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The Response of Auckland Construction Firms to Recent Technological Changes

Urvi Kerai, Lydia Kiroff and Rashika Sharma

Abstract

Over the past decade the impacts of technology on the construction sector have been profound. This trend presents significant challenges for construction firms in an environment characterised by skilled-labour shortages and an ageing workforce that tends to struggle to accept new technology. The purpose of this research is to determine the types of technologies that are being used by Auckland construction firms, the challenges that they face as they adopt new technologies and the impact of technology on the construction workforce. The study employed a face-to-face survey research approach focusing on Auckland construction firms, with the aim of evaluating their response to technological changes. Questionnaires, followed by face-to-face interviews with two separate industry groups, managers and construction workers, were the major methods of empirical data collection. The findings revealed that while the adoption of technology could offset some skill shortages in the near future, the uptake of technology in construction firms was generally poor due to high financial costs, an increasingly ageing workforce and the lack of available training in the new technologies. In conclusion, Auckland construction firms face serious difficulties that could only be overcome through a set of comprehensive measures, such as financial commitment to investing in the latest technologies, provision of extra support and training, as well as ensuring adequate pay.

Introduction

The construction industry presents important opportunities for innovation. The impact of technological advancements on the growth of the construction industry is profound. In this context, the biggest challenge for construction firms becomes the effective utilisation of these advancements in order to become more innovative. The market dynamics and the realities of the entire construction industry impose additional challenges that need to be well managed. Creating a competitive advantage and achieving business success mean working in environments that require continual new knowledge acquisition, increased tension and stress and a constant need to adapt.

The increasingly pervasive use of digital technologies in the construction industry affects all phases of the full project lifecycle, from design and procurement through construction and handover, to facilities/asset management. The uptake of Building Information Modelling (BIM) across the New Zealand construction industry is constantly improving; the overall proportion of industry projects using BIM in New Zealand has risen from 34% to 68% over the past six years (EBOSS, 2020). Figure 1 presents a breakdown of this use across three control groups as well as across the project lifecycle.

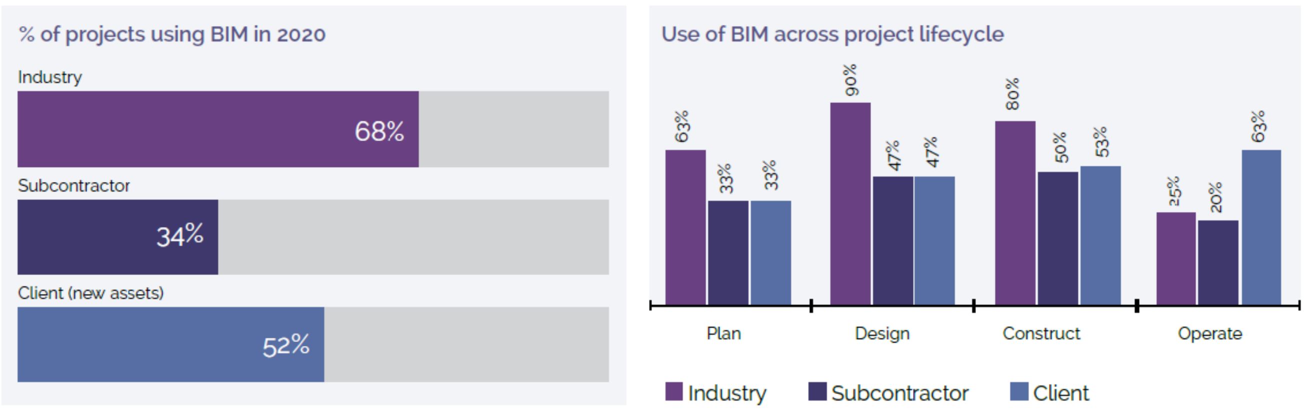

Figure 1. Percentage of projects using BIM and use of BIM across project lifecycle (EBOSS, 2020, p. 4).

As evident in Figure 1, industry (key users of BIM technology within the construction industry) has the highest percentage of involvement at three of the four project lifecycle stages with the highest percentage, 90%, being at the design stage. However, this is closely followed by the construction stage, 80%, which this study focuses on.

There is a wide range of definitions of digital technologies in the literature (Chowdhury et al., 2019), with each source exploring the technological phenomenon from a different perspective. An earlier definition of digital technologies describes them as advanced Information and Communication Technologies (ICT) that enable capturing, storing, processing, communicating, displaying, integrating and collaborating on information (Hamelink, 1997). A further refinement of the concept focuses on specific research contexts. Digital technologies could be considered as stand-alone, web-based technologies and tools used for executing construction procurement activities (Ibem & Laryea, 2014), at the same time playing a key role in facilitating social interactions, knowledge sharing, and co-ordination among stakeholders (Whyte & Lobo, 2010). Digital technologies represent a whole ensemble of the internet, smart devices, cloud computing and other data-processing technologies (Underwood & Isikdag, 2011), and are referred to as innovations that support construction procurement, management and delivery of building projects (Ibrahim, 2013). The Victoria State Government in Australia defines digital technologies as "electronic tools, systems, devices and resources that generate, store or process data. Well-known examples include social media, online games, multimedia and mobile phones" (2019, para. 1). The New Zealand Ministry of Education (2015) provides examples of digital technologies such as the internet, laptops and tablets. A more precise definition, specific to a construction management context, asserts that: "digital technologies include all types of electronic equipment and applications that produce, store or use information in the form of numeric code" (Puolitaival et al., 2019, p. 4). The following working definition has been adopted for the purposes of this study, which examines construction firms' adoption and acceptance of digital technologies: computer hardware, general office and construction-specific software at a project's construction stage, and overarching digital innovations such as BIM, VR (Virtual Reality), RFID (Radio Frequency Identification), e-learning, etc.

A number of studies in the literature explore the increased use of technology by construction firms, and the challenges that both workers and managers face. However, the adoption and acceptance of technology have not been thoroughly examined in the New Zealand construction context. The New Zealand construction industry is characterised by an ageing workforce and skill shortages (Lobo & Wilkinson, 2008; Tipper, 2012). The number of older workers (aged 45–64 years) has increased from 31.8% in 2000 to a projected 36.8% in 2021, whereas young workers (aged 15–24 years) have decreased from 17.4% in 2000 to a projected 14.3% in 2021 (Figure 2).

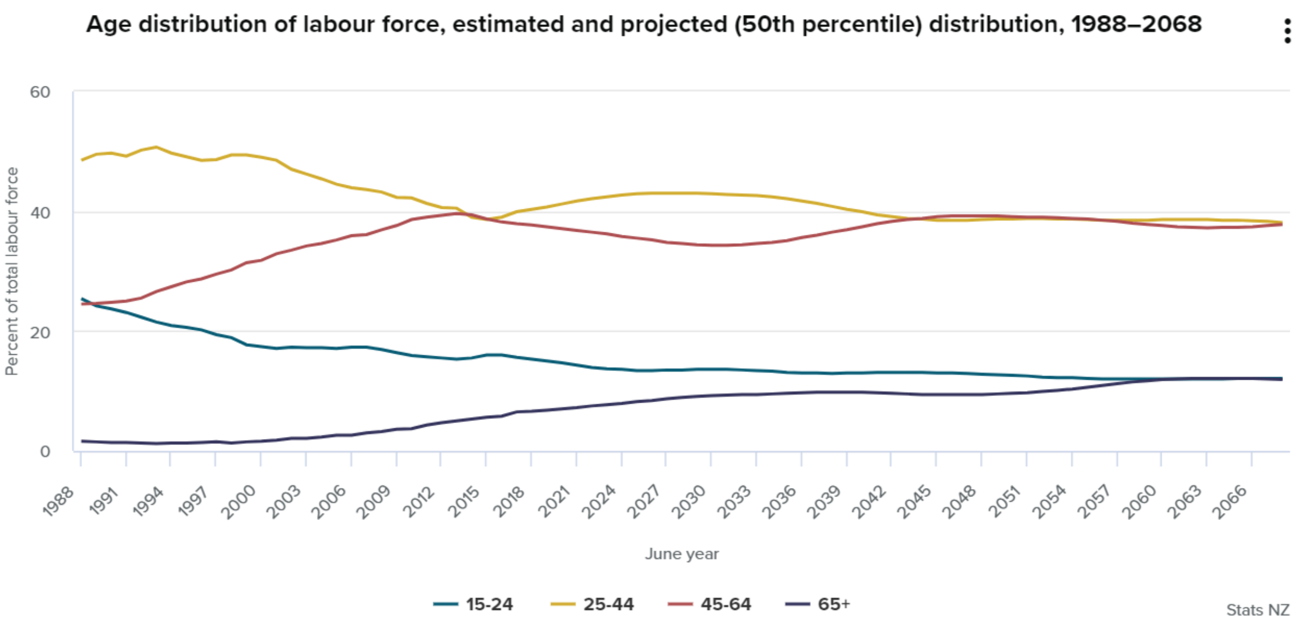

Figure 2. Labour force proportions by age group in New Zealand, 1988–2068 (Stats NZ, 2017).

Another compelling trend is the ever-increasing proportion of the 65+ workforce, from 1.6% in 2000 to a projected 7.2% in 2021 (Stats NZ, 2017).

Based on the line chart above, it is also worth noting the converging trend in the lines representing the two age groups 15–24 and 65+. The projected percentages for these two age groups in 2066 are identical, 12.1%, while the 45–64 age group percentage is projected to have a very slight increase to 37.4% (Stats NZ, 2017).

The overall trend of an increasingly ageing and decreasingly young workforce presents serious challenges, especially in terms of technology uptake – BIM, VR, RFID, mobile technologies and many others. The uptake of technology in construction is problematic, with one of the primary reasons being the extreme imbalance between older and younger workers (Lobo & Wilkinson, 2008).

As the construction industry adopts technology, the skill shortages could only aggravate the situation even further. "Skill shortages occur when there is an insufficient number of workers with the required qualifications, skills or experience necessary to carry out a particular job" (Ho, 2016, p. 533). Furthermore, the poor image of the construction industry and the lack of career advancement could discourage people from joining the industry (Ho, 2016). Delays and disruptions on construction projects are often due to firms spending considerable time on training young workers in traditional construction practices and older workers in new technologies (Chan & Dainty, 2007).

Several influential models of technology adoption have been developed, with the Technology Acceptance Model (TAM), introduced by Davis (1989), being the most widely used. The TAM explores user motivation towards adoption of technology based on three key interrelated factors: perceived usefulness, perceived ease of use and attitude toward use (Taherdoost, 2018). According to TAM, age plays an important role in an adult's perception of technology and their willingness to accept new technology. For example, if an older adult perceives technology to be difficult then they are unlikely to adopt the technology, as opposed to an adult who is willing to accept the challenges offered by new technology (Charness & Boot, 2016). These assertions in the literature suggest possible challenges in terms of new technology adoption in the construction industry due to an increasing imbalance between older and younger workers.

This research utilises the TAM as a theoretical framework to explore the specificities of its key interrelated factors (perceived usefulness, perceived ease of use and attitude toward use) in a New Zealand construction context. The purpose of the study is to determine the types of technologies that are being used in the Auckland construction industry, the challenges that construction firms face as they adopt new technologies and their impact on the construction workforce. These aims led to the formulation of the study's main research question and sub-questions:

- How do Auckland construction firms respond to recent technological changes?
- What are the benefits and challenges of technology adoption for construction firms?

- What are the types of technologies used by Auckland construction firms?
- What are the benefits and challenges of technology adoption for the construction firms' workforce?

Background

BENEFITS AND CHALLENGES OF TECHNOLOGY ADOPTION FOR CONSTRUCTION FIRMS

The construction industry is reluctant to adopt new technologies, employs lower levels of technology than other industries and is often perceived as being relatively slow in developing and accepting technology (Ho, 2016; Yang, 2007). Organisational inertia, or the reluctance of organisations to change the status quo, has often been cited as one of the reasons for the poor uptake of technology (Lawrence & Scanlan, 2007). Yet some construction firms do try to innovate and improve the uptake of technology and its use. Common digital innovations in use are BIM, VR, RFID and e-learning to develop learning skills, performance improvement and skills advancement through training. Technology adoption benefits construction firms, as it improves work productivity (Chowdhury et al., 2019). There is a positive relationship between technology adoption and organisational performance in the construction industry (Sargent et al., 2012). However, access to computers and fast reliable internet connection often prove problematic, especially in remote and regional locations and away from major urban centres (Becker et al., 2011). Furthermore, the introduction of new technologies requires substantial financial commitment in terms of purchasing and ongoing updating of relevant hardware and software. Technology cannot just be introduced without investing in the technological resolutions to master and improve technology (Kruss et al., 2015). The adoption of technological advances is usually associated with hefty up-front expenses which are particularly hard for smaller organisations to deal with (Becker et al., 2011).

Additional investment is required for the training and development of the workforce in order to help existing workers to learn the new technology (Dainty et al., 2005; Yepes et al., 2015). The introduction of new technologies needs internal facilitating conditions and top management support (Sargent et al., 2012). Skill shortages in the construction industry are well documented in the literature, which emphasises the need to invest in workforce training (Chan & Dainty, 2007). However, most companies consider that training is expensive, and often requires higher investment than initially anticipated (Dainty et al., 2005). Any new add-ons to technology require justification "unless there will be a reasonable return on investment or other client-provided incentive" (Ho, 2016, p. 540).

In addition, construction firms have raised concerns regarding the impact that technology adoption has on traditional construction skills (Ho, 2016). Technological advances may offset future skill shortages and result in the de-skilling of traditional on-site activities. Construction has "experienced a slow movement away from manual skills towards white-collar employment, as managerial and professional jobs have increased in relative importance" (Dainty et al., 2005, p. 389). Technology adoption has led to certain changes in traditional work practices, with emphasis on multiskilling (Chan & Dainty, 2007).

AGEING WORKFORCE AND TECHNOLOGY ADOPTION

There is a growing demand for technology use in the current construction environment. Firms tend to adopt the latest technology with a strong belief that it can help improve business performance and offer an efficient use of time. However, the challenge remains to engage the older (ageing) workforce, who face difficulties in accepting technology as they prefer working with traditional construction methods (Becker et al., 2011). Their work practices may not align with those of digital natives (young workers), who prefer to work with the latest technology. Therefore, the full impact of technology on the workforce should be thoroughly evaluated in order to retain the older workforce.

The workforce is increasingly ageing, and 68% of New Zealand construction firms are being held back from expansion due to the skill shortages of staff (Lobo & Wilkinson, 2008). Low birth rates and long life expectancy have impacted the demographic trends of the ageing workforce. The expectation is that, by the year 2025, the proportion of workers between 50 and 64 years old will double in comparison to the younger workers below the age of 25 (Gibb et al., 2013). Similarly, 55% of the Australian construction workforce consists of workers above the age of 35 years (Watson, 2012).

However, age does not appear to be a barrier to employment. Almost half of Italian employers (46.5%) choose to hire workers in the age group of 55–64 years (Lazazzara & Bombelli, 2011) because of their capacity to learn, adapt and contribute to higher productivity. Furthermore, the ageing workforce has a wealth of construction knowledge and valuable skills, and is reliable and loyal compared to young workers (Dainty et al., 2005; Helyer & Lee, 2012; Tipper, 2012). These positive values are counterbalanced by some negative ones such as lacking fitness, being resistant to change and lacking safety behaviours. Construction firms in the UK endeavour to create a friendly work environment for older workers by finding less-demanding tasks (Gibb et al., 2013).

The main problem associated with aged workers is adapting to the high technology sector (Ebrahimi et al., 2008). Older workers face stereotypes of not being flexible as they can face great difficulties working with computers and often are not willing to work or learn how to work in a different way than they are used to (Becker et al., 2011). Strong resistance and lack of motivation to accept new technological challenges are not uncommon (Ebrahimi et al., 2008). There is even a tendency of discouraging older workers, while more value is placed on the younger ones (Barrett & Bourke, 2013). Employees who were born when technology was mainstream have a different view of knowledge from the ageing workers, and interact in different ways with each other (Becker et al., 2011). However, aged workers do have the potential to learn new skills from young workers (Helyer & Lee, 2012).

A NEW, TECH-SAVVY GENERATION

As the construction industry continues to grow, many firms try to adopt new technologies and attract younger workers. Current debate focuses on the younger generation, which has grown up with technology to an extent that is impacting their learning approaches to construction (Helyer & Lee, 2012). University graduates are known to be more technology oriented (Ahn et al., 2012; Aniekwu & Ozochi, 2010). Firms in the construction industry prefer to hire younger workers as they are recognised as being tech-savvy, family-centric, achievement-oriented, team-oriented and attention craving (Bridgstock, 2011; Helyer & Lee, 2012). Unfortunately, this comes at the expense of having sufficient construction knowledge (Becker et al., 2011). Work in the construction industry is based on high speed and efficiency, therefore these workers are considered to be vastly suitable as they are assumed to be highly energetic (Lazazzara & Bombelli, 2011). These digital natives thrive in a construction environment that is encouraging the uptake of technology. However, integrating older and younger workers and their very different work practices remains a challenge (Becker et al., 2011). The older construction workers are willing to share traditional construction skills with their younger counterparts but at the same time they are being blamed for the lack of opportunities for the younger workers in the construction labour market (Helyer & Lee, 2012).

Another well-known challenge in the construction industry is the pace of work being stressful and tiring, which is why workers in this sector tend to look for work in slower-paced sectors (Lazazzara & Bombelli, 2011). The new generation of workers does not consider the construction industry as a viable career option. Some of the reasons that have been identified are: being idle, desire for easy money, unwillingness to follow orders and the perception that construction work is demeaning (Gibb et al., 2013). Current wage levels are not perceived as adequate for the physical demands of construction work (Ho, 2016). There are higher chances of younger workers changing jobs if they are not fully satisfied with the benefits that their current employment offers to their personal lifestyles (Helyer & Lee, 2012). This results in an increase in retirement age as the older workers are not being replaced by younger ones with similar skills (Gibb et al., 2013).

Research approach and methods

The study employed a face-to-face survey research approach focusing on Auckland construction firms, with the aim of evaluating their response to technological changes. Two separate industry groups were specifically targeted – construction workers and managers. Surveys are best suited when the researcher wants factual information relating to groups of people: what they do, what they think and who they are, in an attempt to establish patterns of activity within those groups or categories of people (Denscombe, 2014). In addition, face-to-face surveys offer a number of advantages such as immediate data validation, elimination of false information and potential increase of the response rate (Denscombe, 2014; Fellows & Liu, 2009).

Questionnaires, followed by semi-structured, face-to-face, in-depth interviews were the primary methods of empirical data collection. Two sets of questionnaires with a mix of both open- and closed-ended questions about the participants' age group, expertise, experience, types of technology used and personal experience with technology were used for the two targeted groups – 20 construction workers and 12 managers or people in managerial roles (M/PMRs). The follow-up interviews, using interview question guides, were conducted with 10 managers from different construction firms. In-depth interviews are especially suitable to obtain a more detailed understanding of certain concepts within a particular context (Fellows & Liu, 2009; Fontana & Frey, 2000).

A combination of purposive and snowball sampling was used to select participants from the two groups. Purposive or judgement sampling involves the choice of individuals who are in the best position to provide the information required and is used when a limited number of people have the information that is sought (Cavana et al., 2001). Snowball sampling is an effective technique for building up a reasonable-sized sample through a process of reference from one person to the next (Denscombe, 2014). The participants in the two groups were selected from a wide range of Auckland construction firms to ensure that validity and accuracy of the data were maintained. This also allowed leading information to be obtained from a range of people with different experience and knowledge of technology in the construction industry.

Questionnaire results

DEMOGRAPHICS

Table 1 presents the participants' demographic data: area of expertise, participant's age (15–24, 25–44, 45–64 and 65+); years of experience in the construction industry (0–5, 6–10, 11–15 and 16+); and years of experience working with technology (0–5, 6–10, 11–15 and 16+).

Participants in a wide variety of roles within the Auckland construction industry took part in this research. The 15–24 and 45–64 age groups were represented equally, with 11 participants in each group; nine were in the 25–44 age group and one in the 65+ group. Their years of construction experience varied widely, with the highest number of participants, 12/32, having 16+ years in the construction industry. The remaining distribution was as follows: nine participants had 0–5, five had 6–10, and six had 11–15 years of experience. However, it is interesting to note that the 16+ years of construction experience did not necessarily mean 16+ years of experience working with technology: one participant had only 0–5 years of technology experience, two had 6–10 years and one had 11–15 years.

Table 1. Participants' demographic data.

Participants' demographic data				
No	Area of expertise	Participant's age group	Years of experience in the industry	Years of experience working with technology
1	Project Manager	25–44	11–15	11–15
2	Project Manager	25–44	11–15	11–15
3	Project Manager	25–44	11–15	16+
4	Project Manager	45–64	16+	16+
5	Quantity Surveyor	15–24	0–5	0–5
6	Quantity Surveyor	15–24	0–5	0–5
7	Quantity Surveyor	15–24	0–5	0–5
8	Quantity Surveyor	15–24	0–5	0–5
9	Quantity Surveyor	25–44	11–15	11–15
10	Quantity Surveyor	45–64	16+	16+
11	Mechanical Engineer	25–44	6–10	6–10
12	Project Admin	15–24	0–5	0–5
13	Site Engineer	15–24	0–5	0–5
14	Site Engineer	15–24	0–5	0–5
15	Site Engineer	15–24	0–5	0–5
16	Site Engineer	25–44	6–10	0–5
17	Site Manager	15–24	0–5	0–5
18	Site Manager	45–64	16 +	16+
19	Carpenter	15–24	11–15	6–10
20	Carpenter	25–44	16+	6–10
21	Carpenter	25–44	16+	11–15
22	Carpenter	45–64	6–10	6–10
23	Carpenter	45–64	6–10	6–10
24	Welder/Fitter	25–44	16+	16+
25	Welder/Fitter	45–64	16+	16+
26	Welder/Fitter	45–64	16+	16+
27	Welder/Fitter	45–64	16+	16+
28	Welder/Fitter	45–64	16+	16+
29	Project Controller	15–24	6–10	6–10
30	Electrician	45–64	11–15	6–10
31	Equipment Operator	45–64	16+	6–10
32	Crane Operator	65+	16+	0–5

PARTICIPANTS' RATING OF TECHNOLOGY IN TERMS OF PERCEIVED EASE OF USE

Although managers or people in managerial roles (M/PMRs) belonged to different age groups, their rating of technology in terms of perceived ease of use was similar, ranging from 2.7 to 3.3 on a 5-point scale with 1 being easy and 5 being difficult (Figure 3).

However, the response from the construction workers was different (Figure 4). There was a very slight variation in the rating of technology in terms of perceived ease of use across the age groups, from 2 (for two age groups) to 2.6, with the exception of the 65+ giving a rating of 5. This participant perceived the use of digital technologies as more challenging.

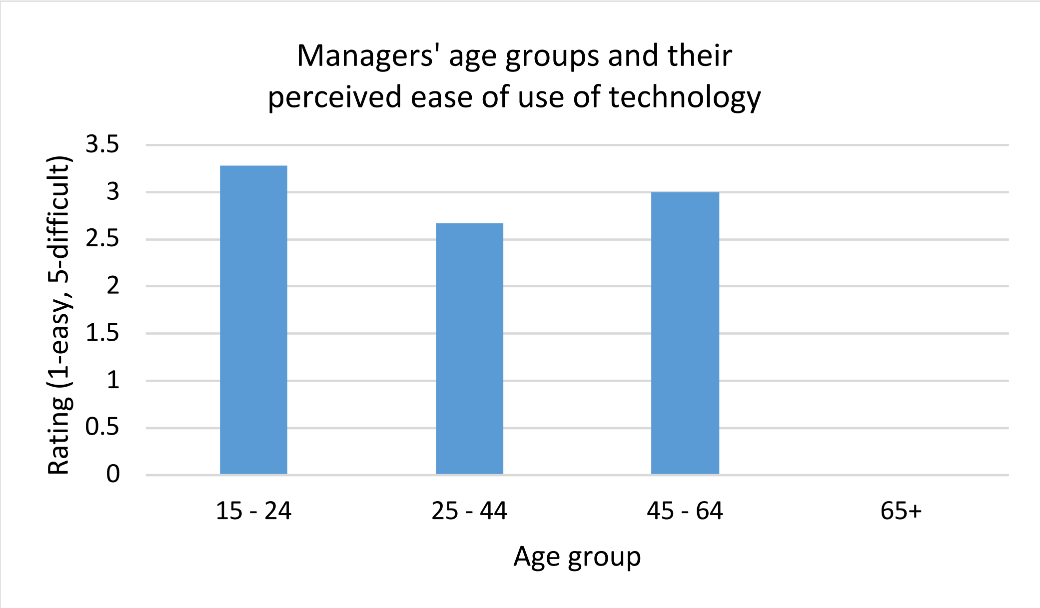

Figure 3. M/PMRs' age groups and their perceived ease of use of technology.

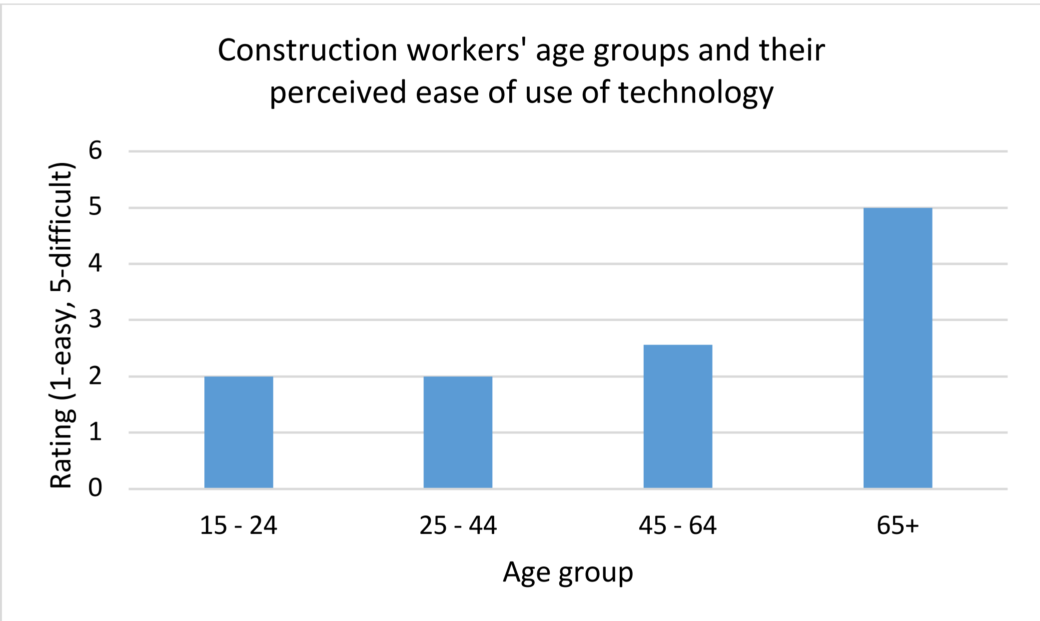

Figure 4. Construction workers' age groups and their perceived ease of use of technology.

TYPES OF DIGITAL INNOVATIONS USED BY AUCKLAND CONSTRUCTION FIRMS

A wide range of digital innovations was listed in the questionnaire, and the M/PMRs were asked to indicate the ones they used in their jobs. Project Information Management Systems (PIMS), BIM, VR and e-learning were the most widely used technologies (Figure 5). Most participants used PIMS for ‘contract admin,’ BIM for ‘understanding the complexity of the model’ and VR for ‘selling purposes.’ E-learning was most popular for professional development purposes. However, the use of 3D scanning and Pipe Stress Modelling was reported by only one participant each.

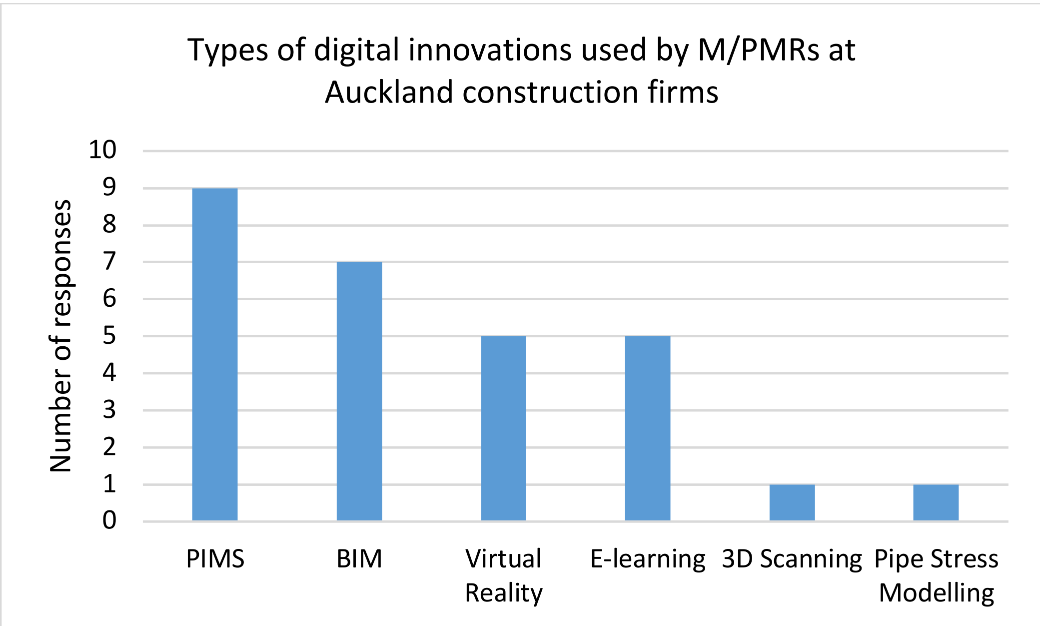

Figure 5. Types of digital innovations used by M/PMRs at Auckland construction firms.

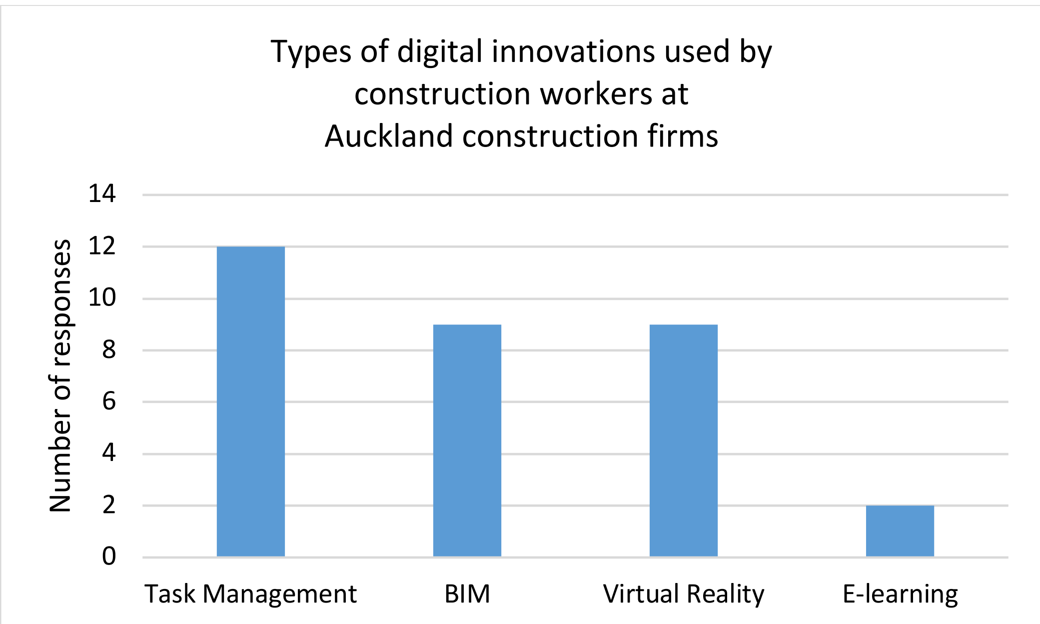

Figure 6. Types of digital innovations used by construction workers at Auckland construction firms.

A wide range of software within these digital innovations was used by the surveyed participants: Aconex (used by three participants), AutoCAD, Procore and Bluebeam (used by two participants each), and CostX, SketchUp, Co-Construct, Candy, Lentune and 3D visual packages (used by one participant each).

Among the construction workers, use of BIM and VR was equally high (Figure 6). However, e-learning was not so common in this group with only two participants reporting on engaging with it. Task Management, based on the use of a variety of software, such as ClickUp, Todoist, MS Project, Asana, etc., was by far the most widely used digital innovation by the construction workers.

In terms of software, the construction workers used less of a variety than the M/PMRs; AutoCAD and SketchUp were used by three participants each.

PERCEIVED USEFULNESS OF DIGITAL TECHNOLOGIES

The greatest perceived usefulness reported by the M/PMRs was 'easy access to design information' and 'decreased workload' (Figure 7). Another benefit mentioned by some participants was 'that projects are completed within budget and deadline.'

For the construction workers, the main perceived usefulness was: 'improved accuracy' and 'easy access to design information,' followed by 'decreased workload' and 'improved communication' (Figure 8). Interestingly, the use of technologies was not seen as useful for the timely completion of projects.

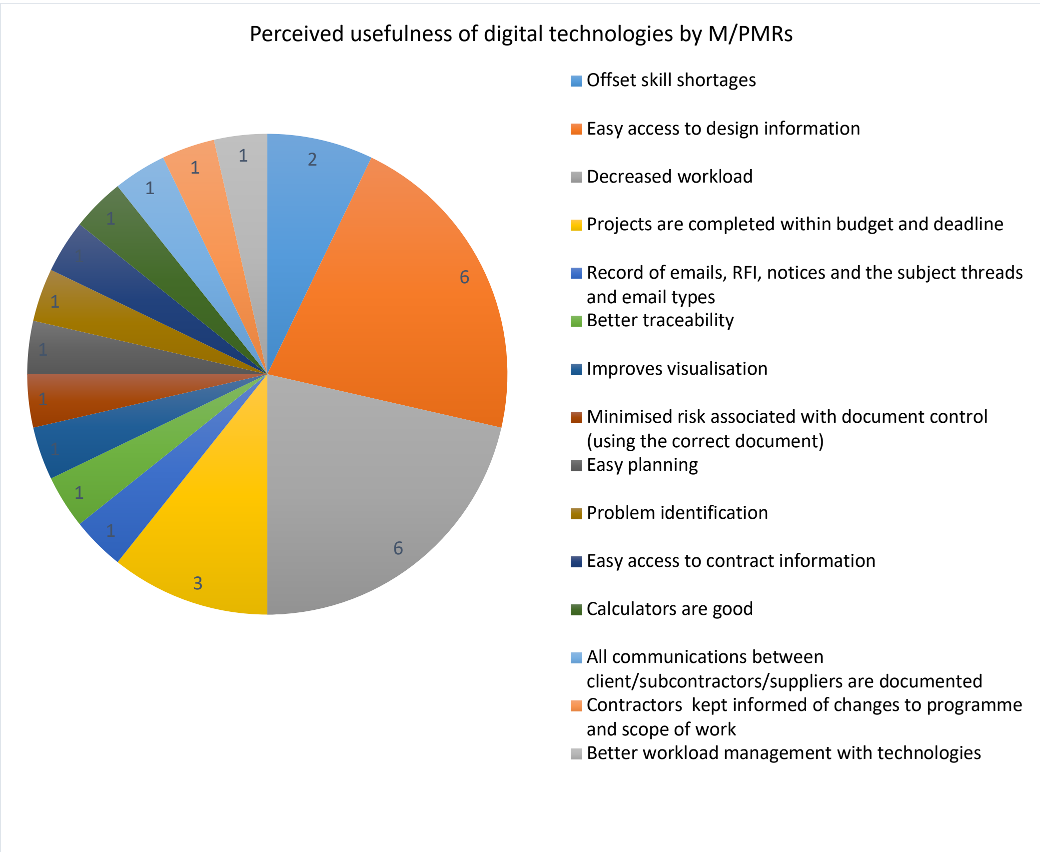

Figure 7. Perceived usefulness of digital technologies by M/PMRs.

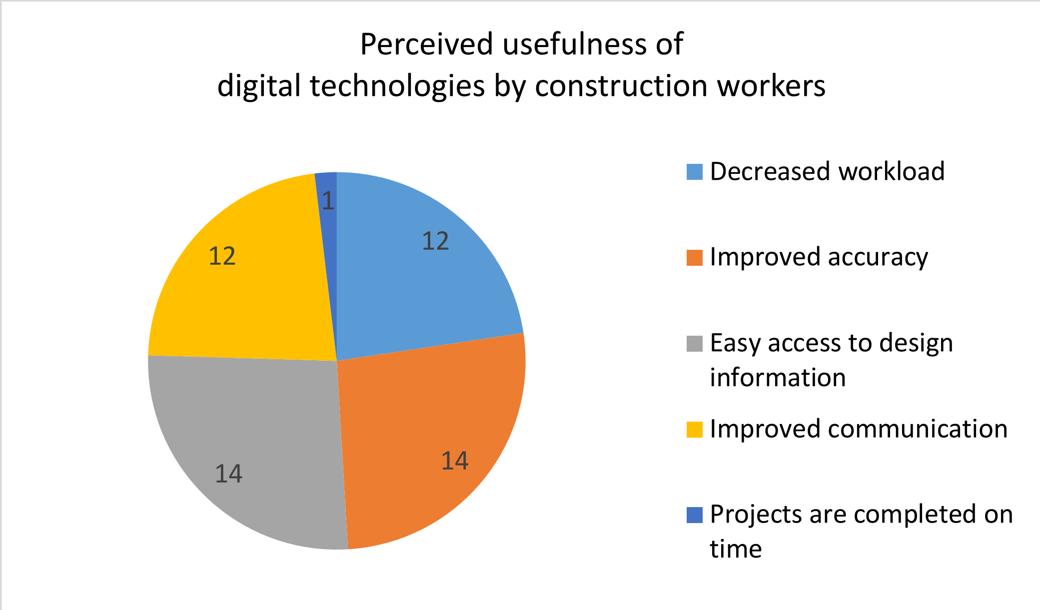

Figure 8. Perceived usefulness of digital technologies by construction workers.

CHALLENGES OF USING DIGITAL TECHNOLOGIES

When the M/PMRs were asked about the challenges faced when firms adopt new digital technologies, 'poor attitude towards technology' was identified as the most likely challenge for most, followed by 'resistance from staff' and the 'inability to use all the properties of the software,' which is usually due to lack of training and knowledge (Figure 9).

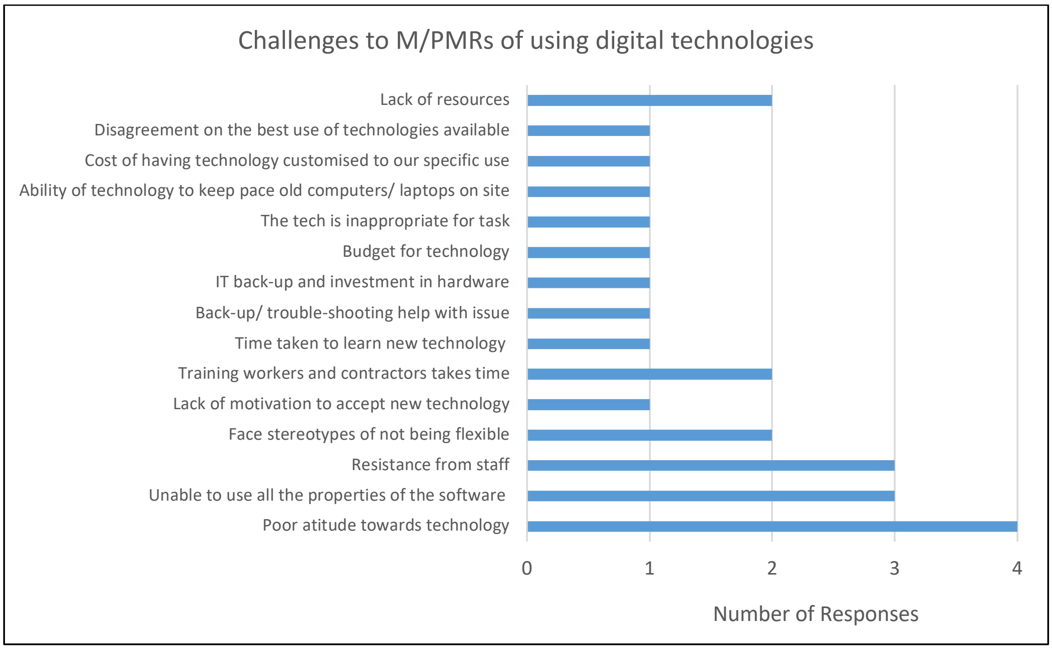

Figure 9. Challenges to M/PMRs of using digital technologies.

In terms of the challenges faced when using digital technologies, most construction workers selected 'face difficulties adapting to computers' as the main difficulty, followed by 'lack of motivation to accept the new technologies' and the perception that they 'affect the interaction of workers in the industry' (Figure 10).

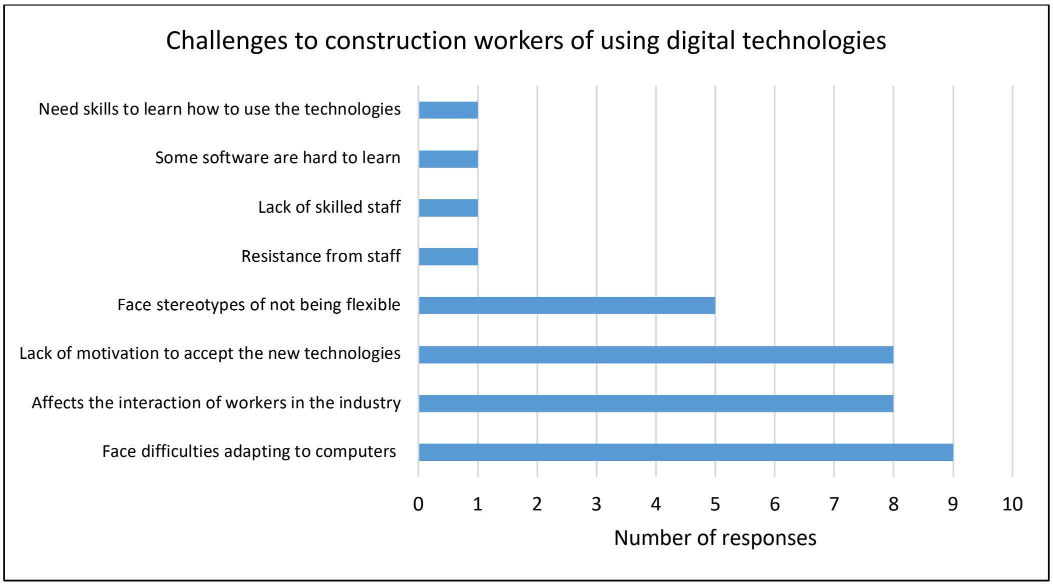

Figure 10: Challenges to construction workers of using digital technologies.

Interview outcomes

The follow-up interviews were carried out with ten M/PMRs. The interview questions built on the answers provided during the face-to-face surveys with the purpose of obtaining a deeper understanding of some of the main issues.

COMPANIES' TECHNOLOGY ADOPTION

All interviewees mentioned that "there was a fair bit of difficulty" when their respective companies adopted new technologies. The most challenging aspect was the difficulty using different software:

> "[I]t will be difficult for people who work in different departments, for example, we do not have access to Candy. It is only available to estimators." (M01)

> "Finding good software that integrates with other software…we are still having to repeat data entry in multiple pieces of software without them all managing to integrate." (M06)

The other major issue was the financial costs associated with the purchase of software or hardware:

> "[W]e have also had challenges in terms of the financial costs in purchasing the hardware to run new technology such as 3D software that required quite an expensive computer system with graphics to power it." (M04)

However, the perceived usefulness for the company of using technologies was clear and made certain aspects of daily work much easier. One example is the use of:

> "…a project management tool that sends out regular construction updates to all of our subcontractors. When the project manager updates the Gantt chart to reset his days, it notifies all of the subcontractors that the date has been adjusted and gives them a new target date to be on site. Also, a health and safety technology where we have a barcode on our hazard boards at the site entry and subcontractors can sign in using their phones, to scan like a QR code, and that can log on to the site, so we know for health and safety reasons who is on-site at each time." (M07)

EMPLOYEES' ATTITUDES TOWARDS TECHNOLOGY

The common shared sentiment among the interview participants was that "the workers are keen to learn and use new technologies as long as the technologies work."

However, M03 also commented:

> "I think that people get frustrated when the technology does not do what they expect it to do."

> "Most workers are keen and have a positive attitude to learn new things." (M05)

However:

> "…the attitude depends. For example, the worker [may not] want to face this technology so they would not even bother and whenever it comes to working with that application or technology, they would not pay much attention to it. But now if they are interested in doing it, then they will focus on what they want to do." (M09)

Unsurprisingly, a main difference between the older and younger employees was the ease with which younger employees adapted to new technologies in comparison to the older workforce, which is more resistant.

> "Younger workers take less time to adapt to technologies and they usually pick up new technology very quickly. However, old/senior workers may be resistant to using new technologies because they are used to the old way that they usually do things…they are not comfortable in learning new things." (M02)

> "The older workers take time to adapt to, but the younger workers can easily adapt to technology." (M08)

MAIN CHALLENGES FOR EMPLOYEES

A common challenge was the lack of available time for learning any software:

> "[B]ecause you need to take time off, you need to be absent from work to do training. So sometimes it is difficult because projects usually have limited time to be completed, so taking time off from work to do training may have a negative impact on project completion." (M10)

Technical obstacles were also cited:

> "[W]e have ordered software from the United States and so one challenge with that is the time zone. Are we getting the right level of customer support?" (M01)

In addition, and related to the time constraints:

> "[T]he lack of practice [is another concern]…because if you learn the new technologies and do not practise, you can forget easily." (M04)

The complexity of using various technologies in a single day and the underlying confusion this may create was identified as a major problem:

> "The workers are usually used to emails, but now when they have to send emails through another technology or application like Aconex, it becomes really difficult coz you have to focus on two different criteria to send emails." (M08)

This is mainly challenging when:

> "[S]ome people, particularly the older people in the workforce who have a lot of construction experience, are not so quick to adapt to technology." (M07)

STRATEGIES TO OVERCOME, REDUCE AND ELIMINATE CHALLENGES

All interviewees felt that providing extra support and training would help immensely:

> "I think the way to equip me with new technology is to do more training…firms need to invest in more resources such as booking training for employees and allowing them to take time out to do training. I think the company should give incentives to workers to learn new technology." (M01)

Some companies reported on running in-house training sessions in an attempt to address ongoing problems:

> "Probably not universally or coherently, but we as a business try and support people when they have the challenges with the technology in terms of running small training sessions within the business and trying to use as much of the customer support from the technology inventors to get their assistance whenever we need it." (M06)

Other quick solutions involved getting extra support:

> "[W]e usually contact the person who is responsible for the technology and if anything goes wrong, we just have that contact person within New Zealand whom we can keep in touch with, and he comes and helps us on where we have gone wrong." (M09)

Discussion

TYPES OF DIGITAL TECHNOLOGIES USED BY AUCKLAND CONSTRUCTION FIRMS

This research found that the M/PMRs in the study predominantly use PIMS, BIM, VR and e-learning, while the construction workers predominantly use Task Management, BIM and VR. The construction industry, in general, is recognised in international studies to be comparatively slow in adopting and accepting new digital technologies (Ho, 2016). Yet some construction firms try to innovate and improve technology usage. The use of BIM in New Zealand's construction industry has gradually increased over time (Harrison & Thurnell, 2015; Succar, 2009).

The common digital technologies that are used by both groups of participants are BIM and VR, which are also becoming common in the construction industry in general. However, there were differences in the use of e-learning, which was prominent in the M/PMRs group but not the construction workers group. Firms invest in e-learning to train their workforce (Becker et al., 2011). VR has also become quite common in the industry, where real-world and virtual information are combined (Johnson et al., 2010).

BENEFITS AND CHALLENGES OF TECHNOLOGY ADOPTION FOR CONSTRUCTION FIRMS

A main finding of this study is that technology adoption offers time-saving benefits and work efficiency. One example is "a project management tool that sends out regular construction updates to all…subcontractors" (M07), eliminating the need for sending individual emails to each subcontractor. This finding that time is reduced when technology is adopted is consistent with the literature (Yan & Demian, 2008).

Another benefit mentioned by a number of participants is that technology adoption may offset future skill shortages, which confirms similar statements in the literature (Dainty et al., 2005). However, the main drawback is that technological advances may result in de-skilling of traditional on-site activities (Dainty et al., 2005), affecting predominantly the older industry workforce that has a preference for traditional practices (Becker et al., 2011; Tipper, 2012).

Most of the participating M/PMRs reported on having financial, technical and training difficulties when adopting new technology. The financial costs for firms associated with the purchase of hardware and software present a definite challenge, identifying the need for "a technology budget" (M02).

Hefty up-front expenses are associated with the adoption of technological advances, and firms struggle to provide them (Becker et al., 2011). Capital investment is required for firms to adopt technology; without such investment technology cannot be introduced (Kruss et al., 2015).

The technological challenges referred to identifying the right piece of software able to work seamlessly with existing company applications without the need "to repeat data entry in multiple pieces of software" (M06). Proper software integration would eliminate the duplication of data entry. Adopting appropriate technology can set a foundation for innovation and learning (Kruss et al., 2015).

Training with new technology usually requires a significant investment of time, which companies struggle to find. Taking time off work for training "may have a negative impact on project completion" (M10). The lack of training development being provided to the existing workforce, as a result of which few trainees complete their qualifications, has been identified as a common problem in the literature (Lobo & Wilkinson, 2008). Only 29% of employers in the construction industry provide training (Watson, 2012). This result demonstrates the perceived usefulness of technology, a factor in the TAM, and relates directly to the need to acquire training. If employers felt that there was a value, usefulness and need to learning a technology then training development would be ingrained in the work culture. However, efforts are being made to provide training to attract new entrants into the industry (Lazazzara & Bombelli, 2011). The lack of proper training and knowledge often leads to using only limited features of the software. Some of the participating companies made time for in-house training, as training acts as "a supportive framework for the other good practices" (Lazazzara & Bombelli, 2011, p. 819), and ensures a loyal workforce to help in the expansion and growth of the business (Chan & Dainty, 2007). However, research also mentions unwillingness of existing workers to engage in training practices (Dainty et al., 2005). The construction industry will only be able to attract new entrants into training programmes if it is willing to pay high wages to these workers (Ho, 2016).

BENEFITS AND CHALLENGES OF TECHNOLOGY ADOPTION FOR THE CONSTRUCTION INDUSTRY WORKFORCE

The collected data suggests a correlation between technology adoption and decreased workload. The reasons could be a more efficient way of information sharing. "When more people know how to do the work, more people share the workload" (Zhang & Ng, 2012, p. 1331).

Construction workers in the age group of 45–64, and particularly over the age of 65 years, find it difficult to adapt to technology compared to those in the age brackets of 15–24 and 25–44 years. The difficulty with technology adoption is the resistance that the older workers have to accepting new technologies (Ebrahimi et al., 2008), especially when they do not use technology in the essential parts of their everyday work (Becker et al., 2011; Tipper, 2012). According to the TAM, attitude towards use of technology also creates the resistance to engage with new technology (Taherdoost, 2018). In this research, older employees' attitudes towards technology, and their perception of its related difficulties, acted as a hindrance to their ease of use. However, this does not mean that the older workforce does not have the ability to learn new skills; the more experienced or older generations can learn more from the younger generations (Helyer & Lee, 2012). In contrast, younger workers (university graduates) are known to be tech-savvy and at ease in adapting to technology – skills that are more appealing to employers. The TAM highlights this fact, indicating that the more at ease workers are with taking up technology, the greater optimism will be expressed in their willingness to learn (Charness & Boot, 2016). Companies usually find it necessary to hire university graduates as they are comfortable with the use of technology (Becker et al., 2011). However, they lack the wealth of construction knowledge and experience that older workers can offer.

The ageing construction workforce presents serious challenges when it comes to technology adoption, as they have a strong preference for traditional work practices. Consequently, firms face challenges in engaging the older (ageing) workforce (Becker et al., 2011). Furthermore, it is evident from the participants' responses that older workers face stereotypes of not being flexible, usually due to difficulties working with computers, and often not being willing to work or learn how to work in a different way as opposed to what they are used to (Becker et al., 2011). This research reflects the TAM and highlights that construction workers are hesitant to accept technology due to their perception of the difficulties associated with learning new skills and their attitude towards new technologies (Taherdoost, 2018). Workers believe that new technology is useful for the industry, but adopting the technology is an ongoing challenge. The older workforce is susceptible to stereotypes in construction environments, whereby there is the tendency of discouraging older workers while placing more value on the young ones (Barrett & Bourke, 2013).

Conclusions and recommendations

This study investigated the use of technology among Auckland construction firms and how it leads to the issues related to age and engagement of different generations of workers. Digital technologies (PIMS, BIM and VR), as well as a wide range of software, are being used by some Auckland construction firms. The data suggests that the difficulties that the participating construction firms faced grew in proportion to the increased uptake of technology. The challenges were due to the financial costs associated with the introduction of various technologies, the lack of specialist technical knowledge to inform the purchase decisions of relevant technologies, and the inability to regularly provide on-the-job training to their workers.

Using the TAM as a theoretical framework, this research highlights that for the participating construction firms, if a technology is perceived as having value and usefulness, then training development is prioritised. The study's findings reveal that these companies endeavour to provide some adequate training to their existing workforce. Most employees are keen to engage with technology. However, there are significant differences between the younger and older research participants. The former are tech-savvy and take much less time to adapt to technology but have difficulties working with traditional construction methods, whereas the latter are more resistant to technology but quite knowledgeable and conversant with various construction practices. In line with the TAM, this study confirms that for the older construction workers in this research, the pre-existing perception that learning new technology is difficult acts as a barrier to technology adoption. Therefore, to overcome the skills shortages, construction firms should invest significant time in training their older workers. They have a wealth of construction knowledge that is beneficial for the industry and investing in their training and development would be advantageous to all parties.

In some instances, it even appears that the challenges outweigh the potential benefits. Despite the study's limited data sets, the findings demonstrate that Auckland construction firms are capable of technology adoption and use. However, professional-development time is crucial to ensure employees' upskilling in these technologies. Otherwise, the lack of available time and resources could have an impact on companies' growth. The significance of this research is that it provides valuable insight for construction companies that are planning on the introduction of new technology, as it highlights the importance of training for all workers. It is essential that construction-related technology or software courses are designed and delivered specifically for busy industry professionals who work under time constraints. This could be done in partnership with industry training organisations.

This study has a few limitations that need to be taken into consideration: first, due to the study's time constraints a relatively small sample size was obtained; second, the age distribution of construction workers was not even, with weaker representation from the 65+ age group; and third, the construction managers were mainly from the younger age group, and perceptions of older managers, which could have provided a different insight into the study, were not obtained. To counteract this issue, for future research, a greater representation from the 65+ age bracket in both groups of participants could provide a clearer picture of technology adoption among construction firms in Auckland.

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