommendation to review and update the current teaching and learning curriculum. By doing so, university staff can execute the revised curriculum, having undertaken training to use and apply the technologies themselves. The recommendation draws upon the findings of rigorous research into new pedagogical approaches revealing that incorporating technologies and adapting to new teaching styles can be challenging. Therefore, providing the platform for staff training is crucial to successfully integrate the new DTs in the university and mitigate against staff teaching obsolete skills in a digital age, which will be the case if they do not have the required training.
4. New DTs are industry-focused tools, and it makes sense that the university fosters a stronger and robust partnership with the industry and the government to ensure continual access to up-to-date practical applications of these technologies and guidance on how to embed them to achieve industry-focused learning, crucial to the development of employability skills for the students.

9.2 Theoretical implications

5. The paper revealed a limited amount of literature in this area, mainly referring to research addressing BAME and DT concurrently, which is considered in this study. As such, emerging findings and recommendations provide theoretical grounds to underpin future research with similar focus. In addition, it was discovered that technological adoption and training awareness are critical variables to achieving a better-equipped workforce for the digitalised world, but yet to be fully explored. Therefore, it implies a need to uncover the relationship between technology adoption and training awareness, which the study has now helped to set the context.

The research provides valuable findings and recommendations, yet, key limitations are identified. For instance, even though the narrowed sample size to one UK university allows a benchmark series of findings to be determined, it would be advantageous to widen the sample size to potentially more UK universities to gain broader and general recommendations. Similarly, the research adopted a quantitative approach to explore BAME CUGS and staff studying and teaching

on construction pogrammes. However, exploring BAME construction professional's perspectives via a qualitative approach would also enrich the discussion. Future studies are therefore encouraged to look into these areas.

References

Aliu, J. and Aigbavboa, C.O. (2020), "Employers' perception of employability skills among built-environment graduates", *Journal of Engineering, Design and Technology*, Vol. 18 No. 4, pp. 847-864. https://doi.org/10.1108/JEDT-06-2019-0162

Aliu, J. and Aigbavboa, C.O. (2021), "Structural determinants of graduate employability: impact of university and industry collaborations", *Journal of Engineering, Design and Technology*, Vol. 19 No. 5, pp. 1080-1100. https://doi.org/10.1108/JEDT-05-2020-0189

Autodesk University (2020) "Blacks and Minorities in AEC: Perspective of Diversity and Inclusion", available at: https://www.autodesk.com/autodesk-university/class/Blacks-and-Minorities-AEC-Perspective-Diversity-and-Inclusion-2020 (accessed 27 July 2021)

Babatunde, S.O., Ekundayo, D., Adekunle, A.O. and Bello, W. (2020), "Comparative analysis of drivers to BIM adoption among AEC firms in developing countries: A case of Nigeria", *Journal of Engineering, Design and Technology*, Vol. 18 No. 6, pp. 1425-1447. https://doi.org/10.1108/JEDT-08-2019-0217

Bakhshi, H., Downing, J., Osborne, M. and Schneider, P. (2017). "*The Future of Skills: Employment in 2030"*. London: Pearson and Nesta.

Boyatzis, R.E., Stubbs, E.C. and Taylor, S.N. (2002) "Learning cognitive and emotional intelligence competencies through graduate management education". *Academy of Management Learning &Education*, Vol. 1 No.2, pp. 150-162.

Buckley M, Zendel A, Biggar J, Frederiken L and Wells J (2016) "Migrant work and employment in the construction sector", ILO, available at: https://www.ilo.org/wcmsp5/groups/public/---ed_protect/---protrav/---migrant/documents/publication/wcms_538487.pdf (accessed 27 July 2021)

Cappelli, P. (2014) "*Skill Gaps, Skill Shortages and Skill Mismatches"*: Evidence for the US.

Christley, R. (2015) "Statistical guidelines for Equine Veterinary Journal". *Journal of Equine Veterinary*, Vol. 47 No. 1, pp. 131-132.

Clarke, L. and Winch, C. (2006) "A European skills framework? —but what are skills? Anglo-Saxon versus German concepts", *Journal of Education and Work*, Vol. 19 No. 3, pp.255-269.

Construction Industry Training Board (CITB) (2018) Unlocking construction's digital future: A skills plan for industry, available at: https://www.citb.co.uk/media/c2njbp2w/unlocking_constructions_digital_future_full_report_1_oct 2018.pdf (accessed 27 July 2021)

Construction Industry Training Board (CITB) (2019) "The impact of modern methods of construction on skills requirements for housing", available at: https://www.citb.co.uk/media/fdyae2zg/citb-mmc-report-mar-2019.pdf (accessed 27 July 2021)

Construction Leadership Council (CLC) (2019) "Future Skills Report", available at: https://www.constructionleadershipcouncil.co.uk/wp-content/uploads/2019/06/CLC-Skills-Workstream_Future-Skills-Report_June-2019_A4-Print-Version.pdf (accessed 27 July 2021)

Construction Leadership Council (CLC) (2020) "Roadmap to Recovery: An Industry Recovery Plan for the UK Construction Sector", available at: https://www.constructionleadershipcouncil.co.uk/wp-content/uploads/2020/06/CLC-Roadmap-to-Recovery-01.06.20.pdf (accessed 26 July 2021)

Construction Manager staff (2020) "Ethnic minorities in construction: pride but prejudice". *Construction Manager*, 25 February, pp 1-3 Available at: https://constructionmanagermagazine.com/ethnic-minorities-construction-pride-prejudice/ (accessed 27 July 2021)

Department for Business, Energy & Industrial Strategy (2019) "Policy paper: Construction Sector Deal", available at: https://www.gov.uk/government/publications/construction-sector-deal/construction-sector-deal (accessed 06 August 2021)

Department of Education (2018) "Employer skills survey 2017", available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/746493/ESS_2017_UK_Report_Controlled_v06.00.pdf (accessed 26 July 2021)

Department of Education (2020) "Employer skills survey 2019", available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/925744/Employer_Skills_Survey_2019_research_report.pdf (accessed 26 July 2021)

Engineering News Record (ENR) (2020) "Race Rises as Top Construction Industry Issue after protest". Retrieved from https://www.enr.com/articles/49578-race-rises-as-a-top-construction-industry-issue-after-protests Accessed July 27, 2021

Field, A. (2013), "*Discovering Statistics Using IBM SPSS Statistics*", 3rd ed., Sage, London.

Findlay, G. (2021, 28 April) "Work with educators to plug construction's digital skills gap". Construction manager, available at: https://constructionmanagermagazine.com/work-with-educators-to-plug-constructions-digital-skills-gap/ (accessed 27 July 2021)

Forde, C. and MacKenzie, R. (2004) "Cementing skills: training and labour use in UK construction". *Human Resource Management Journal*, Vol. 14 No. 3, pp.74-88.

GMB Union (2019) "Construction industry just 12.5% women and 5.4% BAME, press release", available at: https://www.gmb.org.uk/news/construction-industry-just-125-women-and-54-bame (accessed 27 July 2021)

Government Office for Science (2016) "Future of Skills and Lifelong Learning", available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/571667/ER4_Skills_Demand__Training_and_Skills_Mismatch_A_Review_of_Key_Concepts__Theory_and_Evidence.pdf (accessed 27 July 2021)

Gray, D. (2004) "*Doing research in the World*". London: Sage Publications.

Gumble, C. (2021, 01 April) "Racial disparity in construction: a missed opportunity". Construction Manager, available at: https://constructionmanagermagazine.com/racial-disparity-in-construction-a-missed-opportunity/ (accessed 27 July 2021)

HM Treasury (2021) "Build Back Better: Our Plan for Growth", available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/968403/PfG_Final_Web_Accessible_Version.pdf (accessed 27 July 2021)

House of Commons (2020) "Apprenticeships and skills policy in England", available at: https://researchbriefings.files.parliament.uk/documents/SN03052/SN03052.pdf (accessed 26 July 2021)

House of Lords (2017) "Digital skills in the United Kingdom", available at: https://researchbriefings.files.parliament.uk/documents/LLN-2017-0051/LLN-2017-0051.pdf (accessed 27 July 2021)

Industrial Strategy Council (2021) Annual Report, available at: https://industrialstrategycouncil.org/sites/default/files/attachments/ISC%20Annual%20Report%202021.pdf (accessed 26 July 2021)

Learning and Work Institute (2021) "Disconnected: Exploring the digital skills gap", available at: https://www.worldskillsuk.org/wp content/uploads/2021/03/Disconnected-Report-final.pdf (accessed 27 July 2021)

Mackenzie, S., Kilpatrick, A. and Akintoye, A. (2000) "UK construction skills shortage response strategies and an analysis of industry perceptions". *Construction Management &Economics*, Vol. 18 No. 7, pp. 853-862.

Mangham, I.L. and Silver, M. (1986) "*Management Training: Context and Practice"*. Economic and Social Research Council (ESRC).

Mann, W. (2021) "Covid aids BIM adoption, but barriers remain," Construction manager, 04 April, 1-3, available at: https://constructionmanagermagazine.com/wp-content/uploads/2021/05/Construction-Manager-May-21.pdf (accessed 27 July 2021)

Odusami, K. (2002) "Perceptions of construction professionals concerning important skills of effective project leaders". *Journal of Management in Engineering*, Vol.18 No. 2, pp. 61-67.

Olaitan, S., Ali, A., Eyoh, E. and Sowande, K. (2000) "Research skills in education and social sciences". Owerri: Cape Publishers International Limited.

Organisation for Economic Co-operation and Development (OECD) (2012) "Better Skills, Better Jobs, Better Lives": A Strategic Approach to Skills Policies. OECD Paris.

Oyegoke, A. S., McDermott, P., Aouad, G., Cleary, M. (2009) "Skill competency development strategies by a contractor". *Management, Procurement and Law*, Vol. 162 No. MP0, pp. 1-10.

Pathmajothy, N. (2020) “Construction and racism: time to build an equitable industry”. *Construction Manager*, 14 July, pp1-3, available at: https://constructionmanagermagazine.com/construction-and-racism-time-to-build-an-equitable-industry/ (accessed 27 July 2021)

Perera, S., Babatunde, S. O., Pearson, J., Ekundayo (2017) “Professional competency-based analysis of continuing tensions between education and training in higher education”. *Higher Education, Skills and Work-Based Learning*, Vol. 7 No.1, pp 92-111

Race, P. (2020) *The Lecturer’s Toolkit: A Practical Guide to Assessment, Learning and Teaching*. 5th Edition. Oxon: Routledge

Robson, C. (2011) *Real World Research*. 3rd Ed. United Kingdom: Wiley Publications.

Rose, S., Spinks, N. and Canhoto, A. (2015) *Management Research: Applying the Principles*. London and New York: Routledge Publications.

Shah, C. and Burke, G. (2003) *“Skills Shortages: Concepts, Measurement and Implications. Working”* Paper No. 52. Centre for the Economics of Education and Training, Monash University.

Sheikh, K. and Mattingly, S. (1981) “Investigating Non-Response Bias in Mail Surveys”. *Journal of Epidemiology Community Health*, Vol. 35 No. 1, pp. 293-29.

Spenner, K.I. (1983) “Deciphering Prometheus: Temporal change in the skill level of work”. American *Sociological Review*. pp.824-837.

Tether, B., Mina, A., Consoli, D. and Gagliardi, D. (2005) A Literature review on skills and innovation. How does successful innovation impact on the demand for skills and how do skills drive innovation? A CRIC Report for the Department 287 of Trade and Industry, ESRC Centre for Research on Innovation and Competition, University of Manchester.

Times Higher Education (2017) “Fuzzy Logic”. *Times Higher Education*, 03 August, pp. 33-37

UK Commission for Employment and Skills (UKCES) (2010*) National Employer Skills Survey for England 2009*: Main Report.

Watkins O and Hochlaf D (2021) Skills for a green recovery: A call to action for the UK construction sector, IPPR, available at: http://www.ippr.org/research/publications/skills-for-a-green-recovery (accessed 27 July 2021)

Wood, S. (1989) *The Transformation of Work*? Unwin Hyman: London.

Zadok, Y. (2020), "Project-based learning in robotics meets junior high school", Journal of Engineering, Design and Technology, Vol. 18 No. 5, pp. 941-958. https://doi.org/10.1108/JEDT-01-2019-0023

Zaheer, M. I., Ajayi, S.O., Zulu, S.L., Oyegoke, A., and Kazemi, H. (2021) “Understanding the key competencies of market-ready building surveying graduates from employers’ perspectives”, *Journal of Engineering, Design and Technology*, Vol. 19 No.1, pp. 291-314

Zippia (2021) Construction worker demographics and statistics in the US, available at:

https://www.zippia.com/construction-worker-jobs/demographics/ (accessed 06 August 2021)