Examining Critical Perspectives on Building Information Modelling (BIM) Adoption in New Zealand

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Abstract

Purpose

This research aims to explore the perspectives of the key actors in the New Zealand construction industry towards BIM adoption. Specifically, four themes are examined, including what BIM is; BIM knowledge and understanding; benefits of BIM adoption; and challenges/barriers to BIM adoption.

Design/methodology/approach

A qualitative approach using 21 semi-structured interviews with industry experts was adopted.

Findings

The results raise a question concerning whether the New Zealand construction industry needs a unique definition of BIM to achieve a clear and consistent understanding amongst construction practitioners. It was found out that most of the construction practitioners in New Zealand are not well-aware of BIM, especially the contractors, QSs, supply chain companies, and the SMEs. Fourteen potential benefits and ten barriers/challenges to BIM adoption were identified. Individually, time-saving was considered as the most benefit of BIM adoption. While BIM understanding was suggested as the most significant barrier by all the interviewees.

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Originality/value

The research provides valuable insights into BIM understanding as well as recommendations regarding BIM adoption in New Zealand. The results could be considered baseline information for the companies and government to have effective strategies towards BIM adoption. Furthermore, it confirms that characteristics such as benefits and barriers to BIM adoption amongst different countries could be similar. Therefore, it could be useful to analyse the studies, strategies, and practices of the pioneer countries in BIM adoption for the implementation.

Keywords: *BIM; Building Information Modelling; Building Information Management; sustainability; mandate; New Zealand*

1 Introduction

An intense interest in BIM, which is generally defined as Building Information Modelling (Mordue *et al.*, 2015), has been developed because of its potential benefits to the construction industry. The construction industry is still amongst the lowest sectors in innovation (Kenley *et al.*, 2016, Wilkinson and Jupp, 2016). With BIM implementation, extensive changes can occur that enhance performance on construction projects during the entire lifecycle (Ryan *et al.*, 2013). The benefits of BIM adoption to the construction industry have been researched. Nine main benefits were identified by Newton and Chileshe (2012) in South Australia, while 18 BIM drivers were pointed out by Eadie *et al.* (2013b). Also, Ghaffarianhoseini *et al.* (2017) divided benefits of BIM adoption into 9 groups offering a wide range of transparent and current benefits. Besides, 35 cases using BIM in 8 different countries were investigated to determine the BIM impacts on the results of the projects (Bryde *et al.*, 2013). Because of its benefits, BIM implementation has come high on the agenda in many countries. For example, BIM has been mandated for all public sector buildings or government projects in Finland, Norway, Denmark, Netherlands, and the UK (Smith, 2014b).

Despite the increased global interest in BIM development, BIM adoption in New Zealand is still in its early stages with low uptake levels (Miller *et al.*, 2013) and insufficient attention from researchers (Amor *et al.*, 2007), leading to a very few BIM publications. Based on the Scopus database, only four journal papers mentioning BIM in New Zealand are available with the keywords ("BIM" + "New Zealand") limited to the *engineer* area and *journals* type. However, BIM as a key topic was researched in two papers (Davies *et al.*, 2017, Harrison and Thurnell, 2015). Harrison and Thurnell (2015) examined the potential effect of BIM implementation on quantity surveyors (QS) in the use of 5D BIM. Whereas, factors leading to "hybrid practice in BIM" in Australia and New Zealand were identified by Davies *et al.* (2017). Davies *et al.* (2017) did not separate the results of BIM practice between Australia and New Zealand. Furthermore, attempts are being made to enhance BIM uptake in New Zealand, such as the BIM Acceleration Committee, established as the driving force towards BIM adoption (BAC, 2018a), or the National BIM Education Working Group, formed with the involvement of nine fundamental construction tertiary educators to deliver the future workforce possessing adequate BIM skills (BAC, 2018b). It is also noticed that studies from non-high quality sources may provide inappropriate results for the New Zealand context. Doan *et al.* (2019) indicated the inappropriate results of the New Zealand BIM survey to the current practice of BIM in the New Zealand construction industry. In other words, there is a need for further research on BIM adoption in the New Zealand context.

This paper aims to identify and explore the perspectives of the key stakeholders in the New Zealand construction industry towards BIM adoption. Four different themes were examined, including: what is BIM?; BIM knowledge and understanding; the benefits of BIM adoption; and the challenges/barriers associated with BIM adoption. Based on the results, further discussion is presented, while the solutions for BIM adoption in New Zealand are implied from the revealed challenges/barriers to BIM adoption. The paper provides valuable insights into

BIM understanding as well as recommendations regarding BIM adoption. The next section describes the methods used for data collection and the analysis process.

2. Research Methodology

A qualitative approach using semi-structured interviews was used to explore the BIM perspectives of a wide range of industry participants who have been identified as key actors in the New Zealand construction industry. This approach was appropriate as it provides "deep, rich observational data" (Onwuegbuzie and Leech, 2005, Sieber, 1973). Also, gaining familiarity with the topic and generating insights for future research could be achieved with the qualitative approach (Scott, 1965, Eisenhardt, 1989, Haussner *et al.*, 2018). Reliable and comparable qualitative data is gained through semi-structured interviews allowing respondents to freely engage in sharing their views in their terms (Cohen and Crabtree, 2006, Harrell and Bradley, 2009).

A combination of two different sampling methods was used to recruit the participants, see Figure 1. Firstly, purposive sampling was applied to ensure the desirable criteria, in which the interviewees have to be working in the construction industry for at least five years and have been involved in BIM projects and/or Green Star projects in New Zealand. Due to the shortage of BIM specialists in the New Zealand construction industry, snowball sampling was adopted next to identify key stakeholders. Multiple sampling techniques are not uncommon in qualitative studies (Teddlie and Yu, 2007, Tongco, 2007). The LinkedIn source was used to approach the initial interviewees because it is a powerful professional networking tool providing an extensive database of business professionals (Albrecht, 2011, Schneiderman, 2016). Then, suggestions were provided by them to locate further participants.

[Insert **Figure 1**]

Figure 1. Interviewee recruitment process

The interviews were conducted between November and December 2017. This included 19 face-to-face interviews and 3 telephone interviews with a total of 26 interviewees coming from a range of sectors; all of them are considered as experts in the construction industry in terms of their position held and length of time working within the industry, see Table 1. It is noted that the interviews 6, 12, 13, and 20 were conducted with two interviewees each, which were recommended by the corresponding interviewees. The sample size is considered appropriate compared to the nature of qualitative research supported by the following studies. According to Galvin (2015) and Guest *et al.* (2006), 12 interviews are sufficient to achieve saturation, while Crouch and McKenzie (2006) research is less than 20 and 15±10 for Kvale and Brinkmann (2009)'s. Furthermore, previous qualitative studies were also published with similar sample sizes in the construction field (Sacilotto and Loosemore, 2018, Hurlimann *et al.*, 2018).

Table 1. Interviewees demographics

[Insert **Table 1**]

The interviewees came from 21 different companies, 17 large and 4 small and medium companies. The New Zealand Ministries (MBIE, 2017, MED, 2011) defines large enterprises as having a total number of employees equal to or higher than 20, and small and medium-sized enterprises (SMEs) have less than 20 employees. Table 1 demonstrates a wide variety of organisational types including design companies, contractor companies, consultancy companies, 1 information technology company, 1 non-profit organisation, and 2 multidiscipline companies. The study was primarily based in Auckland, with 4 of the 22 interviewees based outside of Auckland (Canterbury: 1, Wellington: 2, Waikato: 1). These characteristics ensure the diversity of the interviewees allowing for an exploration of different BIM perspectives, given the qualitative nature of the study.

The interview questions focused on four themes: what is BIM?; BIM knowledge and understanding; the benefits of BIM adoption; and the challenges/barriers associated with BIM adoption. The interviews were recorded and transcribed before conducting the thematic analysis using NVivo 11. It is frequently used in qualitative studies because of its benefits regarding efficiency, multiplicity, and transparency (Hoover and Koerber, 2011). Thematic analysis was used as it has been identified as "a foundational method for qualitative analysis" producing accurate and insightful findings (Nowell *et al.*, 2017, Braun and Clarke, 2006). Additionally, it is the best method to examine the perspectives of different interviewees generating unanticipated insights (Nowell *et al.*, 2017, Braun and Clarke, 2006).

The research followed the six-stage process suggested by Braun and Clarke (2006). It began by getting familiarised with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report. It was noted that during the transcribing stage, sound issues were detected while recording the interview with participant 9, leading to the inaudible problem. The transcript of participant 9 was then removed to ensure the accuracy of the findings. In other words, 21 transcripts were thematically analysed.

A combination of seven different strategies was adopted to promote the validity and reliability of the findings, see Figure 2. Firstly, the maximum variation method was used to enhance the transferability of the findings to readers for their applications by purposely selecting a wide range of characteristics of participants (Quinn Patton, 2015, Merriam and Tisdell, 2016). The wide range of characteristics of the interviewees is shown in Table 1. Adequate engagement was planned and carried out to make sure that sufficient time spent on the data collection to achieve saturation (Merriam and Tisdell, 2016). Similar to Galvin (2015) and Guest *et al.*

(2006), the findings were saturated after the twelfth interview, the nine interviews that followed provided more explanations for the findings rather than new themes.

[Insert **Figure 2**]

Figure 2. The process of promoting validity and reliability

The transcripts and codes were checked to avoid mistakes during the transcribing stage as well as to ensure that the codes were appropriately grouped and consistent across all the interviews (Creswell and Creswell, 2017, Gibbs, 2018). After going through the analysis process step, the data was returned to the interviewees to validate, verify, and assess the trustworthiness of what has been recorded and transcribed, which is known as member checking (Birt *et al.*, 2016). Next, agreement with the findings was concluded after conducting the data evaluating process with the interviewees (Merriam and Tisdell, 2016). Finally, triangulation using multiple sources of data to confirm the findings was carried out (Merriam and Tisdell, 2016, Barbour, 2001). The triangulation stage is presented in the discussion section.

3 Results and Discussion

Four main themes were analysed and are discussed, including: what is BIM?; BIM knowledge and understanding; the benefits of BIM adoption; and the challenges/barriers to BIM adoption.

3.1 What is BIM?

Interviewees were asked to explain from their perspective how they defined BIM. “A digital representation of a physical as-built real-world environment” (#1) or Building Information Model was considered as one of the definitions of BIM, which is “the best sort of recognized definition” (#16). Building Information Modelling was most commonly mentioned by a total of 16 interviewees. Interviewee 5 suggested that "BIM is not just a 3D model; it is a completely collaborative working environment." While others suggested that BIM is Building Information Management, interviewee 13 stated that "Building Information Management is a big workflow which starts from client concept through to architectural concept, structural concept, detailed design, and then through to construction." Software/technology was also mentioned as an interpretation of the definition of BIM. Three interviewees confirmed that "when I think of BIM, I think of Revit" (#15). In contrast, the rest of the group discussed that typically other construction practitioners in New Zealand suggest "I am doing BIM because I am using Revit" (#19).

The findings are consistent with existing literature indicating a diversity of BIM definitions consisting of Building Information Model, Building Information Modelling, Building Information Management, and software/technology. The first three definitions of BIM were referred by Turk (2016) and Hjelseth (2017), while Eastman *et al.* (2011) analysed the difference between the first two definitions, Building Information Model and Building Information Modelling. A misunderstanding of BIM as Revit was also mentioned by King (2011) and Hongming *et al.* (2017).

It is noted that each of the interviewees (apart from three) provided at least two different definitions, confirming that there is currently no unified interpretation of BIM. This is considered as a factor leading to the fallacies of the definition, which are "overly broad, use obscure or ambiguous language, or contain circular reasoning" (Kak, 2018, van Eemeren *et al.*, 2014). Consequently, it could cause a significant problem regarding what BIM stands for. For example, a result of 57% of projects using BIM in New Zealand from the New Zealand BIM Survey (EBOSS, 2017) was disregarded by most of the interviewees. Interviewee 12 stated that "it never defined what BIM is." This suggests that there is a wide range of opinion within the industry as to what the definition of BIM is. Industry experts have a wide range of perceptions on the topic, and there is no one size fits all definition being utilised. This raises the questions concerning whether there is a need to have a unique definition of BIM to achieve a clear and consistent understanding amongst the construction practitioners in New Zealand.

3.2 BIM Knowledge and Understanding

To develop an understanding of the level of BIM adoption in the existing industry, the interviewees were asked about their perception concerning construction practitioners' level of awareness of BIM. Half of them discussed a lack of general awareness in the industry. They remarked that BIM is "a quite new concept" (#1). Only two interviewees thought that most construction practitioners are well-aware of BIM. Interviewee 5 suggested that "we have got some key project managers and consultants to work with BIM, and most of the top tier contractors are fully aware of what BIM can offer." However, the interviewees that are employed by top tiers contractors pointed out that "BIM is not very common yet" (#16). All the interviewees from SMEs agreed with this lack of knowledge. SMEs dominate the construction industry in New Zealand with 97% of the total companies (MBIE, 2017). This finding is consistent with the view of Rodgers *et al.* (2015), implying that the low level of BIM awareness is due to the operations of the SMEs making up a significant part of the industry.

Interviewees were also asked about the current level of BIM awareness of specific key stakeholders. The designers and consultants within the industry were seen as the leading teams in BIM adoption in New Zealand. Specifically, "most architects are leading the way, followed by structural engineers and services engineers" (#13). Interviewees generally suggested that the size of the companies relates the level of BIM understanding and adoption. The interviewees also confirmed that most of the QSs, contractors and supply chain companies are still delivering the projects with traditional methods without utilizing other innovative approaches. Interviewee 5 stated that "contractors are slowly getting on board, or slowly getting to a stage where they can leverage the information they have been given, and start getting into a stage where they can model to manufacture as well … there are a lot of supply chains who still do not really work in this space."

The findings have parallels to the existing literature. According to Wu *et al.* (2014) and Rodgers *et al.* (2015), contractors are lagging behind architects and designers in BIM adoption. Services engineers and architects were considered as the stakeholders who possess the highest level of competency compared to the rest (Eadie *et al.*, 2015a). While structural engineers were identified as the ones, who are well-aware of BIM with the highest frequent application of BIM levels (Eadie *et al.*, 2015a).

In contrast, supply chain and QS firms have been showing a very poor engagement in BIM adoption due to the high economic investment required (Smith, 2014a, Aibinu and Venkatesh, 2013). Regarding SMEs, it is undeniable that the level of BIM adoption in SMEs is very low compared to the large-sized firms (Hosseini *et al.*, 2016). This is because of the nature of SMEs with limited personnel, finance, and knowledge relevant to management, which prevents them from embracing innovation and technological advancement (Hosseini *et al.*, 2016, Lam *et al.*, 2017). Furthermore, the policymakers, the industry, and researchers have not paid much attention to the SMEs regarding BIM adoption despite their dominant role in the industry (Lam *et al.*, 2017, Hosseini *et al.*, 2016). However, there are still advantages to BIM adoption to SMEs (Arayici *et al.*, 2011). The contractors, QSs, supply chains, and SMEs, therefore, should have more interest from the government, industry, and researchers to orientate them towards BIM adoption.

3.3 Benefits of BIM Adoption

A range of benefits associated with BIM adoption was discussed. All the interviewees agreed that BIM could bring many potential benefits to construction projects. Time-saving was considered a significant benefit of BIM adoption by most of the interviewees. Interviewees also felt that the time-saving of BIM is linked to other benefits of BIM, including the collaboration/coordination improvement, rework reduction, visualization improvement, risk reduction, clash detection, and variations reduction. Additional benefits discussed were improvements to efficiency, costs and client satisfaction.

3.3.1 Fourteen benefits of BIM adoption in New Zealand

Time-saving was indicated as a significant benefit of BIM adoption by 16 interviewees. The collaboration amongst stakeholders leads to a shorter time for clash detection and checking and verifying things. “Having all their information is stored centrally as well as all of the other project information in one place, it works extremely fast because you are not doing anything that will be aborted” (#11). Interviewee 13 explained that “saving in time with regards to resolving it on a computer screen might take 5 to 10 minutes, while on-site, it takes days if not weeks.”

BIM is believed to improve collaboration/coordination. Interviewee 2 stated that “BIM allows better collaboration between the architects, engineers, clients, project managers, all that kind of stuff. Regarding design, you can pretty much see the 3D assembling of the whole thing, visualisation, coordination, collaboration, and transparency.” Interviewees suggested that information management was another benefit of BIM as the data can be shared and managed effectively. By improving collaboration/coordination and information management, this can lead to rework reduction. The improvement in visualisation was also expressed as a benefit of adopting BIM. Interviewees confirmed that it means that the project can be presented accurately and encourages collaboration. Interviewee 21 went on to discuss the visualisation aiding risk management “we have the ability to visualise documentation … we can process, understand the risks, and communicate the risks through the project more efficiently and effectively." It was suggested that the clash reduction and risk reduction are two of the factors that could lead to variation reduction in construction projects.

Efficiency or productivity improvement was also seen as one of the significant BIM benefits. Interviewee 10 explained that "everyone is working on the same information; everything is current … I would say efficiency is number one." Cost improvement is a perceived benefit of using BIM by 14 interviewees, as it can lead to better coordination and less cost and fewer variations. As a result of cost and time savings, 7 interviewees felt that BIM adoption could improve client satisfaction. Competitiveness improvement was revealed as another benefit of BIM adoption. It is "seen as a marketing tool" (#6), which "decently sells a project better to a client" (#4). Regarding the environment, BIM adoption is believed to improve the sustainability of the project. "It is going to make it easier for modelling … things like heating, ventilation, and air conditioning (HVAC), daylight, etc., ... In that sense, it is going to improve sustainability" (#5). Besides, BIM could also improve health and safety by "looking at the 3D model … to spot the dangerous areas" (#7).

The understanding of BIM benefits is similar amongst the interviewees despite the different construction types, company sizes, the number of BIM projects that they have been involved in, and years of experience. This could be because all of the interviewees have been working in the construction industry for at least eight years, holding significant positions in their companies. Therefore, they obtained specific knowledge about BIM.

3.3.2 Benefits of BIM adoption in other countries

The BIM benefits raised by the interviewees align with the existing literature. Clash reduction and visualization improvements are the two most well-acknowledged benefits of BIM adoption in the UK and Australia, respectively (Eadie *et al.*, 2013b, Newton and Chileshe, 2012). According to Khosrowshahi and Arayici (2012), information management and efficiency improvements were identified as major benefits of BIM adoption along with the minor ones, including rework reduction, risk reduction, and sustainability improvement, etc. Environmental issues could be minimised with proper BIM implementation (Bensalah *et al.*, 2019, Bu *et al.*, 2015, Yang, 2012). Interestingly, the competitiveness improvement has the same rank, 7th, regarding the important level of the BIM benefits in both the UK and Australia (Newton and Chileshe, 2012, Eadie *et al.*, 2013b); besides, collaboration/coordination, health and safety, and client satisfaction improvements, time and cost savings were also remarked as the BIM benefits in these two studies (Newton and Chileshe, 2012, Eadie *et al.*, 2013b). Whereas, Sebastian and van Berlo (2010) mentioned the capability of BIM, which could minimise the variations of the project.

3.4 Barriers/Challenges to BIM Adoption

Interviewees were asked about the barriers/challenges preventing construction practitioners from implementing BIM.

3.4.1 Lack of understanding

BIM understanding was identified as one of the significant barriers by most of the interviewees. Interviewee 10 stated that "lack of understanding is probably the biggest barrier, like knowledge about what it is, what the benefits are, how the process can be used." BIM's lack of understanding falls into two different themes, amongst clients, and amongst other stakeholders. Regarding clients, "to a lot of them, when you mention the word BIM, they do not know what it means, how to achieve it, and what to do with it." (#20). Amongst other stakeholders, "it is always the perception of what people mean by BIM. They can just do 3D modelling, and they said they are doing BIM" (#5). These findings are supported by Alabdulqader *et al.* (2013), Alreshidi *et al.* (2017), and Khosrowshahi and Arayici (2012). The lack of BIM understanding is always one of the first challenges/barriers to BIM adoption in their findings, proving its essential role, which needs to be solved for BIM development.

3.4.2 Lack of benchmark projects

Interviewees also confirmed that a lack of knowledge concerning BIM means that they are unable to determine the benefits of using it. In other words, "if somebody experiences no benefits, they are going to be reluctant to do it" (#14). Additionally, we do not have BIM benchmark projects for BIM adoption in New Zealand. BIM benchmark projects have been steadily realised because of its essential role in BIM adoption. For example, a multination data centre project used to record BIM best practices was awarded in the BIM Excellence category by ICEA (Irish Construction Excellence Awards) (ICEA, 2018).

3.4.3 High economic investment required

The high economic investment required, including software, hardware, training, specialist recruitment, etc. was also identified as a barrier/challenge to BIM adoption. Interviewee 3 explained the issue of staff and recruitment, "it is a high investment if you have to hire a BIM manager or hire a brand new staff member." Interviewee 1 also outlined the issue of investment, "the investment in hardware and software, changing workstreams and the need to restructure construction company skills composition and service offerings that is a significant capital investment cost and change management risk." Interestingly, BIM practitioners in New Zealand, the UK and Australia have the same view about the high economic investment for BIM adoption (Alabdulqader *et al.*, 2013, Alreshidi *et al.*, 2017, Khosrowshahi and Arayici, 2012). A cost model developed by Olatunji (2011) indicated that software, training, and hardware are the three highest costs for BIM adoption for the SMEs.

3.4.4 Lack of expertise

Interviewees confirmed that the lack of expertise is a significant challenge to BIM adoption associating with costs. "Lack of expertise, yes … the knowledge pool and the people that are able to do the work. BIM managers, BIM coordinators, they are all like hen's teeth. They are rare, and it is hard to find those people" (#5). Interviewee 20 stated, "definitely, we are desperately short of good expertise." Interviewee 3 mentioned, "the contractors, in particular, do not necessarily have any BIM technicality, so it is just upskilling, which is missing." The finding reflects the view of Zhao *et al.* (2016), indicating that the lack of BIM competency or BIM expertise is one of the critical risks regarding BIM adoption.

3.4.5 Lack of client demand

A lack of client demand was identified as the next most significant barrier/challenge to BIM adoption. Interviewee 16 explained that "the clients are sort of lacking behind on saying they want a BIM project … it has to do with the fact that potentially architects and structural engineers they sell BIM as being more expensive, and the client will say no to that." Moreover, less interest in FM from the owners is also a factor leading to the lack of client demand for BIM adoption. It is noted that the lack of client demand is a problem to BIM adoption in New Zealand and also around the world such as in the Middle East (Gerges *et al.*, 2017), Sweden (Bosch-Sijtsema *et al.*, 2017), and Hong Kong (Chan, 2015).

3.4.6 Cultural resistance

Cultural resistance was also revealed as a barrier/challenge to BIM adoption. "I do not believe the industry currently wants it … they are afraid of change" (#1). "People like to stay in their comfort zone" (#14). It is suggested that this resistance is a result of the combination of the lack of understanding, expertise, benchmark projects, and the incapacity of the industry. These findings are in line with the existing literature finding that cultural resistance is one of the most common and essential challenges/barriers to BIM adoption, which needs more attention (Zhao *et al.*, 2016, Gerges *et al.*, 2017, Eadie *et al.*, 2013a).

3.4.7 Legal issues

Legal issues such as intellectual property (IP), liability and contractual requirements were also considered as major barriers/challenges to BIM adoption. Interviewee 5 explained that "people do not want to give out information because they feel like they are losing IP." This finding supports the work of Arensman and Ozbek (2012) and Eadie *et al.* (2015b). It demonstrates a need for further research in legal issues to BIM adoption to improve the transparency of the BIM process, along with the confidence of the BIM users to share their information willingly.

3.4.8 Lack of collaboration and coordination

Eadie *et al.* (2013a) explained that collaboration amongst stakeholders has the highest impact on BIM adoption, one of the top three critical barriers/challenges affecting the BIM implementation is that lack of collaboration (Zhao *et al.*, 2016). In this research, the lack of collaboration and coordination was mentioned by interviewees as a significant barrier/challenge. Currently, "the contractors are not taking the BIM model and using it necessarily to coordinate throughout the construction" (#3). "If we look at the supply chain … and how we want to gather and collect the information now, they are still not up to speed with all the requirements that we want" (#5). This mirrors Chan (2015) and Bosch-Sijtsema *et al.* (2017), remarking that "BIM does not help if our counterparties are not using BIM."

3.4.9 Technical problems

Another challenge for BIM adoption relates to technical issues in terms of software, compatibility and interoperability. Interviewee 5 stated that "you need specialised software with certain characteristics, but it is a limited pool of what you can use currently." Interviewee 7 explained that "what happens is when you use one package like ArchiCAD, and you use the IFC protocol and read it, you then lose things in translation." Interviewee 8 also acknowledged that "technologists still have to catch up a little bit in various aspects … people's computers and software requirements or capabilities are really lagging behind what it actually requires for this technology and process to kick off." These findings reflect the view of Elena *et al.* (2018) stating that "none of the BIM software can provide solutions to all specialized tasks"; whereas, IFC still fails to be a solution to overcome the current interoperability problems (Benghi and Greenwood, 2018, Chen *et al.*, 2017). Tulenheimo (2015) also expressed the need for the strong power of computers to BIM adoption.

3.4.10 Lack of guidelines and standards

The lack of guidelines and standards was also discussed by the interviewees as a challenge. Most of the interviewees agreed that we need more guidelines and standards for BIM adoption. "There is probably no New Zealand standard; companies here follow those standards from Europe or the UK … The problem with European standards out there was set up for Europe, which may not be 100% suitable for New Zealand" (#4). Interviewee 13 expressed the inconsistency of the standards applications in New Zealand, "In New Zealand, we do not have any standard at the moment … We want to do the same as the rest of the world, but the rest of the world have different standards."

According to Edirisinghe and London (2015), there is a connection between BIM adoption and BIM standards, regulations, and policy initiatives. However, BIM adoption in European countries and New Zealand are different. European governments have been politically active leading the development of BIM adoption in their countries; BIM has been mandated for certain types or stages of the projects (Travaglini *et al.*, 2014), compared to the passive resistance from the New Zealand government. McAdam (2010) and Maradza *et al.* (2013) revealed that the BIM standards and regulations in the UK and US are hardly applicable to each other. This is because those standards are only perfectly suitable for particular regions owing to the different approaches pursued by each area (Maradza *et al.*, 2013, McAdam, 2010). In other words, the BIM standards from different countries should be analysed, discussed, and amended before applying it. This is parallel to Sielker and Allmendinger (2018) suggestion in which the consistent national framework, including handbooks, guidelines, standards, and regulations should be established to have a successful BIM implementation.

In Canada, a national BIM strategy, standards, guidelines, protocols, technical codes were planned to develop to ensure consistency of the BIM implementation process (buildingSMART, 2014). Although the Ministry of Education in New Zealand realised the vital role of the BIM standards and planned for its development (Cunningham, 2015), current BIM resources are still modest with only two documents including International BIM Object Standard (Masterspec, 2016) and New Zealand BIM Handbook (BAC, 2016) were developed for BIM implementation in New Zealand, see Figure 3.

[Insert **Figure 3**]

Figure 3. Standards and guidelines for BIM adoption in the UK and New Zealand (adapted from Bew and Richards (2008))

3.4.11 Cross-case analysis

It is noted that the interviewees have the same view towards the barriers/challenges to BIM adoption despite their experience and their business types. The interviewees working in the SMEs expressed more barriers/challenges compared to their counterparts, especially in the high economic investment, lack of expertise, cultural resistance, legal issues, and lack of collaboration and coordination. These findings are consistent with the results and existing literature in section 3.2. Regarding the number of BIM projects, those who have been involved in less than 15 BIM projects are struggling with BIM in comparison with the ones participating in equal or higher than 15 BIM projects, especially with the lack of benchmark projects, technical issues, and lack of collaboration and coordination. This could be because those with more BIM experience came up with solutions that could minimise the technical issues along with the collaboration and coordination problems.

3.5 BIM mandate in New Zeland

Interviewees were asked for their perspectives concerning the idea of BIM mandate in New Zealand. Interviewees were of differing views. A third of them believe that the government will mandate BIM. In terms of the timing of a possible mandate, interviewees did not think it would happen quickly. In contrast, half of the interviewees stated that BIM would not be mandated in New Zealand. It is due to several reasons, including the capacity of the industry. Also, the benefits of BIM have not been proved yet in New Zealand, and politicians lack knowledge concerning the construction industry or buildings, so the concept of BIM could be lost on them. When asked whether the government should mandate BIM in New Zealand, the group was divided. Half felt that the government should mandate BIM because “BIM mandate would make a difference” (#20). Whereas, half thought that it should be business-driven, “BIM should be a business solution … if you make BIM mandatory, people tend to become lazy" (#2).

3.6 Further Discussion

BIM adoption in New Zealand is still in its early stages; the level of depth of BIM definition as well as its understanding is not being achieved sufficiently. It is necessary to collect, analyse, and learn lessons from pioneer countries who have been managing to succeed at a certain level of BIM adoption. After identifying and analysing the benefits and barriers/challenges to BIM adoption in New Zealand, they were compared with the benefits and barriers/challenges to BIM adoption globally, see Table 2.

Table 2. Benefits and barriers/challenges to BIM adoption amongst the countries and regions

[Insert **Table 2**]

It is clear that those benefits and barriers/challenges identified in the New Zealand construction industry are common to BIM adoption around the world despite the unique characteristics of the industry in each region. This helps to confirm that the lessons and practices of BIM adoption globally can be valuable and worth examining and analysing for further BIM implementation in the New Zealand construction industry context. It is, however, noted that those practices need to be carefully reviewed regarding their time-scale of BIM adoption and their distinctive characteristics. For example, there are two milestones to BIM adoption in the UK, 2011-2016 (BIM was planned to be mandated by 2016 by the UK government (CO, 2011)) and after 2016. It is suggested that the studies and practices of BIM in the UK should be examined rigorously between 2011-2016 rather than the period after that as an example of planning and preparing for BIM development in New Zealand.

The time-scale can also have a considerable impact on the research into BIM adoption. Taking the software and hardware costs for implementing BIM in Malaysia for example, they were not considered as the significant barrier anymore despite its existing in the previous literature (Rogers *et al.*, 2015). Furthermore, the unique characteristics of the countries could also be taken into consideration. Compared to other countries around the world, the UK, Australia, and New Zealand have many things in common. "Australia, New Zealand, and the UK have a similar basis of law. They have a common democratic system, and they have the same types of legislation and regulations around investment and trade" (Scheer, 2017). It is, therefore, suggested that the plans, practices, and studies towards BIM implementation in the UK and Australia should be critically analysed for further BIM development in New Zealand. This suggestion reflects the view of interviewee 16, "we generally follow the UK, Australia, or America. I think we almost follow the UK more than Australia … and normally take whatever they have done, and recycle that, and legislate things that are quite similar to what they did." While analysing case studies in the UK on BIM projects could "help to inform the New Zealand law" for avoiding legal issues, suggested by interviewee 20.

Furthermore, several solutions were implied by the interviewers when barriers/challenges to BIM adoption in New Zealand were revealed. Providing education and training is necessary to mitigate the challenge of lack of understanding, expertise, and client demand. Also, benchmark projects should be showcased to cover the challenge of lack of benchmark projects. BIM guidelines and standards should be developed with the inputs of the government. Developing a BIM execution plan and investigating in technology could also be the solutions to improve BIM adoption in New Zealand. Further research should also be conducted on BIM mandate topic, whether BIM should be mandatory in New Zealand where 97% of companies are SME.

4 Conclusion

This paper examined the perspectives of the key construction practitioners towards BIM adoption in the New Zealand construction industry. BIM definition, understanding, benefits, challenges/barriers, solutions for BIM adoption, along with mandating BIM in New Zealand were critically analysed to provide a full picture of the existing situation of BIM adoption. The data was collected by conducting 21 semi-structured interviews with 25 interviewees working in a wide range of positions, construction types, company sizes.

The results revealed that the understanding of BIM definition varies, and it is inconsistent amongst the construction practitioners. Also, it is found that most of the construction practitioners in New Zealand are not well-aware of BIM, especially the contractors, QSs, supply chain companies, and the SMEs, see Figure 4.

[Insert **Figure 4**]

Figure 4. Results of the research

Regarding the benefits of BIM adoption, 14 potential benefits were identified by the interviewees. Amongst those 14 benefits, time-saving, cost-saving, collaboration and coordination improvement, efficiency improvement, and visualisation improvement are considered as the most significant benefits outlined by most of the interviewees.

Whereas, concerning challenges, a lack of BIM understanding, a lack of expertise, high economic investment, a lack of collaboration and coordination, and legal issues were perceived by the majority of interviewees as barriers. Additionally, there is a division amongst the interviewees towards the barriers/challenges of BIM adoption. Those working in SMEs and have been involved in less than 15 BIM projects perceived more BIM barriers/challenges than their counterparts.

Whether New Zealand will or should mandate BIM was also analysed. While only one-third of the interviewees believed that BIM would be mandatory, half of them provided an opposite answer. However, more interviewees agreed that BIM should be mandatory in New Zealand. This could be because they have perceived the benefits of BIM adoption, but the construction industry is just not ready yet for the implementation because of the identified barriers/challenges. It is recommended that the government should be involved in investigating the role of BIM adoption towards the current practices of the construction industry instead of being inactive and standing outside of its development. The findings indicated that the government inputs into BIM implementation could be a significant solution to the SMEs, contractors, and those who do not have much experience in BIM adoption.

In summary, this research contributed to the existing body of knowledge in two key ways. Firstly, the study provided valuable insights into BIM understanding. It highlights the current barriers/challenges and provides recommendations regarding BIM adoption in New Zealand. Secondly, it was found out that characteristics such as benefits and barriers to BIM adoption amongst different countries could be similar. Therefore, it could be useful to analyse the studies, strategies, and practices of the pioneer countries in BIM adoption for the implementation. To be more specific, BIM adoption in the UK and Australia could provide valuable lessons for the New Zealand construction industry owing to the similar basis of law, democratic system, legislation, and regulations.

The data collection was conducted mainly in Auckland. Therefore, a more extensive study examining perceptions in other regions in New Zealand is suggested for future work. Also, the statistics of the BIM adoption rate were not collected due to the different understanding of BIM definition of each interviewee. This research is the first stage of a larger project examing the relationship between BIM adoption and Green Star certification uptake in New Zealand. It is clear from the results that sustainability improvement is one of the potential benefits of BIM adoption in New Zealand. Therefore, there might be a relationship between BIM and Green Star in New Zealand. Moreover, the findings indicated that there is a lack of metrics to measure the success of BIM projects in the industry. Further studies will be conducted to develop a framework to analyse the factors having a significant impact on BIM adoption and to assess the success of the BIM projects.

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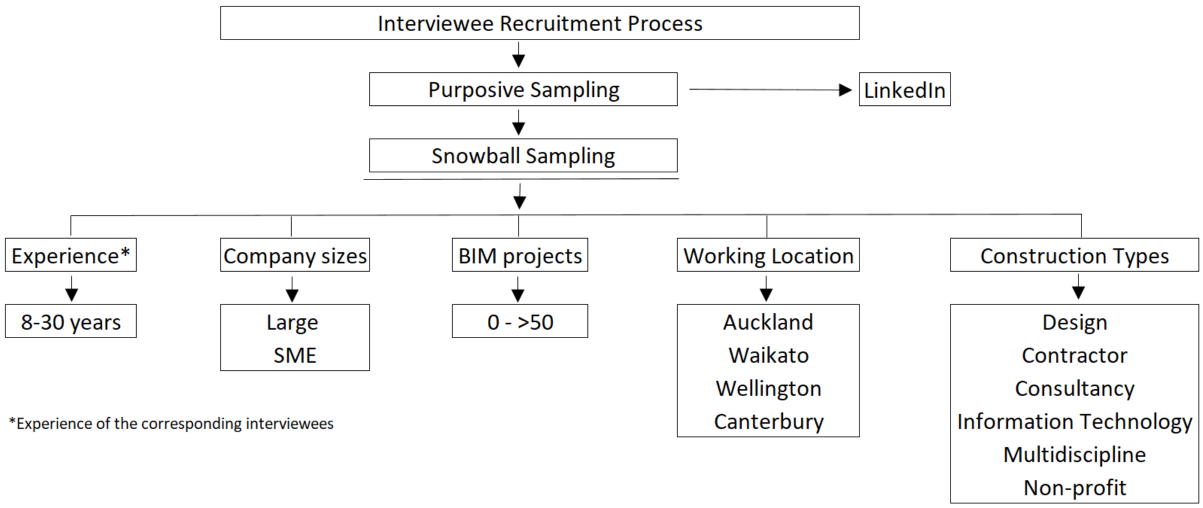

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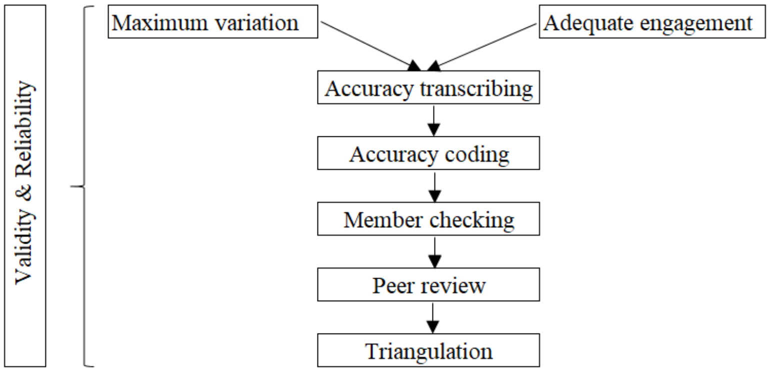

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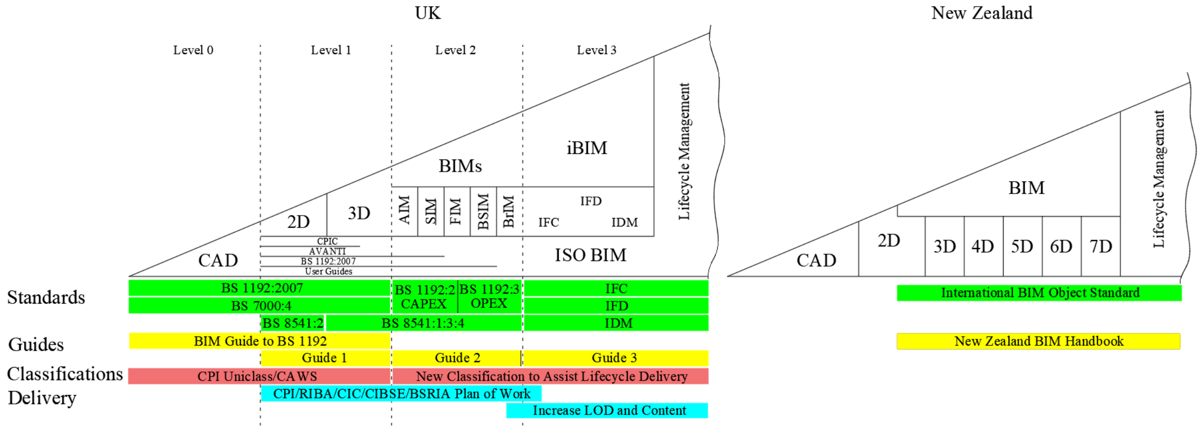

Figure 3. Standards and guidelines for BIM adoption in the UK and New Zealand (adapted from Bew and Richards (2008))

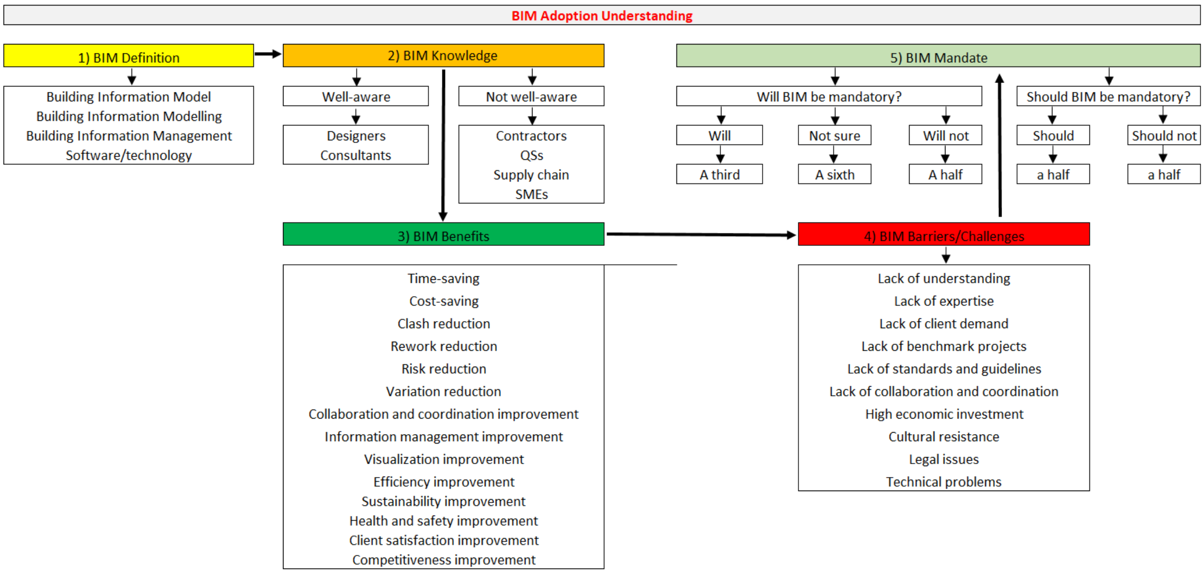

Figure 4. Results of the research

Table 1. Interviewees demographics

Interviewee	Construction Position	Experience (years)	Construction Type	Company Size	BIM Projects
#1	Senior QS	10	Contractor	Large	1
#2	BIM Manager & GSAP[1]	14	Design	Large	>50
#3	Director, Building Scientist, Green Star Assessor, & GSAP	12	Consultancy	Large	>50
#4	Senior Architect, GSAP, & Green Star Assessor	15	Design	Large	30
#5	Technical Services Manager, Design Manager, GSAP, & Green Star Assessor	22	Contractor	Large	6
#6	1) Director & Building Surveyor[2] 2) Building Surveyor	14 4	Consultancy	SME	15
#7	Principal & Designer	30	Design	SME	4
#8	Senior Cost Manager	20	Consultancy	Large	1
#9	Project Director	23	Contractor	Large	11
#10	Building Services Technical Leader	8	Consultancy	Large	7
#11	Director & Building Performance Expert	19	Consultancy	SME	1
#12	1) BIM Manager[2] 2) Building Scientist	22 3	Design	Large	>50
#13	1) Associate & Structural Engineer[2] 2) Drawing Office Manager	10 19	Design	Large	>50
#14	Structural Technician	8	Design	Large	1
#15	Sustainability Leader, Green Star Assessor, & GSAP	13	Design	Large	>50
#16	BIM Construction Manager	11	Contractor	Large	40
#17	Technical Lead & Senior QS	12	Multidiscipline	Large	>50
#18	BIM Consultant, Application Engineer, & Business Analyst	17	Information Technology	SME	>50
#19	Associate Senior Architect	11	Design	Large	>50
#20	1) BIM Development Engineer[2] 2) Senior Structural and Sustainable Engineer, & GSAP	20 8	Consultancy	Large	50
#21	Principal QS	8	Multidiscipline	Large	2
#22	GSAP & Green Star Assessor	10	Non-profit	Large	0

[1]Green Star Accredited Professional; [2]Corresponding interviewee.

Table 2. Benefits and barriers/challenges to BIM adoption among the countries and regions

Benefits	**UK**	**Australia**	**US**	**Singapore**	**China**	**Middle East**	**Finland**	**Turkey**	**Indonesia**	**Malaysia**
RC	[1, 2]	[4]	[7, 8]	[10]	[11]		[14]	[15]		[17]
RRW	[1, 2]		[7, 8]		[11]		[14]	[15]		
RR	[2]	[4]	[7, 8]	[10]	[11]		[14]	[15]		
RV			[7, 8]					[15]		[17]
ICC	[1]	[4]	[7, 8]	[10]	[11]	[12]	[14]	[15]	[16]	[17]
IIM	[1, 2]	[4]	[7, 8]	[10]		[12]	[14]	[15]		
IV		[4, 5]	[7, 8]	[10]			[14]	[15]		[17]
IE	[2]		[7, 8]			[12]	[14]	[15]	[16]	
IS	[2]	[4]	[8]	[10]				[15]		
IHS				[10]				[15]		
ICS	[1]	[4]	[7, 8]		[11]	[12]		[15]	[16]	
IC	[1]	[4]	[7, 8]	[10]	[11]	[12]			[16])	
ST	[1]	[5]	[7, 8]		[11]	[12]		[15]	[16]	[17]
SC	[1]	[5]	[7, 8]		[11]	[12]		[15]	[16]	[17]
Barriers	**UK**	**Australia**	**US**	**Singapore**	**China**	**Middle East**	**Finland**	**Turkey**	**Indonesia**	**Malaysia**
LU	[1-3]	[5, 6]	[9]		[11]	[12, 13]	[14]	[15]	[16]	
LBP	[1, 2]			[10]		[12]				
HEI	[1-3]	[5, 6]	[9]	[10]	[11]	[12, 13]		[15]	[16])	[18]
LE	[1, 2]	[5, 6]	[9]	[10]	[11]	[12, 13]	[14]	[15]	[16]	[17]
LCD	[1-3]	[6]		[10]	[11]	[12, 13]		[15]		
CR	[1-3]	[5]	[9]			[12, 13]	[14]	[15]	[16]	
LI	[1-3]	[5]	[9]			[12]			[16]	[18]
LSG			[9]	[10]	[11]	[12]	[14]	[15]		[18]
LCC	[1-3]		[9]					[15]		
TP	[3]	[5]	[9]			[12, 13]	[14]	[15]	[16]	[18]

Note: RC: reduce clash; RRW: reduce rework; RR: reduce risk; RV: reduce variation; ICC: improve collaboration and coordination; IIM: improve information management; IV: improve visualisation; IE: improve efficiency; IS: improve sustainability; IHS: improve health and safety; ICS: improve client satisfaction; IC: improve competitiveness; ST: save time; SC: save cost; LU: lack of understanding; LBP: lack of benchmark projects; HEI: high economic investment; LE: lack of expertise; LCD: lack of client demand; CR: cultural resistance; LI: legal issues; LSG: lack of standards and guidelines; LCC: lack of collaboration and coordination; TP: technical problems.

[1]: Eadie et al. 2013; [2]: Khosrowshahi and Arayici 2012; [3]: Alreshidi et al. 2017; [4]: Newton and Chileshe 2012; [5]: Alabdulqader et al. 2013; [6]: Hosseini et al. 2018; [7]: Azhar 2011; [8]: Gokuc and Arditi 2017; [9]: Ku and Taiebat 2011; [10]: Teo et al. 2015; [11]: Jin et al. 2017; [12]: Venkatachalam 2017; [13]: Gerges et al. 2017; [14]: Gerbov et al. 2018; [15]: Aladag et al. 2016; [16]: Chandra et al. 2017; [17]: Rodgers et al. 2015; [18]: Hamid et al. 2018.