'Being' BIM: An exploration of BIM practice and practitioners

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Abstract

Building Information Modelling (BIM) is a set of technologies, tools, processes and approaches that is bringing a fundamental change to construction industry across all stages of design, delivery and operation. Although BIM is encouraged, promoted, and even in some cases mandated at upper levels of the AEC industry, successful adoption and implementation requires the efforts of individuals who are prepared to take responsibility for driving and influencing practice at a project and organisational level.

The importance of human factors in BIM implementation, such as competencies, training and education, relationships, attitudes and personal traits, are often identified in the literature. However, in much of the ongoing research in BIM, they are merely acknowledged to be necessary or important, but not examined in any detail. Their influence on BIM progress are sometimes touched on in case studies and surveys, but the focus tends to be much more centred on technology and practice. This study looks to the people identified as leaders and influencers in BIM environments, and explores the roles they fill, their backgrounds and understanding of the BIM process. Their perspectives on these soft issues, as well as the broader technical and process context of BIM, form the focus of this thesis.

The overall inquiry into the impacts of BIM adoption on roles within the AEC industry is addressed through two central research questions. The first explores the ways in which BIM adoption has created or influenced the creation of new roles within the industry, whilst the second considers how the characteristics of the individuals tasked with BIM adoption and implementation have affected the development of BIM. These questions have been addressed through a qualitative interview survey which included 73 BIM practitioners identified by their peers as BIM specialists or leaders in BIM implementation in New Zealand, Australia, the Netherlands, the UK, and the US. This was supported by a comparison of two case studies of emerging BIM practice in New Zealand.

The findings show that the introduction of BIM has progressed to a point where BIM roles are now common across many sectors of the AEC industry. Many of these are traditional roles that have expanded or changed to include significant BIM responsibility. Others are new roles that have emerged to fulfil specific needs for management of BIM information, process and strategy in projects and organisations. However, even with this increasing involvement of specialist practitioners in BIM and wider industry practice, the status of BIM as a professional role is still not established. Many practitioners expressed feelings of insecurity regarding their current position, suggesting that work to provide greater clarity around expectations, education and certification, and career progression is necessary so that BIM practitioners can be assured that such roles have value and recognition. The experience, skills, passions and concerns of those tasked with 'being' BIM within a company or project environment have a significant influence on BIM implementation. Employing and developing people with the appropriate skills and attitudes to take on BIM roles thus has a great benefit to companies and the industry as a whole.

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Glossary and abbreviations

AEC	architecture, construction and engineering; also referred to as 'the construction industry', or simply 'the industry'.
BIM	building information modelling
BIM model	a model created using the process of building information modelling
BREEAM	Building Research Establishment Environmental Assessment Method; a UK-based certification scheme for rating the environmental performance of a building.
CPD	continuing professional development; often expressed as a specific number of hours of training and education required for professionals to maintain accreditation or certification with a professional body.
CF	consent form, used in the interview process to ensure informed consent.
'digital natives'	the generation of people who have grown up with digital technologies and so are assumed to have a natural ability to use computers and associated technologies.
Hybrid BIM	BIM implementation where project information and documentation within a single project are created using a mix of BIM, CAD and other approaches.
IDDS	Integrated Design and Delivery Solutions; approaches for improved building design, construction and operation based on principles of data and information sharing, and incorporating BIM and IPD.
IPD	Integrated Project Delivery; a collaborative approach to building design, construction and delivery that brings participants together to share both risk and reward based on project contribution and outcomes.
LEED	Leadership in Energy and Environmental Design; a US-based certification scheme for rating the environmental performance of a building.
MEP	mechanical, electrical & plumbing trades.
PIS	Participant Information Sheet, used in the interview process to ensure informed consent.
Solo BIM	BIM implementation which is carried out by one project participant for their own purposes, where the model is not transferred to other project participants.
Social BIM	BIM implementation where models are exchanged between project participants.
VA	United States Department of Veterans Affairs.
VDC	virtual design and construction; used in this thesis as a synonym for BIM.

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Nature of contribution by PhD candidate	Lead author; planned and carried out the research and wrote the text
Extent of contribution by PhD candidate (%)	95

CO-AUTHORS

Name	Nature of Contribution
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Suzanne Wilkinson	Discussion on research direction, feedback on an early draft

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1 Introduction

Chapter summary

In this thesis on 'Being' BIM: An exploration of BIM practice and practitioners' I offer a view of Building Information Modelling (BIM) which is situated within the experience and from the perspective of the BIM practitioners who are tasked with the implementation and management of BIM. In this introductory chapter I contextualise the status of BIM in the architecture/engineering/construction (AEC) industry in New Zealand and globally, and in particular consider the various definitions of BIM and what they might mean for the BIM specialist role. I describe the research area, and explain the motivation for the study.

In this chapter I also present the research objectives and questions that directed the course of the project, and the scope of the work undertaken. After defining the research goals, I explain in some detail the research design that was chosen to achieve them, providing the conceptual and research framework of the project. Finally, I describe how the thesis has been organised, and connect the following chapters with associated publications.

1.1 Building Information modelling

The introduction of Building Information Modelling (BIM) is a recent and significant development in a largely conservative industry that "in principle has not changed for millennia", particularly in how information is produced and managed (Brandon, Li & Shen, 2005, p282). By changing the industry's approach to information, BIM is now creating change in almost all aspects of the design, construction, operation and use of the built environment, from individual buildings (so-called vertical BIM) to infrastructure (horizontal BIM), industrial applications such as mining or manufacturing operations (heavy BIM) or large scale urban planning (UIM – urban information modelling). Initiated primarily as a technological advance for the design sector, BIM is now creating a steady transformation in the industry environment that encompasses facets as broad as technology use, work processes and responsibilities, policy and legislative environments, contractual and other relationships, and industry culture. Although extensive and ongoing, such a significant shift is not a straightforward process. Because of the breadth of elements undergoing change, there are many and varied perspectives of what changes are appropriate and necessary, who needs to be involved, and how best to manage the change process. There have been, and continue to be, many conflicts, challenges and problems emerging in the transition.

In response to BIM, new roles are emerging in the AEC industry, based around the BIM specialist. Wherever BIM adoption and implementation are taking place, individuals from a wide variety of backgrounds are developing additional skills, forming new relationships, modifying and revising processes and establishing standards to support both the change process and the new circumstances as BIM evolves. Although the involvement of BIM specialists is implicit throughout any examination of BIM implementation, few studies have addressed roles directly, and codification of role characteristics has not yet been developed. This thesis examines the role(s) of the BIM professional from the perspective of those who have been the forerunners of this specialisation in their various fields. It advances the concept of the BIM specialist as a new professional role within the construction industry, and examines the characteristics of such a role in terms of tasks and responsibilities, relationships, and skills. It also examines the influence that BIM practitioners have on the adoption and implementation process that they are involved in, and how their relationships, identity and skills impact on the BIM outcomes achieved. According to Heidegger, 'being' is inseparable from 'doing', and thus competence is "not primarily as a thing or entity we possess, but rather something we embody and enact in the sense of what we do and at the same time are" (Sandberg & Pinnington, 2009). In this sense, then, through exploring the experience and understanding of the individuals who embody BIM practice, we can gain insight into how that practice takes shape, and how practice shapes the practitioners.

1.1.1 Defining BIM

Unsurprisingly, given the wide scope of BIM as described above, many definitions of BIM are used in different contexts. Aspects from software and technology to broad industry outcomes and aspirations are emphasised depending on the position and interest of the observer. Uncertainty of how to define BIM is often a result of this multiplicity of viewpoints.

The definition provided by NIBS (as cited in Eastman, Teicholz, Sacks & Liston, 2011) was one of the earliest formal definitions of the concept of BIM, and emphasises information as the central element. Another widely adopted definition that is that of Eastman et al. (2011), which firmly establishes BIM as concerning both technology and process. Succar (2009) offers a third definition, which further broadens the scope to position BIM as a "knowledge domain," and adds policy as an element. Other definitions emphasise specific characteristics in order to support a particular application of BIM, as identified in **Error! Reference source not found.**.

In some cases, particularly in the US, more recent usage has adopted the term Virtual Design and Construction (VDC) and refers to BIM as the *product* (i.e., the model) and VDC as the *process* involved in creating and using a BIM model for building design, construction and operations (Kunz & Fischer, 2009). For the purposes of this thesis, in line with common usage in New Zealand, the term *BIM* has been used in the sense defined by Eastman et al. (2011, p16) as "a modeling technology and associated set of processes to produce, communicate and analyse building models", whereas *BIM model* has been used to refer to the product of that process, i.e., the model created using the process of building information modelling.

The potential benefits of BIM have been widely reported, including better visualisation and communication for all parties to a project; increased collaboration and coordination throughout the design stage; greater predictability and control; reduced time and cost in construction processes; through to enhanced management of assets and facilities

Source	Focus	Definition
NIBS (2008) (as cited in Eastman et al., 2011)	Information	[BIM is] an improved planning, design, construction, operation, and maintenance process using a standardized machine-readable information model for each facility, new or old, which **contains all appropriate information** created or gathered about the facility in a format usable by all throughout its lifecycle.
Eastman et al. (2011)	Technology and process	[BIM is] **a modeling technology and associated set of processes** to produce, communicate and analyze building models
Succar (2009)	Knowledge domain	[BIM is] **a set of interacting policies, processes and technologies** generating a "methodology to manage the essential building design and project data in digital format throughout the building's life-cycle"
Li, Fu, Zhong & Luo (2012)	Design for sustainability	[BIM] allows for multi-disciplinary information to be superimposed within one model, it **creates an opportunity for sustainability measures to be incorporated throughout the design process** to areas such as sustainability, parametric design, and so on.
Papadonikolaki, Vrijhoef & Wamelink (2015)	Supply chain management	[BIM is] a technology-driven approach that offers benefits to both **products and processes** of AEC, by collecting and representing building project information, and hence **supporting information sharing**.
Merschbrock & Munkvold (2012)	Information systems	[BIM] can be best described as a **platform of IT tools** employed to design virtual models seeking to present all physical and functional characteristics of a building.
Sebastian (2011)	Collaboration	[BIM is] is an integrated model in which all process and product information is combined, stored, elaborated, and **interactively distributed to all relevant building actors**.
AGC (2010)	Contractors	[BIM] is the development and use of a computer software model to simulate the **construction and operation of a facility**.

Table 1 Selected definitions of BIM (emphasis added)

throughout the building's life cycle (Bryde, Broquetas & Volm, 2013). Essentially, BIM provides a framework which allows buildings to be represented three-dimensionally, not simply geometrically, but using objects which have information attached to them. The amount of information included determines the value of the model and the uses to which it may be put. At the early design stage, the modelling capabilities of a BIM tool allow rapid interaction with design options to determine appropriate building mass and location for site planning, overall spatial relationships and areas for determining feasibility, and early visualisation of design concepts. The inclusion of material properties and plant and services data allows simulation of various design configurations for aspects such as thermal comfort, energy use, lighting, acoustics and ventilation. As the design progresses, the three-dimensional model allows coordination between consultants for consistency of design, and detection and resolution of clashes between services or structural members.

For the construction stage, it provides comprehensive modelling and documentation of construction details and systems. With the addition of time data (termed a 4D model), construction planning and site works can be incorporated into the process, and a variety of approaches can be modelled in order to identify the most efficient. Use of plant and equipment can be included, health and safety risks and alternatives can be modelled, and various scenarios for labour utilisation and optimisation can be examined. Cost data (in a 5D model) provides the opportunity for rapid revision of budget estimates based on changes in the design or selection of materials and products, or optimisation of design or construction choices from a cost perspective. Identified products may have information attached which details the cost, manufacturer, installation instructions and maintenance requirements, and allows ongoing record keeping of the building in operation for facilities and asset management.

Given this flexibility of definition of what constitutes BIM and how it is applied, and the potential it offers for improved productivity and performance in so many facets of the industry, it follows that there is similar variation and potential in the roles and development of the practitioners involved in making BIM happen, at industry, organisation, and project levels. It is also clear that the scope of change made possible by BIM adoption must have an impact on almost every role within the industry. This research proceeds from the perspective of BIM practitioners, and so no single definition of BIM has been imposed. Rather, any definitions or descriptions of what BIM itself or BIM roles may constitute have been drawn from those directly involved in the process.

1.1.2 Motivations for BIM – New Zealand context

The productivity of the New Zealand AEC sector has decreased over recent years, both in real terms, and in comparison with the productivity of other sectors (Page & Norman, 2014). This has been attributed to a longstanding lack of innovation, and there is now increasing pressure to deliver substantial improvement. In order to address this issue of low productivity, the Building and Construction Productivity Partnership (BCPP) was established in 2010 as a partnership between the New Zealand Government and the construction industry. The BCPP set a target of a 20% productivity gain by 2020 across the industry as a whole. Although no specific targets or directives were imposed for use of BIM on public projects, the BCPP emphasised increased adoption and development of tools such as BIM so that teams can work more effectively within and across projects (BCPP, 2012). The BCPP ended in 2014, and since then the BIM Acceleration Committee that was established under its auspices has continued to work to establish BIM in the NZ construction industry, as part of the Ministry of Business, Innovation and Employment (MBIE).

Factors such as industry structure and company sizes, client base and related market forces, and local and central government and regulatory structures in New Zealand all serve to differentiate the industry context here from overseas experience. For much of the industry here, these differences have resulted in many taking a wary view of enthusiasm about BIM in the United Kingdom, United States, Singapore, Scandinavia and Singapore, to name a few of the countries where BIM adoption is considered more advanced. Surveys of the New Zealand industry suggest that while awareness of BIM within the construction industry is comparable with that in other developed countries, adoption was initially relatively low (Masterspec, 2103). The conservative BIM uptake in New Zealand has meant that the industry here is able to learn from the experience of other countries. There are already indications that the advance of BIM in New Zealand is rapid (EBOSS, 2016), and that progress is likely to be accelerated here, compared with many other countries. The industry here is thus in a position to orient itself to the best practice and lessons learnt from the experience of others, and avoid the developmental pitfalls and culs-de-sac encountered elsewhere.

1.1.3 International adoption of BIM

Surveys of BIM adoption have been carried out in many countries and sectors around the world. Although not the first to investigate the field, McGraw-Hill Construction has been arguably the most thorough with investigations of North America (2008, 2009, 2012a) Europe (2010), Australasia (2014a, 2014c), Asia (Korea, 2012b, Korea & Japan, 2014a, China, 2014b) and South America (Brazil, 2014a), with follow up surveys providing a longitudinal view or focusing on specific sectors. A number of countries have also been surveyed by local organisations, for example NBS in the UK (NBS, 2011-2016) and BIM Institute in South

Africa (Harris, 2016). In addition, research initiatives such as the IT Barometer (Samuelson, 2008) have included BIM as an element of a wider investigation into the use of IT in construction.

Many countries have taken an ambitious stance on improving industry productivity and building quality through the use of BIM, particularly for government clients and public buildings (Owen, Amor, Dickinson, Prins and Kiviniemi, 2013). The US General Services Administration has required the use of BIM on new Public Buildings Service projects since 2007. Norway, Denmark and Finland introduced similar requirements for state-funded construction projects at the same time, and The Netherlands followed suit in 2010. Other countries have implemented plans for more gradual introduction of BIM and associated processes. For example, the Singapore Building and Construction Authority put a development roadmap in place in 2010, to work towards having 80% of the construction industry using BIM by 2015, and now requires digital submissions, including BIM files, for new building permit applications. The UK Government mandated that from April 2016 all public works projects must use Building Information Modelling tools and techniques. Although the Australian Government opted not to pursue a mandate approach, the Australian Department of Defence has pursued the use of BIM on Defence projects, and various state governments are similarly implementing BIM in state contracts. As a result of such strong requirement or encouragement to use BIM approaches for new buildings, there has been considerable development of standard documents, training approaches, and guidelines to support the use of BIM in these countries (Kassem, Succar and Dawood, 2015).

1.1.4 Progress in BIM practice

Even before the term BIM was first popularised (Laiserin, 2002), the concept of an integrated modelling environment was hailed as a new paradigm for the industry (Dikbas, Yitmen & Morten, 2000), which would bring a completely different approach to designing and building across the sector. The tools and technology required for successful BIM have progressed enormously in the past two decades, taking BIM from an experimental approach to its current status where BIM is “emerging as a prerequisite for many projects” (Eadie, Odeyinka, Browne, McKeown & Yohanis, 2013, p349).

The implementation of BIM is not simply an incremental change in technology, however, but is intended to transform the way the industry operates, and requires process change to be integrated with the technological change. Approaches such as Integrated Project Delivery (IPD) and Integrated Design and Delivery Solutions (IDDS) maximise the improved communication and information exchange opportunities of BIM to facilitate a more cohesive and efficient design and construction process (Owen et al., 2010). To make these gains, however, a significant shift in focus and processes across the AEC industry is required. This shift is associated with work undertaken in a number of countries to develop related approaches to procurement and contracts (Arensman & Ozbek, 2012; Hurtado & O'Connor, 2008).

There is also significant potential for the new technology or processes to have unexpected impacts on the nature of the product (the design and construction of the built environment), on the organisations using it, or on the structure of the industry broadly, beyond the productivity improvements and quality enhancements intended (Neff, Fiore-Silfvast, and Dossick, 2010). Furthermore, different companies, projects and partnerships take different approaches to the adoption of BIM, and are willing to accept varying degrees of collaboration and cross-party integration (Ghassemi & Becerik-Gerber, 2011). Thus there is a wide variety of interpretations of what constitutes successful or appropriate BIM use. Changes may not be synchronised across different levels or roles within an organisation, and the impacts of introducing BIM and associated technology or process changes may vary considerably depending on whether a global or an incremental approach is taken within the project or organisation (Hartmann, van Meerveld, Vossebeld & Adriaanse, 2012).

These various transformations in technology and process lead to associated changes in professional roles and relationships in a BIM context. Traditional role definitions for the various professionals involved in a construction project may become less distinctly separate, or new roles may emerge. Despite being significantly affected, however, the topic of roles and responsibilities of the individuals involved in the process has received only scant attention. Research on integrated information technology has remained largely focused on the computing systems and standards required to achieve the goals, with less attention paid to the effects the introduction of such systems would have on the individuals involved. Nonetheless, some early researchers did note that there would be changes to roles in the industry. Fischer, Waugh and Axworthy (1998, p43) identified that, "These systems will enable some project participants to become generalists because they will provide feedback on particular design alternatives from multiple perspectives very rapidly. They will also enable other project participants to become more specialized…." Similarly, Ahmad, Russell and Abou-Zeid (1995, p165) asserted that "these new practices require new standards, new specifications and new ways of interaction between various project participants." Such discussions are remarkably similar in content and tone to those of more recent publications, with general statements regarding the need for change and the potential for new roles. For example, Mäki and Kerosuo (2015, p173), conclude that "expanding the use of a new tool, such as BIM, requires changes in activities and collaboration between the designers and the site managers." Eadie, Browne, Odeyinka, McKeown and McNiff (2015) present results of a survey in which less than 5% of respondents considered current project team structures to be satisfactory in a BIM environment, but with a wide variety of views on what change is required. Although the technology and the knowledge environment have progressed in the past twenty years, there has been much less development, in specific terms, of how roles and responsibilities of participants in the process need to change, for successful BIM implementation.

Within the scope of BIM-related industry initiatives internationally, the influence of the practitioners' roles in BIM adoption and implementation tends to be overlooked. While there is some ongoing work that includes the capability assessment of individuals using BIM (Succar, Sher & Williams, 2012), most endeavours within the BIM field neglect the impacts that such a significant change in technology and processes has on the roles, relationships and skills needs of the people involved, and conversely, the effects that these practitioners have on BIM implementation. The consequent career implications for the practitioners who pursue such roles have also received little attention.

1.2 Contribution and research rationale

Despite the wide range of benefits evident from the capabilities of BIM technology, there is still a great deal of uncertainty in the construction industry regarding its adoption. Companies are hesitant to commit to a change that has an undetermined impact on their activities. The extent to which they need to change their current practices and processes is hard to define, and the staffing, skills and training requirements of BIM is difficult to identify from current published guidelines and industry documentation. The impact of BIM on people working in the industry has had far less attention than the impact of BIM on the process and product aspects of the industry, but the introduction of new technology and working practices has the potential to profoundly change the type of people, relationships and skills that companies require to effect the desired improvements. Equally, the people taking on the leadership and 'champion' roles in the BIM environment also shape the way the environment evolves and develops. Factors such as the attitudes and expectations of these influential individuals, how they perceive themselves in relation to the wider organisation and project teams they are involved with, and their relationships and networks, all contribute to how successful a BIM implementation will be in practice.

This thesis seeks to contribute to the development of BIM roles in the industry, through an examination of a range of people currently working as BIM practitioners. A fuller knowledge of BIM roles is sought, by positioning the BIM practitioner as a new profession within the industry, and investigating the background, role requirements, training and skills that are considered necessary or contributory to the role, and the career implications of BIM practice for these individuals. Phua (2013) argues the necessity of individual-level studies as a means of providing insight into performance issues within the construction industry. This study contributes to the increasing body of work in this field.

1.2.1 Research questions

The key question for this research is:

> What impact does the adoption of Building Information Modelling (BIM) have on professional roles in Architecture, Engineering and Construction (AEC)?

Two secondary questions have been identified to help address this primary question:

1. What are the spheres of responsibility of BIM practitioners?
2. How do the characteristics of BIM practitioners affect BIM adoption and implementation?

Issues examined under the umbrella of these research questions include:

- BIM adoption frameworks
- authority and decision-making in a BIM environment
- spheres of responsibility of BIM practitioners, and how they relate to traditional industry roles
- skills requirements for BIM practitioners, and how organisations appoint and develop individuals in these roles
- how BIM affects formal and informal interactions between project participants
- differences in roles and practices between different disciplines.

Figure 1 presents the relationship between the secondary questions and the issues and themes investigated through this study.

What are the spheres of responsibility of BIM practitioners?

- What BIM roles have developed in the industry because of the progress in BIM practice?
- How do the roles of BIM practitioners relate to traditional industry roles?
- How do organisations appoint and develop individuals in these roles?
- What are the skills requirements for BIM practitioners?

Themes: role definitions, background and training; skill sets; role development; reporting and accountability; differences in roles/practice between AEC disciplines; career trajectories

How do the characteristics of BIM practitioners affect BIM adoption and implementation?

- How do BIM practitioners perceive the BIM adoption and implementation process?
- How do BIM practitioners construct their professional identity?
- How do BIM practitioners fit into formal and informal interactions between project participants?
- What changes are evident at project and organisational levels?

Themes: professional identity, relationships and networks; authority and decision making; BIM adoption frameworks

Figure 1 Articulation of research questions and themes

The key research question and two secondary questions serve to direct inquiry into the way in which individual roles and interactions are developing within BIM-mediated projects and in the industry more generally, and the impact those roles have the introduction of BIM. This is an area that has been largely overlooked in BIM research to date, and is thus a significant contribution.

1.3 Research design

This thesis includes a collection of published articles or manuscripts under consideration for publication; as a result, the description of research methodology is distributed in various levels of detail in the following chapters. However, to establish the overarching research design and how it has been applied in this project, this section seeks to provide a view of the philosophical framework that supports the data collection and analysis methods used.

This research project is fully positioned within the qualitative paradigm, using an interpretative framework. This is traditionally a minority approach in construction management research, but is an important addition to the dominant positivist paradigm in order to "provide a rich and nuanced understanding of industry practice" (Dainty, 2008, p7). Many projects have been carried out that investigate aspects of BIM adoption, benefits, barriers, etc using quantitative analysis based on questionnaire surveys. Most of the surveys carried out by national and international organisations, as previously discussed, have used this approach, as have many academic researchers who have explored the subject. Such studies have focused on different international markets, for example in the UK (Eadie, Browne, Odeyinka, McKeown & McNiff, 2013), China (Xu, Feng & Li, 2014), USA (Becerik-Gerber & Rice, 2010); or in different market sectors or applications—for example, constructors (Ku & Taiebat, 2011), building owners (Giel & Issa, 2015), and design management (Elmualim & Gilder, 2014). All of these studies have contributed by measuring and documenting aspects of BIM implementation, but they do not explore the meaning and experiences that underpin the phenomena they record.

The current research instead takes a qualitative approach, which seeks to explore issues identified in those studies and delve into the experiences, motivations, challenges and preoccupations of individuals involved in practical and ongoing work around implementing BIM.

1.3.1 Research methods

To address the identified research questions and obtain a qualitative understanding of the development of BIM practice from the perspective of the practitioners involved, attention was given to the development of an appropriate research process. Four main research methods were used to obtain data across the project.

- The research topic was developed and refined through an initial review of the literature, which was later refined to focus specifically on the chosen aspects of practice and performance of BIM practitioners. The main source of literature was articles from journals, acquired through online databases and wider internet searches. Supplementary material was drawn from conference proceedings, books and reports.
- A structured document analysis was carried out on a range of BIM standards and handbooks in order to establish an understanding of formal descriptions of BIM roles, and determine the extent to which the practice of BIM specialisations was prescribed by industry specifications. These were obtained through internet searches and contributions from industry and academic contacts.
- Data related to the direct experience of BIM practitioners was gathered through two approaches, namely comparative case studies of two projects demonstrating emerging BIM practice, and an international explorative survey using in-depth qualitative interviews. These approaches were chosen because they offered the opportunity to obtain a rich picture of how BIM practice develops and matures, across a wide variety of settings.

These latter research methods and their manner of application are further detailed in the following sections.

1.3.1.1 Case study

A multiple case approach was used for the case study component of the research, based on two New Zealand projects of similar nature and location. In both cases, the clients had identified that they wanted a BIM approach but there were a number of key differences between the projects. Each had a different client and set of project participants. Project 1 included large national and multi-national companies, while the participants for Project 2 were mostly small and medium-sized enterprises (SMEs) but also included a large consultancy. Most of the participating companies on Project 1 had been involved in previous BIM implementations, though for several of the individuals it was their first experience. The team for Project 2 had less BIM experience; this was the first BIM project for almost all of the individuals involved. Project 1 was of considerable size and significance for the client, whereas Project 2 was a relatively minor extension to an existing building.

In essence, this was intended as a replication format, drawing on access to similar participants across both cases to collect aligned data. The case studies were proposed as exploratory in character, and set out to observe the implications of BIM adoption. Because of the degree of interactions between project participants, and the importance of the context in which the activity takes place (the construction project), case studies were considered an appropriate methodology to explore the ways in which BIM practitioners worked with process and technology to develop their practice, and the impact that BIM has on practitioners in traditional (non-BIM) roles.

Although the initial research intention was to follow Yin's (2014) recommendation that multiple sources of data be used, restrictions on access imposed by both project clients meant that this was not possible. Data collection was planned to include non-participant observation at project meetings, to see first-hand how BIM models and associated documentation were used in practice, and who was involved in using them; access to project documentation and models themselves, to evaluate the extent of BIM practice within the wider project framework; and interviews with key project participants. In the event, only the latter method was possible. In the construction projects identified for case study, each client representative was initially supportive of the research, but then vetoed the observation and document analysis components. The other participants in the construction projects were willing to make their documents available, and were open about meeting processes and discussion. However, the project clients expressed concerns around confidentiality and commercial sensitivity of their information, despite the evaluation and approval of the project by the University of Auckland Human Participants Ethics Committee (UAHPEC). Without the clients' consent, these forms of data were thus unavailable from any of the project participants. This resulted in the case studies being of far less significance in the research than initially planned. The clients did however give consent to interviews taking place with project representatives, and participated in interviews themselves, so a more limited form of case study was conducted based solely on interview data. The interviews were used to explore attitudes, expectations and experiences of key project participants, in relation to BIM practice on the projects.

Five participants were interviewed from Project 1, and six from Project 2, as shown in Table 2. A range of project documents were viewed as part of the interview process, though close scrutiny or analysis of the documents was not permitted, and they were solely used as talking points during the interviews.

Table 2 Roles of case study participants

Participant	Project 1	Project 2
Client–capital works		x
Client–operations	x	x
Project architect	x	x
Architect's BIM manager	x	
Architect's BIM manager/modeller		x
Services engineer	x	x
Construction site manager	x	
Construction BIM manager		x

1.3.1.2 International survey

The bulk of the research presented in this thesis is based on a qualitative survey of BIM practitioners currently involved in the construction industry, from a wide range of roles and disciplines. Practitioners from five countries were included. The intention behind the geographical diversity was to draw on experience from countries at different levels of BIM maturity (although their inclusion was also influenced by practical considerations of access to people and networks in those countries over the course of the project.) Maturity was judged by the criteria proposed by Kassem, Succar and Dawood (2013), essentially based on the number and nature of 'noteworthy BIM publications' (NBPs) for the various countries. NBPs are defined as "publicly-available industry documents incorporating guidelines, protocols and requirements focusing on BIM deliverables and workflows. These publications are the product of various governmental bodies, industry associations, communities of practice and research institutions, intended to facilitate BIM adoption, and realise BIM's value-adding potential" (Kassem et al., 2013, p6).

New Zealand was the starting point of the research, as previously described, and was considered to be a low-maturity BIM environment. At the time the project commenced, early work had been carried out on developing a BIM Handbook for the New Zealand construction industry, and two surveys of industry attitudes and progress towards BIM (Masterspec, 2012, 2013), but there was little or no formal development of BIM documentation or guidance.

Australia was selected for two reasons. As a near neighbour to New Zealand there is a considerable amount of shared knowledge and expertise between the two countries. For example, the developers of the Australian National BIM Guide (NATSPEC, 2016) were closely involved in initial drafts of the New Zealand BIM Handbook, and several large companies were developing expertise in BIM through trans-Tasman appointments where BIM specialists had a role in both the New Zealand and Australian operations. Australia was also recognised as a developing BIM market by Kassem et al. (2013) who identified seven NBPs for the Australian industry, so while higher on the BIM maturity scale it was still not a fully mature environment.

The United Kingdom was also an obvious choice. The UK has become an important source of information and inspiration for the BIM community internationally (Byrne, 2015). The UK Government's BIM Mandate set an ambitious target for Level 2 BIM to be used on all of their centrally procured projects. This required "fully collaborative 3D BIM (with all project and asset information, documentation and data being electronic)" (BIM Level 2, n.d.) by April 2016. An extensive infrastructure of advisory boards, standards, guidance documents, training and support was put in place by the government to achieve this goal. Additional effort came from industry bodies and commercial organisations wanting to capitalise on the momentum generated by the government initiative. The size and range of the UK BIM effort has seen it very quickly become a leading influence in BIM adoption worldwide.

The USA is a well-established BIM market, as documented by the McGraw Hill Construction surveys carried out there since 2007 (McGraw Hill Construction, 2012a). Kassem et al. (2013) documented a large number and variety of NBPs available to US BIM practitioners, and although there has not been any centralised requirement to use BIM, state governments and large federal clients have long-standing mandates for BIM use in their procurement requirements. As one of the perceived leaders in BIM and the source of many exemplar documents and projects, the USA was seen as a logical comparison for a mature market. The USA has a variety of regional and client-driven BIM initiatives, and an interesting point of difference is that the development of BIM has been more client-led than elsewhere (Kassem et al., 2015).

All three of the above construction markets share much in common with New Zealand, even beyond the shared language. The construction processes and technologies are similar, and common terminology assists in comparing progress and learning from each other. The Netherlands was added to the project as a country outside the traditional range of markets that New Zealand is compared with. While the widespread use of English made the people and processes accessible for this research, the perceived differences between the New Zealand and Dutch industry culture and approach provided an alternative view of BIM practice and practitioners. Dutch researchers and industry consortiums have been working on a variety of BIM initiatives for over 2 decades (van Nederveen, Beheshti & Willems, 2010), and in 2012 the Dutch Rijksgebouwendienst (Government Buildings Agency) instituted a BIM Standard ('BIM Norm', in Dutch) for use on selected government buildings. Although BIM adoption is not yet universal it appears to be well-accepted in the major design and construction companies (Sebastian & van Berlo, 2010), and is represented in various education programmes (Peterson, Hartmann, Fruchter & Fischer, 2011). The Netherlands was seen to be more active in BIM across a wider variety of disciplines than the New Zealand market, and to be undertaking tracking of progress and maturity (Sebastian & van Berlo, 2010).

Interviews were carried out in New Zealand and Australia in 2013/2014, and the Netherlands, UK and USA in 2015. The order of interviews was determined so that distinctions between the BIM maturity of the identified countries would not be attenuated by the time between interviews. It was anticipated that the lower maturity countries would progress quickly in their BIM adoption and development, so the interviews in the least mature markets were carried out first, progressing to the most mature as the final set of interviews.

1.3.2 Interview participants

The interviewees in the international survey included a range of industry participants who were identified as 'BIM specialists' by their peers. In the absence of an organised industry body that represents BIM specialists, a peer-esteem snowball sampling approach was adopted (Christopoulos, 2009). This involved approaching initial 'seed' contacts and questioning them about who they perceived as 'BIM specialists' in their discipline or wider industry networks. Those 'expert' BIM practitioners who were recommended by multiple seed contacts were then approached for interviews, and were also asked for their recommendations of other BIM specialists to contact. As part of the request to seed contacts, the following definition of *BIM specialist* was presented:

> A BIM specialist is a practitioner with a formal job description involving BIM (e.g., BIM manager, BIM coordinator), or one who is identified by their peers as the BIM champion or BIM leader in their company or discipline group.

Initial seed respondents in New Zealand were identified through academic and industry networks, and provided connections in New Zealand, Australia and the UK. In the Netherlands and the USA, academics working in the BIM field were approached and asked to provide introductions to seed contacts, and a similar approach followed in industry networks within those countries. The key people who received multiple referrals were the primary subjects for interviews, but a selection of less well-connected individuals was also interviewed to ensure that responses did not come from a single insider group or clique. The smaller network of contacts in the Netherlands and the USA resulted in a more traditional snowball sampling approach in identifying these respondents, with much fewer cross-referrals. A range of industry participants were included from a variety of disciplines and levels. The full list of interviewees, with job title and company type, is presented in Table 3. Where job titles are unique or easily identifiable, these have been changed to more generic titles, to ensure confidentiality of participants.

Table 3 Interview participants—job titles and affiliations

Identifier	Country	Job title	Company type
Interview 1	New Zealand	Engineer/Data Analyst	Owner/facilities management
Interview 2	New Zealand	CAD/BIM Manager (architecture)	Multi-disciplinary consultancy
Interview 3	New Zealand	BIM/CAD Manager	Architectural practice
Interview 4	New Zealand	CAD/BIM Manager	Architectural practice
Interview 5	New Zealand	BIM Manager	Documentation specialist
Interview 6	New Zealand	CAD & Revit Manager (structures)	Engineering consultancy
Interview 7	New Zealand	Revit/BIM Specialist (MEP)	Engineering consultancy
Interview 8	New Zealand	BIM Specialist	Engineering consultancy
Interview 9	New Zealand	Services Manager	Construction company
Interview 10	New Zealand	Construction Manager	Construction company
Interview 11	New Zealand	Quantity Surveyor	Quantity Surveying consultancy
Interview 12	New Zealand	Quantity Surveyor	Cost and planning consultancy
Interview 13	Australia	BIM Manager	Architectural practice

Identifier	Country	Job title	Company type
Interview 14	Australia	BIM Manager	Multi-disciplinary design practice
Interview 15	Australia	Facilities Manager	Property development and management company
Interview 16	Australia	BIM Development Manager	Multi-disciplinary consultancy
Interview 17	Australia	BIM Manager	Architectural practice
Interview 18	Australia	Architect	Architectural practice
Interview 19	Australia	BIM Consultant	BIM consultancy
Interview 20	Australia	Revit Manager	Architectural practice
Interview 21	Australia	BIM Leader	Engineering consultancy
Interview 22	Australia	Senior Draftsperson	Architectural practice
Interview 23	Australia	Director	Professional organisation
Interview 24	New Zealand	Architect	Architectural practice
Interview 25	New Zealand	Architect	Architectural practice
Interview 26	New Zealand	BIM Technician	Architectural practice
Interview 27	New Zealand	Project Director	Owner/property developer
Interview 28	New Zealand	Site Manager	Construction company
Interview 29	New Zealand	Director	Architectural practice
Interview 30	New Zealand	BIM Manager	Architectural practice
Interview 31	New Zealand	Project Manager	Project management consultancy
Interview 32	New Zealand	Director	Architectural practice
Interview 33	New Zealand	Director	Architectural practice
Interview 34	New Zealand	CAD/BIM Manager (MEP)	Engineering consultancy
Interview 35	New Zealand	Architect	Architectural practice
Interview 36	New Zealand	Senior Engineer (electrical)	Engineering consultancy
Interview 37	New Zealand	Technical Director (services)	Engineering consultancy
Interview 38	New Zealand	BIM Development Manager	Construction company
Interview 39	The Netherlands	BIM Program Director	Engineering and management consultancy
Interview 40	The Netherlands	BIM Manager	Construction company
Interview 41	The Netherlands	BIM Process Manager	Construction company
Interview 42	The Netherlands	Regional BIM Coordinator	Construction company
Interview 43	The Netherlands	BIM Process Manager	Construction company
Interview 44	The Netherlands	BIM Manager	Cost consultancy
Interview 45	The Netherlands	BIM Consultant	BIM consultancy
Interview 46	United Kingdom	BIM Director	Multi-disciplinary consultancy
Interview 47	United Kingdom	BIM Manager	Fit-out designer and manufacturer
Interview 48	United Kingdom	Design Manager	Construction company
Interview 49	United Kingdom	Capital Programme Manager	Client organisation
Interview 50	United Kingdom	Architect	Architectural practice
Interview 51	United Kingdom	BIM Director	Construction company
Interview 52	United Kingdom	Information Manager	BIM consultancy
Interview 53	United Kingdom	BIM Consultant	BIM consultancy

Identifier	Country	Job title	Company type
Interview 54	United Kingdom	Director	BIM consultancy
Interview 55	United Kingdom	Architect	Architectural practice
Interview 56	United Kingdom	BIM Specialist	Multi-disciplinary consultancy
Interview 57	United Kingdom	BIM Integrator	Construction company
Interview 58	United Kingdom	Senior BIM Manager	Cost and planning consultancy
Interview 59	The Netherlands	BIM Process Manager	Construction company
Interview 60	The Netherlands	Senior Project Manager	Project management consultancy
Interview 61	The Netherlands	BIM Consultant	BIM consultancy
Interview 62	The Netherlands	BIM Consultant	BIM consultancy
Interview 63	The Netherlands	BIM Specialist	Software company
Interview 64	United Kingdom	Technical Director	Multi-disciplinary consultancy
Interview 65	The Netherlands	BIM Manager	Construction company
Interview 66	The Netherlands	Director	Building information specialist
Interview 67	United States	BIM Program Manager	Multi-disciplinary consultancy
Interview 68	United States	Facilities Manager	Owner/facilities management
Interview 69	United States	Project Manager	Construction company
Interview 70	United States	Project Engineer	Construction company
Interview 71	United States	Integrated Construction Manager	Construction company
Interview 72	United States	VDC Manager	Construction company
Interview 73	United States	VDC Director	Multi-disciplinary consultancy

Participants represented 56 companies, from a range of company types. Most of the companies represented by these individuals were involved to some extent in ‘social BIM’, where collaboration and information exchange takes place within wider project teams. However, even within the companies that were considered leaders in BIM practice, this was not necessarily true across all of their projects. Many were also using ‘solo BIM’ where modelling, simulation and analysis are used to inform the decision-making within a single part of the design and construction process, usually because other project participants were unable or unwilling to share models and associated information. Hybrid implementations were common, where BIM processes were used in conjunction with traditional approaches.

The diversity of respondents allowed for an exploration of differences in BIM roles and performance expectations across a range of project and organisation types.

1.3.3 Narrative approach

The purpose of the interviews was to elicit rich data that could then be used to examine the development of BIM roles as a professional endeavour, and explore perspectives of BIM practice and practitioners. Within the sphere of qualitative construction management research, the dominance of interviews as a research method has previously attracted criticism (Dainty, 2008). However, Phua (2013) defends semi-structured interviews as a dominant approach for individual-level research within construction management, arguing that it is an appropriate and productive method for conducting research related to the role and professional environment of construction practitioners. Clandinin and Connelly (2000) argue that to study experience in a professional context, a narrative approach is pertinent since narrative is central to how practitioners reflect on experience and relate it to practice. Czarniawska (2004) goes further, asserting that professional and organisational narratives are the enactment of experience, and actions gain meaning through being expressed in a narrative. The key criticisms of interviews as a research method, as related by Dainty (2008), are that what interviewees say is not necessarily truthful but is influenced by how they desire to present themselves, and so what they say may not correspond with what they do. In a narrative approach, this concern has less weight, since the act as recounted through narrative is considered part of the practitioner's reflection or interpretation of their practice.

The majority of interviews were loosely-structured and participant-led (Alvesson, 2011). They follow a narrative approach that covered the range of issues identified by the interviewer, but in the sequence and depth that followed the interests or concerns of the interviewee. Open questions and prompts included a range of topics, including industry background, skills development, practice and project-based responsibilities and roles, industry networks and relationships, career trajectory, and attitudes and expectations. Table 4 identifies the main sections and example topics covered in the interviews. Interviews were typically one to one-and-a-half hours in length, and the majority were conducted in private meeting rooms at the participant's workplace.

As emphasised by Alvesson (2011), the value of using loosely structured interviews is that they provide a framework so that specific issues can be addressed, but have the flexibility to allow in-depth exploration of the interviewees' varied opinions and experiences. A small minority of participants were unwilling to engage with a more narrative approach and so the topic framework was used in a more structured fashion to elicit responses. This challenge in eliciting narratives is addressed by Czarniawska (2004), who notes that despite such difficulties, even minimalist research interviews include an element of improvisation that goes beyond formal representations of data. Bruner (1991) states that 'narrative accrual' is one of the key aspects of narratives, in that each narrative adds to the

Table 4 Interview framework

Section	Topics and prompts
Organisational context	Organisation type Organisation size Organisation interests & project involvement Organisation hierarchy/structure
Current role	Job title Role within company (reporting structure) Balance of project vs overhead role
Responsibilities	Job description Project activities Process development Strategy and oversight Training others
Training and background	Formal education Vocational/professional training Skill set Areas of interest/expertise, e.g., software, design, management Motivators
Career path	Entry into the industry/role Progression since entering the industry Expectations/aspirations Role models or leaders
Networking and relationships	Networking and relationships Sources of information

listener's understanding in the context of wider experience. The stories that are told can be seen to delineate the various positions and perspectives taken by participants as the narrator or as a character in the narrative, or both. As such, exploring the various narratives told by BIM practitioners allows an examination of what stories are being told around the wider BIM experience, and how these impact on the roles of the specialists and other characters and narrators involved in the process. Individual experience can thus be aggregated to a broader narrative of professional agency and experience.

All interviews were recorded and transcribed. In the first stage of the transcription process, verbatim transcripts were produced. These were then edited to remove hesitations, repetition and other features of speech which interfered with the narrative flow of the transcript, and to withhold identifying elements such as names of individuals, companies and projects, and any very specific descriptions of background or activity that would serve to identify the participant. Respondent validation of the transcripts was sought, where participants were provided with a copy of their edited transcript following their interview. Lincoln and Guba (1985) explain the value of member-checking to verify that the data was received and interpreted correctly. As well as a check on the accuracy of the interview data, this was a requirement of ethics approval, because of the potential for commercial sensitivity of the material discussed in the interviews. Participants had the opportunity to remove information that they considered to identify them personally, or the company or projects they have been employed in, or where they felt they had disclosed information that had commercial impact. Very few participants considered that the transcripts required further editing, and this process resulted in only minor editing of the transcripts.

1.3.4 Thematic analysis

As previously described, the data presented here is diverse, representing 73 individuals across five countries and 56 companies from multiple disciplines and company types that varied widely in type and size. This thesis does not claim that the findings are generalizable to the industry as a whole, and no attempt has been made to quantify the various positions and findings as representative of a particular type of role, industry discipline, or national characteristic. Instead, the goal of this thesis is to identify and describe experiences and influences that have affected the practice of BIM and the development of the roles of BIM practitioners in a variety of different contexts and circumstances, and explore the potential implications of these on the BIM adoption and implementation process.

Thematic analysis was used as the primary approach for analysis of the interview data, based on the methodology outlined by Braun and Clarke (2006). Thematic analysis involves "searching across a data set …to find repeated patterns of meaning" (Braun & Clarke, 2006; p86), and involves an inductive coding process to identify and refine themes. The preliminary activity involved transcribing and editing the interview recordings, as previously described. Initial codes were assigned to features within the data that were related to the research questions and sub-questions. Structural coding was used at this stage, based on the research questions and interview framework (Saldaña, 2013). Several iterations through the data were required to code and collate the entire data, in a process that progressively served to develop a research 'storyline' (Stuckey, 2015). Once codes had been assigned to all of the data, each category was revisited, and broader patterns of action and interaction were identified. At this stage, the themes were reviewed to ensure they were clear and distinctive, and the connection to the storyline was established. This required a further iterative process of revisiting themes and reviewing in the wider context of the full data set. Re-coding and revising data was then carried out to refine the themes, and a process took place to define and label the themes and subthemes both individually and in relation to the other themes. Finally, the final analysis was structured and written up. Representative quotes from the interviews have been used throughout the write-up to illustrate the experiences and opinions expressed by participants, in order to connect the data into a theorised storyline (Golden-Biddle & Locke 2007). In this way, the narratives of the participants are woven together into an analytic narrative that connects with the wider BIM literature.

The overall approach to analysis was framed from the perspective that narratives do not simply represent a description of experience or events, but provide a dynamic process whereby narrators create an interpretation of their experience to make sense of their world in relation to the context of the narrative (Czarniawska, 2004). As such, it must be recognised that the expressed objective of the interviews ('investigating the impact of BIM on roles and relationships in the AEC industry') will have influenced the way that participants have shaped their narratives. A different interviewer, or a different interview objective, would have delivered a different set of narratives from the same participants. Nevertheless, the data provides a view of the experiences and perceptions of these BIM practitioners that allows consideration of relevant issues and concerns that are current in the AEC environment.

1.3.5 Ethical considerations

This research study was conducted with ethics approval obtained from the University of Auckland Human Participants Ethics Committee on 23 October 2013, with the reference number 10039. The ethics approval letter for this research, and subsequent approvals for amendments, are included in Appendix A. The central requirement of the ethics approval was that for each interview, the participant and a management representative from their company were provided with a Participant Information Sheet (PIS) describing the nature and objectives of the research study and the process of data collection; and a Consent Form (CF), to be signed by the participant and a management representative from their company, in agreement to the terms stated in the PIS. Samples of the PIS and CF used for each stage of this study are also included in Appendix A. Approval was sought and granted to allow minor modifications to the original PIS and CF documents to allow interviews via Skype or similar media as required.

1.4 Thesis organisation

As a thesis with publications, this thesis follows the framework provided in the University of Auckland 2011 Statute and includes published and unpublished research papers. All the papers included were conducted under supervision for this degree, and were written by the candidate as lead author. In order to present the thesis in a consistent format, as the statute requires, some deviations have been made from the published form of each paper, and additional commentary has been added where required. Given that several of the chapters were written for independent publication, a degree of redundancy, particularly of the project description, was inevitable. Wherever these sections are not necessary for the flow of the argument of each paper, they have been removed or modified. As a result, each included paper varies to some extent from the versions submitted for publication, as permitted in Guideline 4 of the Statute. However, Chapters 2 to 9 still contain some degree of repetition, particularly in the introduction and methodology sections, where the structure of the papers requires the published description or some part of it to be retained.

Table 5 Contributing publications

Chapter	**Reference**
Chapter 3	Davies, K., Wilkinson, S. and McMeel, D. (2017) A review of specialist role definitions in BIM guides and standards, *Journal of IT in Construction (ITcon),* 22, 185-203. Retrieved from http://www.itcon.org/2017/10
Chapter 4	Davies K., Wilkinson S., and McMeel D. (2017). Baby steps with BIM – learning to walk the talk. In *LC3 2017: Volume 1 – Proceedings of the Joint Conference on Computing in Construction (JC3)*, July 4-7, 2017, Heraklion, Greece, pp. 399-406. doi:10.24928/JC3-2017/0253
Chapter 5	Davies, K., McMeel, D. and Wilkinson, S. (2017) Making friends with Frankenstein: Hybrid practice in BIM. *Engineering, Construction and Architectural Management, 24*(1), 78-93. doi:10.1108/ECAM-04-2015-0061
Chapter 8	Davies, K., McMeel, D. & Wilkinson, S. (2015). Soft skills requirements in a BIM project team, In J. Beetz, L. van Berlo, T. Hartmann, & R. Amor (Eds.) *Proceedings of the 32nd CIB W78 Conference 2015*, Eindhoven, The Netherlands. pp 108-117. Retrieved from http://itc.scix.net/cgi-bin/works/Show?w78-2015-paper-011
Chapter 9	Davies, K., Wilkinson, S. and McMeel, D. (2017) Approaches and attitudes to BIM certification and credentialing. Submitted to *Professional Issues in Engineering Education and Practice* (under review)

A chapter summary has been provided before each chapter to help connect individual chapters into a coherent whole, and to identify the source publication of each, where applicable. Table 5 presents chapter titles with associated articles and manuscripts.

Two additional conference papers produced during the course of the project were also used to help refine key ideas and develop the chapters and papers presented in this thesis, but are not included as individual chapters. These are given in Table 6.

Table 6 Additional publications

Reference	Contribution
Davies, K., McMeel, D., and Wilkinson, S. (2013). Mapping roles in an altered landscape – the impact of BIM on designer-constructor relationships. In Z. Ma, J. Zhang, Z. Hu, & H. Guo (Eds.) *Proceedings of the 30th CIB W78 International Conference* (pp89-98). WQBook, Beijing, China. Retrieved from http://itc.scix.net/cgi-bin/works/Show?w78-2013-paper-45	Chapter 2 – BIM roles Chapter 3 – role definitions
Davies, K., McMeel, D., & Wilkinson, S. (2014). Practice vs. prescription—An examination of the defined roles in the NZ BIM Handbook. *Computing in Civil and Building Engineering*, 33-40. doi:10.1061/9780784413616.005	Chapter 3 – role definitions

The structure of the thesis is as follows:

Part 1 provides an observational perspective to the research question, in an attempt to define the role(s) of the BIM professional, and what impact the evolution of BIM has had within the construction industry.

- Chapters 2 and 3 are intended to address sub-question 1, and as such are an examination of the various definitions and understandings of the spheres of responsibility of BIM practitioners. Both chapters consider the development and characteristics of BIM specialist roles from the perspective of published information. This includes a critical review of construction management literature, presented in Chapter 2, and an analysis of a selection of the many BIM guides and handbooks that have been developed internationally, in Chapter 3.
- Chapters 4 and 5 move from literature into an examination of practice. Both chapters address sub-question 2, with perspectives of the role and influence of BIM practitioners on BIM adoption and implementation. Chapter 4 presents two case studies of emerging BIM practice in the New Zealand context, while Chapter 5 is an exploration of the phenomenon of hybrid BIM practice as described by many of the

BIM practitioners interviewed. Both chapters describe an environment of BIM use that is less structured and defined than is commonly represented in literature.

Part 2 takes a more discursive approach to the research question, and interprets the impact of BIM, firstly from the participants' personal perspectives. From this personal level, the professional environment of BIM practice and BIM careers is examined, to develop an understanding of the interactions between BIM practitioners and their wider industry context. As the research progressed, initial assumptions about the 'BIM trajectory' of the industry were challenged, and accounts provided by participants described BIM practice as a far more idiosyncratic and 'messy' process than the structured progression presented in literature and industry commentary. It became evident that BIM professionals' roles cannot be summed up solely in terms of activities and skills, but encompass personal and social interpretations. Hence the attempt to deliver a more nuanced discussion of impacts of BIM identity in this part of the thesis.

- Chapter 6 focuses on the BIM identity of participants, the characteristics they express and how they perceive themselves as BIM practitioners in the context of personal, professional and industry expectations and transformation.
- Chapter 7 also explores the impact of BIM practitioners' identity on their practice, looking at performance of BIM roles within projects, organisations and the industry.
- Chapter 8 provides a synthesis of the preceding discussions through an examination of BIM roles from a career perspective. Factors such as vocational choice and career development are considered, and a professional life cycle model is used to consider BIM adoption and implementation from a role development perspective, to explore the progression of professional maturity and the associated challenges for practitioners.
- Chapter 9 expands on the view of BIM as a career choice, and examines the current environment of certification and credentialing. Insights drawn from the exploration of practitioners' personal experience are applied back to the wider industry context.

Part 3 of the thesis presents the research conclusions, and so Chapter 10 returns to the original research questions to present the conclusions of the thesis, discussing answers to the questions posed and exploring where and how definitive answers were able to be obtained. The limitations of the research are described, and some consideration of future research directions is also included, together with a reflection on the research and analysis process. The research indicates that although there is no consensus on what it means to be a BIM professional, BIM practitioner roles are necessary and well-established in current practice. BIM practice offers both frustration and enjoyment for those involved. The BIM context is still evolving, providing challenges for organisations and industry bodies to appropriately define and support BIM roles.

Part 1

2 Practicing BIM: A critical review of the literature

Chapter summary

In Chapter 2 I present a critical review of recent literature on the role of the BIM practitioner in BIM adoption and implementation. This explores the various descriptions and definitions of BIM roles which have been presented in published case studies, surveys and other explorations of practice. I focus on the challenges that the literature suggests are faced by BIM practitioners in establishing BIM practice. I also examine the limited literature which considers the personal drivers, interests and other characteristics of the people who take BIM theory and put it into practice.

2.1 Introduction

The introduction of BIM in organisations and projects has required practitioners to take on new roles and responsibilities in the BIM process. As BIM practice has increased and evolved, the need for BIM practitioners has become more significant, and it is becoming more and more a specialist role. BIM professionals, construction professionals working in the BIM space, technology and implementation specialists: the multiple roles are evident in practice. This review examines the literature, particularly case studies reporting BIM implementation, but also surveys and other discussion, to identify research which has addressed BIM roles, responsibilities and relationships, and the various ways in which BIM practitioners operate.

2.1.1 Distinguishing between practitioner and practice

Differentiating between the functions and outcomes of a particular activity (practice), and the characteristics and performance of the individuals carrying out the activity (practitioner) may at first glance seem an overly fine distinction, since practice only occurs because of the actions of the practitioner. However, distinguishing between BIM practice and the BIM practitioner can offer insight into the ways in which BIM is changing the construction industry, at a more granular level than the project or organisational perspective can show. Concentrating on the *practitioner* moves the focus to the impact of BIM on the individual, and vice versa, whereas BIM *practice* frames the discussion around process and outcomes. It is widely recognised that, "BIM is about people and process as much as it is about technology" (SEC Group/NSCC BIM Working Group, 2013, p11), but most of the information around BIM adoption and implementation tends to focus on the technology first, process second, and assumes that the aspects related to people—roles, responsibilities, relationships and skills—will fall into place as a result (He, Wang, Luo, Shi, Xie & Meng, 2017).

2.1.2 Reviews of BIM literature

While it is common for research publications to include some form of literature review, at least 21 publications in the past decade have consisted largely or entirely of an in-depth review of BIM literature. Table 7 summarises these reviews in terms of their domain and scope. Most address specific topics or applications of BIM, with a few taking a more global perspective of the entire BIM field. This focus on the literature is to be expected in a rapidly developing field—as a topic matures, the amount of relevant literature increases correspondingly, and serves as an indication of the progress and development in the knowledge-base of the topic. The availability of literature on BIM topics is evident, with reviews finding between 11 and 975 relevant sources for analysis, depending on the narrowness of the frame of interest.

Table 7 BIM-related literature reviews

Year	Authors	Domain	Approach/scope
2011	Cerovsek	Technological development of BIM tools and standards.	Qualitative review of literature and software using a multi-standpoint framework
2011	Olatunji	Implications of BIM for legal frameworks and e-business models.	Qualitative review using a thematic analysis
2012	Merschbrock & Munkvold	BIM from an information systems and construction informatics perspective.	Systematic review with quantitative and qualitative (thematic) analysis; 264 journal articles from Scopus database; search terms "BIM," "3D Modeling," "VDC," and "ICT
2012	Zhou, Whyte & Sacks	Impact of BIM (as one element in a range of digital initiatives) on construction safety	Qualitative review using thematic analysis
2014	Volk, Stengel & Schultmann	Use of BIM in existing buildings with focus on maintenance and deconstruction	Systematic review with quantitative and qualitative (thematic) analysis; 184 articles; search keywords "BIM", "building (information) model", "existing buildings", "maintenance", "facility management", "retrofit" and "deconstruction"
2014	Wong, Wang, Li, Chan & Li	Integration of BIM with cloud computing technology	Qualitative review using thematic analysis; 30 publications.
2015	Bu, Shen, Anumba, Wong & Liang	Green retrofit design for commercial buildings	Qualitative review using thematic analysis; 21 articles
2015	Chen, Lu, Peng, Rowlinson & Huang	Connecting BIM information with physical building processes	Qualitative review using thematic analysis; 75 papers across 6 journals; search terms 'BIM', 'virtual design and construction (VDC)', "as-built" model, 'virtual model'
2015	Ilter & Ergen	BIM use in building renovation, retrofitting, refurbishment and maintenance	Systematic review with quantitative and qualitative (thematic) analysis; 24 articles from academic databases; search terms "BIM" or "building information model*" and "retrofit*" or "refurbish*" or "renovat*" or "maintenance" or "facilit*" or "post-occupancy"
2015	Wong & Zhou	BIM for environmental sustainability monitoring and management	Qualitative review, categorised according to key stages of building development. 84 articles from Scopus database, published between 2004 and 2014; search terms 'green building information modelling', 'building environmental sustainability', 'building environment design', '(whole) building energy simulation' 'energy performance analysis'
2015	Yalcinkaya & Singh	Analysis broken down into twelve principal research areas and ninety research themes.	Quantitative review using Latent Semantic Analysis; 975 abstracts from journals and conference papers; search terms "building information modeling", "bim" AND "building", "bim" AND "information modeling"

Table 7 BIM-related literature reviews (continued)

Year	Authors	Domain	Approach/scope
2016	Abdirad & Dossick	Integration of BIM into architecture, engineering, and construction education	Systematic review with quantitative and qualitative (thematic) analysis; 59 papers from selected academic databases; keywords “BIM” and “curriculum,”
2016	Bradley, Li, Lark & Dunn	Application of BIM to the infrastructure sector	Systematic review with quantitative and qualitative (thematic) analysis; 259 sources from 4 academic databases; search terms ((BIM OR Building Information Modelling) AND (Infrastructure OR Construction))
2017	Chong, Lee & Wang	BIM for environmental sustainability	Systematic review with quantitative and qualitative (thematic) analysis; 36 BIM standards and guidelines and 91 academic publications; search terms “BIM sustainability,” “BIM LCA,” and “green BIM.”
2017	He, Wang, Luo, Shi, Xie & Meng	Managerial issues in BIM adoption and implementation	Systematic review with quantitative and qualitative (thematic) analysis; 126 papers published between 2007 and 2015, sourced from Scopus and Web of Science databases; search terms (“BIM” OR “building information modeling” OR “building information modelling” OR “building information model” OR “virtual design and construction” OR “VDC” OR “as-built model” OR “virtual model”) AND (“management” OR “managerial” OR “managing” OR “manage”)
2017	Oraee, Hosseini, Papadonikolaki, Palliyaguru & Arashpour	Collaboration in BIM-based construction networks	Systematic review with quantitative analysis of 1031 papers and qualitative (thematic) analysis of 62 papers, published between 2006 and 2016.
2017	Santos, Costa & Grilo	BIM-related literature published between 2005 and 2015	Systematic review with quantitative analysis of 381 papers from journals with Impact Factor higher than 1.0; keywords “BIM”; “Building Information Modelling”; “Building Information Modeling”; “Building Information Model”
2017	Soust-Verdaguer, Llatas & García-Martínez	Use of BIM for life cycle analysis	Qualitative analysis of 11 case study papers from selected sources in the past 5 years
2017	Sun, Jiang, Skibniewski, Man & Shen	Factors limiting BIM application	Qualitative analysis based on 5 categories; search terms “Building Information Modeling” or “BIM” or “Building Information Model” or “Virtual Design and Construction” or “4D” or “nD” AND “barrier”, “inhibit”, “drawback”, “obstacle”, “flaw”, or “impediment”
2017	Zou, Kiviniemi & Jones	Risk management using BIM	Qualitative analysis based on 5 categories; keywords “BIM”, “building information model”, “risk”, “risk assessment”, “risk analysis”, “risk management”, “knowledge management”, “safety”, “quality”, “time”, “cost”, and “budget”.
2017	Zhao	Co-author, co-word and co-citation analysis of BIM publications	Quantitative (scientometric) analysis; 614 articles from Web of Science database, published between 2005–2016. Search terms (building information model* AND BIM*

Five of the reviews explicitly address topics that can be considered ‘people factors’ in their stated area of interest. Olatunji (2011) reviews legal aspects of BIM practice, which includes issues such as professional responsibilities and duty of care. Abdirad and Dossick (2016) is concerned with educational frameworks for BIM, He et al. (2017) reviews managerial areas of BIM, while Oraee, Hosseini, Papadonikolaki, Palliyaguru & Arashpour (2017) reviews the collaboration aspect of BIM. Sun, Jiang, Skibniewski, Man & Shen (2017) includes personnel and management factors as two of five categories of factors limiting the application of BIM. A further 3 reviews provide an overview of the BIM literature, using different methodologies to document the body of knowledge available regarding BIM. However, of these only Yalcinkaya and Singh (2015) identifies social or cultural factors in the themes identified whereas Santos, Costa and Grilo (2017) and Zhao (2017) is highly technology-oriented. Furthermore, both He et al. (2017) and Oraee et al. (2017) observe that BIM literature is strongly slanted towards technological issues, even within their specific interest areas that might be expected to focus on more people-oriented aspects. For example, where communication or collaboration is discussed, it tends to be presented from the perspective of applicable technologies or processes rather than from a practitioner-centric view. Such comments further confirm that the roles and influence of the practitioners driving adoption and implementation of BIM has been largely overlooked. This review seeks to rectify that omission, and examines the literature to identify research which has addressed BIM roles, responsibilities and relationships, and the various ways in which BIM practitioners operate.

2.1.3 Literature search process

A structured search was undertaken of the core databases in the construction discipline, including ASCE Library, Elsevier ScienceDirect, Emerald Insight and Taylor & Francis Online. The open source Journal of IT in Construction (ITcon) was also included specifically as it is not indexed in the other databases, but publishes BIM-related research. A set of terms related to BIM roles was used, of the form ("*BIM role*" OR "*VDC role*"). The top three role descriptors identified by Uhm, Lee and Jeon (2017) in a review of BIM-related job listings have been included, namely *BIM/VDC manager*, *BIM/VDC coordinator* and *BIM/VDC engineer*. A range of more generic roles associated with BIM or VDC have also been included, drawn from a preliminary consideration of BIM literature, i.e., *BIM/VDC expert*, *BIM/VDC specialist*, *BIM/VDC professional*, *BIM/VDC champion*. The term *BIM practitioner*, although not currently in common use, has been included because it is the term chosen for this thesis to refer to the variety of people and roles involved in BIM practice. The initial search resulted in 244 sources that use one or more of these terms, as shown in Table 8.

Many of the papers found through this approach use the titles of BIM manager or BIM professional simply to refer to participants' roles in a survey or case study project, with no specific consideration of what the role entails. Similarly, in a few papers, the search terms came up because of the author's affiliation or job title, and not because of the content of the paper. Such references demonstrate how prevalent the terms have become, but do not add to a discussion of the detail of the roles.

Table 8 Literature search results for BIM roles

Search term	Source	ASCE Library	Elsevier Science Direct	Emerald Insight	Taylor & Francis Online	ITcon	
BIM or VDC	manager	40	37	7	23	10	
	coordinator	20	23	4	14	2	
	engineer	16	10	0	7	1	
	expert	11	30	1	4	2	
	specialist	10	12	1	1	2	
	professional	8	12	3	1	1	
	champion	8	0	2	3	2	
	practitioner	1	0	0	1	0	
	Total	74	96	15	42	17	244

Given that the examination of previous reviews identified a lack of practitioner-centred material through traditional search approaches and sources, this formal search approach was supplemented by a more organic search process using the references in these studies as the starting point to find other relevant publications.

2.2 The role of the BIM practitioner

The concept that BIM practice requires the institution of new roles for it to function successfully is relatively new. Although BIM in some form has been developing within the industry for the better part of four decades (Eastman, 1992), and building information modelling became an established term in the early 2000s, reference to specific roles for BIM adoption is much more recent. The earliest formal description of a BIM manager role was provided in 2006 by the US Army Corps of Engineers (Brucker et al., 2006), although the term had been in industry use prior to that, as evidenced by one of the contributing authors of that report, Mr. Brian Huston, being identified as a BIM Manager (p.*v*). Since then, the title of BIM manager and a range of associated BIM roles have become more prevalent in industry usage and in the research literature, to the current situation where Uhm et al. (2017) identified 242 BIM-related online job postings collected from the US, UK, and China in a 3-month period. These included 35 different job titles related to BIM or VDC. In the research literature, a similar increase in acceptance of BIM roles is apparent. Figure 2 illustrates the occurrence of terms relating to BIM roles, as identified from the 244 sources resulting from the literature search. This shows the steady increase from occasional use before 2010, to widespread use just 7 years later.

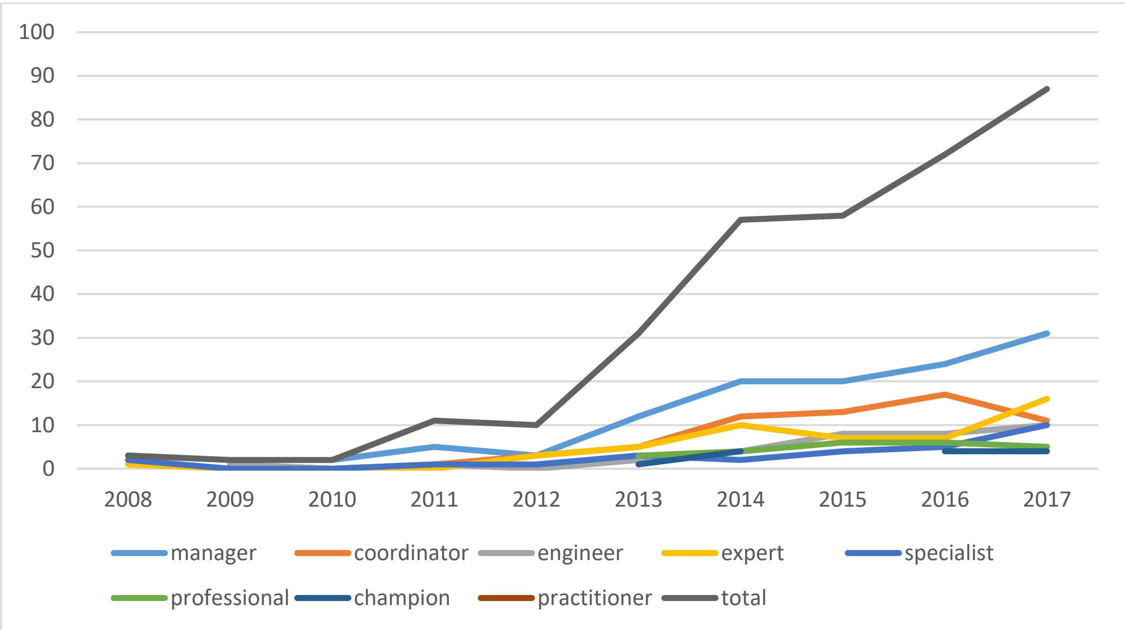

Figure 2 Frequency of reference to BIM roles, by year

2.2.1 Scope of BIM roles

Many commentators have asserted the need for new roles in organisations and project teams as a result of BIM adoption (e.g., Gu & London, 2010; Porwal & Hewage, 2013; Uddin & Khanzode, 2014). Initially, these BIM specialists were identified as necessary for the transition period, to support organisations moving from traditional ways of working into the "new paradigm" of BIM (Aranda-Mena, Crawford, Chevez & Froese, 2009). However, the need for professionals who have specific BIM skills has continued beyond this introductory stage. Turk (2016) contends that BIM creates greater specialisation in the industry, and thus more specialised knowledge and roles become necessary as BIM becomes embedded in industry practice. Eynon (2011) and Rekola, Kojima & Mäkeläinen (2010) suggest that the emergence of the role is in response to the increasing complexity of building design and construction. Both arguments are supported by the observation that as BIM has become more well-established, it has become correspondingly more expected that BIM practitioners will be present in the process (Ku & Taiebat, 2011). In a survey of the Swedish construction industry, Gustafsson, Gluch, Gunnemark, Heinke, & Engström (2015) found that while VDC professionals are relatively rare in that market at present, there was strong support that they would be more involved in projects in the future. The majority of the respondents considered that VDC professional roles currently have, and will continue to have, a high level of significance in the success of a project. The rise of BIM professional roles has created new career paths within the construction industry, that did not exist even a decade ago (Uddin & Khanzode, 2014).

The most commonly identified BIM role, both in literature and in job postings, is that of BIM Manager. As previously noted, the US Army Corps of Engineers provided a seminal description of the BIM Manager role in 2006, and identified this individual as a critical staff member (Brucker et al., 2006). Other roles described in the literature are the BIM Coordinator (e.g, Ahn, Kwak & Suk, 2016; Eynon, 2011), BIM Modeller and BIM Engineer (Gu & London, 2010), while the more generic descriptors of BIM expert, BIM specialist and BIM professional are all well-recognised.

2.2.2 Relationship to traditional roles

BIM practice is of course not limited to specialist BIM practitioners. It has become common in more advanced implementation environments for BIM to be used in some way by construction professionals throughout the project team (Lucas, 2016). Awareness and expertise in BIM is seen as adding value to the career of any industry participant (Uddin & Khanzode, 2014), although changes to traditional roles have been widely observed. The effects of BIM are not all beneficial, however; nor do they appear consistent across all scenarios. To take the architect's role as an example, in many environments architects appear to have led the way in BIM implementation (Azhar, 2011; Cao et al., 2015), with some observers suggesting that the BIM process allows the role of the architect to be re-evaluated (Forgues & Lejeune, 2015). Related views are that the architect becomes more central to the project communication process in a BIM project (Papadonikolaki & Wamelink, 2017), and that BIM provides an opportunity for the architect to reclaim a pivotal project role that has been eroded over recent years (Burr & Jones, 2010; Deamer, 2014). For other aspects of the architect's role, however, the changes introduced with BIM may be negative; for instance, many have argued that designers' creativity may be reduced by a shift in focus to production when using BIM, rather than their traditional emphasis on generation of ideas (Ambrose, 2012; Coates et al., 2010; Turk, 2016).

Other commentators place the design manager in the central BIM role (Emmitt, 2016; Eynon, 2011; Elmualim & Gilder, 2014). As a role in which coordination is traditionally a prominent part, the integration and coordination elements of the BIM process align well with a design management function. However, as with the architect, there are tradeoffs in that BIM introduces additional tasks that are not part of the design manager's remit, and conversely the expected scope of the design manager's role goes beyond purely BIM-oriented tasks. The same arguments can be made for the positioning of the traditional project manager as a central BIM role. Although seen by some as an appropriate combination because of the involvement of both roles in management and decision making (Rokooei, 2015), others sound a note of warning that each role requires skills and responsibilities that are outside the usual expectations of the other (Liu, van Nederveen & Hertogh, 2017; Rahman, Alsafouri, Tang & Ayer, 2016). Combining both into one role would therefore require an extended skill set, and challenge the ability of one person to manage the full range of responsibilities appropriately.

Even where traditional industry participants do not take on specific BIM functions, the process change involved in BIM adoption also has an impact on how they develop. Merschbrock and Munkvold (2015) emphasise the collaboration and communication aspect of BIM and its impact on design roles, indicating that the increased transparency of the process, and ability to more clearly articulate the design, results in better relationships between the members of the design team. Similarly, Gustavsson (2015) describes a BIM environment that facilitates a collaborative approach and promotes greater sharing of information, which thus increases trust both within and between project organisations. Other changes have been identified to traditional roles, for example Porwal and Hewage (2013) noted that steel detailers became more involved in the design process within a BIM framework, reducing the traditional role of the structural engineer. Sebastian (2011) suggests that the project manager's role may be threatened where parallel roles are introduced specifically for BIM processes.

Gustavsson (2015) indicates that like many other construction industry roles, the BIM manager role is not essential throughout a project, but is important for particular stages. Papadonikolaki, Verbraeck and Wamelink (2017) take a different perspective, demonstrating that the role continues throughout the project, but can be taken by different actors at different stages, for example by the architect during the design stage, and handed on to the contractor during construction. Potentially the role could then pass to a facilities management representative in the project handover process.

2.2.3 The role of the BIM champion

The need to have key individuals ready and willing to take on the role of change agents, champions or innovation leaders is a long-established principle in innovation management (Nam & Tatum, 1997). The construction industry is no exception to this rule, and the impact of such individuals in establishing an appropriate environment for wider acceptance of innovation has been explored in a variety of contexts, including in introducing new construction techniques (Winch, 1998; Gambatese & Hallowell, 2011), lean construction (Pekuri, Herrala, Aapaoja & Haapasalo, 2012), sustainability (Qi, Shen, Zeng & Jorge, 2010) and ICT (Peansupap & Walker, 2006). Similarly, the role of the champion in successful BIM adoption and implementation has been noted (Holzer, 2015). Bosch-Sijtsema, Isaksson, Lennartsson and Linderoth (2017, p11) identified that "the main driving forces [in BIM adoption] were primarily driven by the subjective positive or negative evaluation of BIM by individuals", suggesting that adoption processes would benefit significantly by the presence of a BIM champion to generate a positive view of the move to BIM, and Xu et al. (2014) demonstrated that the presence of staff proficient and experienced in BIM (such as a BIM champion) increase the perception of ease of use of the required technologies for other staff.

While there is widespread recognition that successful BIM adoption and implementation at either a project or organisation level requires the involvement of a BIM champion, there is disagreement about whether that should be a BIM expert operating at a practical, hands-on level, or a BIM enthusiast who may not have the direct BIM knowledge but has a more senior role and can provide endorsement at a management level for the BIM team and its endeavours. According to Azzouz and Hill (2017, p53), "a BIM Champion should be a person who has the technical skills, theoretical knowledge and the motivation to lead and guide teams in improving their BIM implementation." This view of the BIM champion as someone with the technical competence required to create and use a BIM model is also supported by Davies and Harty (2013) and Xu et al. (2014). However, Davies and Harty (2013) also noted that the project had to have the support of more senior staff in order to gain necessary approvals as well as access to resources. Ho and Rajabifard (2016, p5) placed this senior person in the role of BIM champion, with the statement that “champions should be at a sufficiently senior position within the organisation to effect change.”

2.3 Challenges to the BIM role

BIM specialists, or those moving into BIM practitioner roles, face challenges associated with the perception and position of such roles by the wider industry, as well as more structural challenges to do with the resourcing and management of their roles. Some of these are the result of a lack of knowledge or understanding about the changes that BIM imposes on practice, or from undefined expectations around the roles involved.

2.3.1 IT, CAD and BIM

The relationship of Information Technology, CAD and BIM roles is an area that has both perception and structural implications. Because BIM is widely perceived as a technology function, it is not uncommon for IT managers to be expected to maintain a level of control over the implementation and operation process of BIM. Traditionally, IT functions have operated quite separately from the construction domain, and IT specialists were able to focus purely on the computing solutions required by the company or project organisation. The introduction of BIM entails integration between the technology and the construction process, so requires practitioners involved to bridge both domains (Kokkonen & Alin, 2016). Expecting IT managers to take responsibility for achieving the necessary process and workflow changes is unrealistic (Love, Matthews, Simpson, Hill & Olatunji, 2014). However, in some instances, IT managers may try to retain authority over the area despite the involvement of BIM practitioners who are involved in the construction process. Davies and Harty (2013) describe such a scenario, where the project teams were required to circumvent the authority of the IT management in order to adapt the BIM implementation in a way that allowed them to achieve their project goals.

It is also common for CAD managers and operators to move into BIM roles as a company transitions to BIM. The introduction of BIM has been presented to many companies as simply an upgrade in the drawing production process from CAD to BIM. For these projects, the ‘BIM team’, while described as a new function, is effectively an upskilled version of the CAD operators or manual draftsmen from pre-BIM project delivery (Fox, 2014). This may be a challenge for BIM development because the skill sets do not necessarily align (Holzer, 2016). It has also been noted that users with a high level of CAD proficiency can also be resistant to change, because BIM poses a threat to their area of expertise and authority (Barison & Santos, 2010).

2.3.2 Lack of skilled practitioners

One of the key challenges to BIM roles identified in the literature is the shortage of appropriately trained and skilled practitioners available to the industry. This is clearly a barrier to successful BIM implementation in projects and organisations, as "the success of the project is more dependent on the weakest contributor than the strongest" (Walasek & Barszcz, 2017, p1230). Chien, Wu and Huang (2014) state that the lack of appropriately skilled practitioners is a critical risk factor for BIM projects, and advises that a project should not be accepted if personnel with the necessary skills in both the technology and the construction process are not available. As well as the risk to projects, the lack of skilled people is also a challenge to those currently or aspiring to be BIM professionals. High demand for BIM expertise has led in many cases to inappropriate people moving into BIM roles (Poirier, Forgues & Staub-French, 2016). This not only harms the company or project team that they are involved with, but also the status or reputation of other BIM professionals.

Another negative impact of the shortage of skilled practitioners is that it affects the training and development opportunities available to the wider industry. There is a widespread need for university level integration of BIM for new entrants into the industry, and vocational or on-the-job level training to upskill current practitioners. Both of these education contexts require skilled and experienced instructors to transfer their knowledge. The lack of trainers leads to iterative learning processes, with practitioners developing knowledge through trial and error on projects (Ku & Taiebat, 2011), causing wasted resources through rework and poor productivity (Kaner, Sacks, Kassian & Quitt, 2008). Alternatively, inadequately experienced instructors produce a 'blind leading the blind' situation where even though many institutions are moving to integrate BIM into their AEC education programmes, the staff are learning at the same time as the students, or are teaching from a traditional practice perspective. This can lead to students receiving less than adequate instruction in traditional as well as BIM methods (Russell, Cho & Cylwik, 2013). Approaches to bridging this gap include teaching the principles of BIM in an academic context and leaving BIM knowledge to be developed in practice (Holzer, 2015), and encouraging experienced practitioners to engage more directly with academia and share their knowledge with students and educators (Lee, Dossick & Foley, 2013; Wu & Issa, 2013). Although companies have appeared reluctant to recruit graduates to fill BIM practitioner roles, the increasing demand for BIM capable staff will leave many with no alternative (Wu & Issa, 2014). In any case, it is clear that educators require greater resources for developing their own skills and knowledge, and enlisting the support of established BIM professionals in a collaboration between academia and industry is one route to achieving this. Despite the obvious benefits of such a collaborative approach, however, this involvement in the educational process adds additional demands and skills requirements to the already substantial range of expectations placed on the BIM practitioner (Gustafsson et al., 2015).

2.3.3 Lack of permanence of BIM roles

The ongoing debate about the potential longevity of BIM-specific roles is a challenge to the standing and authority of the BIM practitioner. Sebastian (2011) describes the discussion that arose between representatives of traditional roles when BIM-specific roles were introduced into a case study project. This questioned the relationship between BIM-specific roles and traditional practice, and centred on reclaiming some of the authority and agency that had been handed over to the BIM practitioner. Such discussions indicate that there are still adjustments and accommodations to be made, and that BIM roles are likely to evolve as BIM becomes embedded in standard practice. Gu and London (2010) state that where BIM is in the early stages of adoption and implementation, BIM practitioners are required to provide strong leadership to direct the course of development, but suggest that this requirement is likely to decrease once BIM is established as accepted practice. Others also suggest that BIM roles will reduce in importance and scope as BIM becomes more embedded in the industry. Akintola, Venkatachalam & Root (2017) take a stronger view and assert that BIM specialist roles are only required as an interim measure while the wider industry develops the necessary skills. In this assessment of the future transformation of BIM, BIM practitioners are only likely to have a longer-term role as technical support, rather than as a core professional role in organisations and project teams.

To date, the introduction and evolution of BIM practice has been substantially influenced by the actions and initiative of individuals whose vision and enthusiasm for BIM have seen them take a leading role in transforming practice. Davies and Harty (2013) described a case study in which it was observed that the effectiveness of the innovative practice was dependent on the efforts of the individuals involved. Samuelson and Björk (2013) identified that, unlike some other AEC innovations, while there may be organisational support for BIM implementation, the process is very much driven by individuals with specific BIM knowledge and skills. Miettinen and Paavola (2014) similarly describe the extent to which BIM development depends on the experimentation and learning of practitioners involved in the process. The risk inherent in the view of BIM specialisation as an impermanent phase in the development process is that the legitimacy of BIM practitioners is undermined, and the desirability of BIM as a career path may be compromised. If BIM specialisation is a temporary need, it may be challenging for BIM practitioners to justify the level of personal development and associated effort that is required to bring about the transformation required by projects, companies and the industry as a whole. The lack of a structured career path and future opportunities may be a negative influence for professionals who might otherwise choose to move into a BIM role, and limits the potential for professional development and associated continuous improvement (Sacks & Pikas, 2013). It also reduces the incentives for students entering the industry to commit to a BIM-oriented career path (Wu & Issa, 2014). Correspondingly, managers may be reluctant to fully commit the necessary time and resources to developing individuals for what may be seen as a short-term need. The use of third-party BIM consultants rather than in-house expertise may be a consequence of such a view, which brings the additional risk that a few individual consultants within a particular region may dominate the BIM implementation process, leading to a lack of objective benchmarking of the implementation process (Sebastian & van Berlo, 2010).

2.3.4 Expectations of skills and abilities

The skill set required of BIM practitioners, while varying depending on factors such as discipline, company size, seniority and specific BIM role, is generally extensive with high expectations across a broad range of skills. Several studies have explored the expectations of a variety of construction practitioners with regard to the types of BIM expertise and knowledge required of new entrants to the industry. This has been predominantly from the perspective of curriculum development for BIM education (Ku & Taiebat, 2011; Sacks & Pikas, 2013; Wu & Issa, 2013). Uhm et al. (2017) took a different approach and examined the requirements described in BIM job advertisements. Succar, Sher and Williams (2012, 2013) have done extensive work in identifying and classifying the range of competencies required for successful BIM operation. They identify that,

> there are arguably hundreds of generic BIM competencies common across disciplines, specialties and roles. There are also, depending on the level of detail used to define competencies, thousands of specialized BIM competencies reflecting the unique requirements of each discipline, specialty and role… (Succar et al., 2013, p183).

Across the board, BIM practitioners are expected to be expert across three broad skills categories: soft skills, including personal and interpersonal management skills; BIM-technical skills, which relate to the use of modelling and associated software, BIM standards and frameworks, and technical aspects of information exchange and management; and discipline-specific skills, which relate to knowledge of construction, project and practice processes and techniques. A common criticism to date is that practitioners rarely possess more than one of these skill sets, and particularly that there is a lack of people who combine BIM-technical skills with a sound knowledge of the construction process (Farnsworth, Beveridge, Miller & Christofferson, 2015).

Debate continues over whether BIM practitioners need to be specialists, with BIM skills customised for the specific discipline area in which they operate, or generalists, with a broad industry knowledge supplemented with BIM expertise (Wu & Issa, 2013). Turk (2016) argues that the potential for greater specialization is one of the most important benefits offered by BIM technology, and places greater emphasis on the construction informatics side of BIM skills development. Others downplay the technical elements of BIM roles and emphasise the need for soft skills such as collaboration, communication and trust (Becerik-Gerber, Ku & Jazizadeh, 2012; Zhao, McCoy, Bulbul, Fiori & Nikkhoo, 2015). Still others contend that discipline knowledge and a deeper understanding of how a building is constructed is the most important skill set (Holzer, 2016). Whether practitioners take a specialist or generalist approach to developing their BIM skills, it is clear that there are extensive and high expectations to be met (Gustafsson et al., 2015); soft skills are at least as important as hard skills (Liu et al., 2017); and experience within the industry is a further requirement for many roles (Uhm et al., 2017).

2.4 Motivation and attitudes of practitioners

The discussion around motivation and BIM practice revolves around the motivations of companies to adopt BIM, which have been thoroughly canvassed in the literature (Azhar, 2011; Bryde et al., 2013; Farnsworth et al., 2015). However, taking up a BIM role has explicit challenges as previously identified, including to, the motivation that leads practitioners to follow such a path is also a highly relevant factor (Adriaanse, Voordijk and Dewulf, 2010). It is also an aspect that employers consider when recruiting BIM practitioners. Both Barison and Santos (2011) and Uhm et al. (2017) identify characteristics sought in job advertisements such as enthusiasm for BIM and the ability to enthuse others, motivation for new challenges, and a flexible and positive attitude to the BIM role.

2.4.1 Personal and organisational motivation

Various approaches have been used to explore the connection between the beliefs and attitudes of the individual and the outcomes of technology adoption in the organisation, and to argue the importance of understanding the personal perspectives of the individuals involved in the innovation process. In many cases the central concern is still the organisation, however. Attitudes examined tend to be centred on the individual's beliefs about the impact of BIM on the organisation, or about appropriate adoption routes for BIM, rather than on the impacts of BIM on the individual's career or motivation (see for example, Brewer & Gajendran, 2012; Cao, Li, Wang & Huang, 2017). It is not uncommon for such studies to conflate the motivations of the organisations and the individuals involved, without distinguishing between 'project participants' as individual practitioners or as project-participating organisations.

This tendency to ascribe common motivations across both individual and organisational levels is shown in the use of Maslow's motivational theory to investigate the drivers that lead to BIM adoption (Singh & Holmström, 2015). Maslow's hierarchy of needs is a model developed to describe the motivations of humans through a progressive layering of needs, and Singh and Holmström (2015) suggest it can be applied to the BIM adoption process. Primary needs are said to be driving BIM adoption for some practitioners, where the skills are required for 'survival' in maintaining their job, or for a sense of belonging where BIM is the norm for a particular peer group. Secondary needs are the drivers for other individuals who seek opportunities for innovation, creativity and leadership. These individual characteristics are further aligned to the motivations of an organisation in BIM adoption.

Rogers' theory of diffusion of innovations (Rogers, 2003) is another model which has been used to explore the development of BIM environments, from both an individual and organisational perspective (Samuelson & Björk, 2013; Singh & Holmström, 2015). Within this framework, Samuelson and Björk (2013) make a distinction between the motivation of the individual at a personal level, as opposed to individuals making decisions which apply at an organisational level. They suggest that BIM adoption may occur through the self-interest of individuals who see clear benefits of BIM in their own professional role, which may not necessarily meet the needs or expectations of the organisation.

2.4.2 Resistance to change

Resistance to change may be considered the inverse of motivation in the BIM environment, and is a commonly described barrier to BIM implementation (Sun et al., 2017). The most frequently cited form is habitual resistance to change, where people are fixed in the way of doing what they do, simply because it is the way it has always been done. This resistance is often increased by the rhetoric around BIM as a transformative innovation that will change the way the industry functions, sending the message that previous experience, knowledge and practice is outdated and incompatible with modern ways of working (Davies & Harty, 2013).

Technophobia, lack of knowledge, or lack of experience with technology in general can be factors that reduce the motivation of practitioners to become involved in BIM (Dainty, Leiringer, Fernie & Harty, 2017). Negative past experiences of technology, such as having struggled in an adoption environment due to poor investment decisions or inexperienced project partners, also act as a personal demotivator which may discourage practitioners from involving themselves in BIM (Brewer & Gajendran, 2012). Such issues around change and technology have been particularly highlighted in BIM literature as examples of the 'digital divide' between older and younger generations (Gledson, 2016).

Although overcoming resistance to change is often described as a core role of BIM practitioners (Holzer, 2016), BIM specialists themselves are not immune to it. BIM practice is still evolving, and those who may have been early adopters and developed their own way into BIM may find that their understanding and experience is now out of step with more widespread practice and greater degrees of standardization (Gu & London, 2010). Support from upper management, and ongoing training and development are necessary even once BIM practice has been established, in order to ensure that resistance to change does not build up further and inhibit ongoing innovation in the BIM space (Lin, Lee & Yang, 2016).

The disincentives to BIM practice also need to be examined and managed. Holzer (2015) suggests that architectural graduates may be actively demotivated from following a BIM career path, because their BIM skills may see them being classed as technologists rather than designers, which is traditionally seen as a lesser role. Kokkonen and Alin (2016) consider the need for practitioners, including BIM professionals, to reflect on practice in order to create a new mindset that can help to generate new views of practice, and new practices.

2.5 Conclusions

BIM is permeating the design and construction process, and the concept of the BIM practitioner as a new role within the industry appears to be gaining momentum. Although there is still some debate about the longevity of specialist BIM roles, current practice requires practitioners with skills in both information technology and the technical aspects of BIM, and also a strong knowledge of the design and construction process. The collaborative and integrated work processes that are aligned with BIM also require practitioners to be strong in soft skills such as communication and leadership.

Introducing BIM into company or project operations also requires support from aligned practitioners who may not be BIM specialists but who need to be open to the changes that BIM entails. A management or senior level champion is important to demonstrate the value that is placed on BIM by the company. They may or may not be a hands-on BIM user, but need to understand the implications of BIM and be prepared to support the investment and process shift required for successful implementation. Professionals in traditional roles may not need to become specialised BIM practitioners, but will have to modify practice to integrate BIM requirements, work with and through BIM processes, and change to a collaborative working style.

Challenges to BIM practitioners at all of these levels primarily occur when BIM is seen as just a technological intervention. When the practitioners who are leading BIM implementation are focused solely on the IT solution required, the much broader benefits possible through use of BIM are not attained. A more significant challenge to BIM practice however is the current dearth of appropriately skilled practitioners who have experience with both the technology and the construction process. As a result, unqualified or inappropriate individuals are taking on BIM specialist roles and putting projects and companies in jeopardy.

While there is a great deal of commentary that references the BIM practitioner and the various roles, responsibilities and relationships involved in BIM practice, the majority of the discussion is at the level of organisational and industry implications of BIM. The gap identified here is the need for an examination of the impacts of BIM on the workplace and career path of individual BIM practitioners.

3 Role definitions in BIM guides and handbooks

This chapter is based on the following manuscript:

Davies, K., Wilkinson, S. & McMeel, D. (2017) A review of specialist role definitions in BIM guides and standards, *Journal of IT in Construction (ITcon)*, 22, 185-203. Retrieved from http://www.itcon.org/2017/10

Chapter summary

In Chapter 3 I present an examination of the formal descriptions of BIM roles, as presented in the plethora of guidelines and handbooks which have been developed to help direct BIM implementation and practice. Having collected an international selection of 36 of these documents, I have examined and categorised their purpose and contribution, and consider the expertise and intentions of their developers. I further review how the roles of BIM practitioners and project participants are described. The number and variety of guides and standards available raises concern, as findings suggest that while BIM practice generally is becoming more standardised, BIM specialist roles may be developing in an uncoordinated manner, even when companies and individuals consider themselves to be following best practice guidance.

3.1 Introduction

In order to establish Building Information Modelling (BIM) in the many facets of the construction industry where it has potential to impact, organisations have had to develop a range of new resources and capability sets. As part of this process, formal and informal BIM-specialist roles are becoming established in all aspects of architecture, engineering and construction (AEC), from initial design, project management and construction, through to operations and maintenance. However, literature suggests that the scope of tasks and responsibilities within such specialist roles remains both disparate and poorly defined (see for example Čuš Babič & Rebolj, 2016; Wu, Xu, Mao & Li, 2017).

Many countries, industry bodies, research coalitions and individual organisations have introduced guidelines and handbooks for BIM implementation and practice, which often include definitions of the key roles required for successful BIM implementation. One challenge for the authors of such documents is that industry adoption of BIM has progressed without the structure they seek to provide. As described by Samuelson and Björk (2013), BIM implementation has often started through bottom-up implementation in a company, as the result of an individual pursuing a personal interest or advantage, and only later has this limited introduction become adopted by the company as a whole. As a result, roles and processes have emerged in an ad hoc fashion, and in many cases continue to do so. Standards developers have had to balance the need to introduce a coherent yet representative structure, alongside the challenge of defining processes and roles that are still evolving in practice. Thus these guides vary widely in their defined purpose and areas of interest. They also vary in terms of the level of support or requirement they entail, whether they represent mandatory or recommended practice, or are simply providing information for the industry or sector concerned. One of the commonly espoused purposes of BIM guides generally is to achieve a higher degree of project collaboration. Hartmann et al. (2012) identified the prevalence of bottom-up BIM implementation, and noted that companies which followed this path tended to operate in low collaboration environments; hence the structured top-down approach taken by most BIM guides would seem to be appropriate to achieve this aim.

A number of projects have acknowledged the plethora of guidelines available, and have sought to provide a synthesis across a range of sources. Fiatech (2013), for example, reviewed 28 BIM standards and guidelines, from the perspective of automated code compliance. Kassem et al. (2015) reviewed “noteworthy BIM publications” from eight countries, with the aim of producing a BIM knowledge content taxonomy to help practitioners and researchers identify and address knowledge gaps in the BIM domain. Many BIM guides have originated with public sector entities, and Cheng and Lu (2015) included a number of them in a review of public sector involvement in BIM adoption. Similarly, Sacks, Gurevich and Shrestha (2016) focused on BIM guides developed by large construction clients. A buildingSMART International project is currently collating a wide range of documents for future categorization and review, with the aim of producing a standardised international framework or template for future development of BIM guides, based on an analysis of standards already used in industry (Beange & Keenliside, 2015). The definition and description of BIM specialist roles is also in need of this sort of standardization.

The role of BIM specialists has been identified in the literature as an important factor in successful BIM project implementation. Howard and Björk (2008) identified the need for a specialised role in modelling and technology, applying standards and spatial coordination. However, as the adoption of BIM has increased, it has become evident that it is not just about software solutions or technology upgrades, but involves process change and change management. Additionally, it is increasingly recognised that the way in which BIM is adopted in a company or project varies according to the business objectives and desired outcomes of the parties involved. This analysis of requirements has to take place between, as well as within, organisations, thus adding a further layer of complexity to the BIM specialist role.

Conflict is evident in the literature when considering the extent to which BIM adoption affects industry roles. The Contractors' Guide to BIM, produced by the Associated General Contractors of America, asserts that "BIM does not change the fundamental roles and responsibilities of project participants” (AGC, 2010, p19), and goes on to say that “the effective use of BIM does not require that the project participants assume any roles other than their traditional ones.” (AGC, 2010, p35). Conversely, Al Hattab and Hamzeh (2015) suggest that BIM affects all roles in a project, with a much higher degree of interconnection and interaction than traditional practice entails. They consider that BIM adoption involves a change to most, if not all, relationships within a project. If this is the case, there would be a corresponding effect on the scope of each role, as more communication, collaboration and shared decision-making takes place. The BIM Guide produced by ASHRAE for its members makes the same argument, and states that the industry as a whole must consider "crossing organisational boundaries" and "reorganizing design and construction processes" to fully benefit from BIM (ASHRAE, 2009, p20). Gu and London (2010) take an intermediate position, with the claim that some old roles will become obsolete, and specific new roles will be introduced. With such disparate positions held by different participants, defining key BIM roles becomes a vital activity in successfully advancing BIM implementation.

The following section examines the types of BIM guides available, and reviews their development process. The next section provides an analysis of a selection of the many guides currently available, specifically examining the definitions they provide of BIM roles and the associated responsibilities, and identifying commonalities of advice, purpose or structure. A further section discusses the findings, and outlines the implications for practice.

3.2 Document review

A selection of documents from international sources has been compiled and examined for this review. Almost all of these are freely available online, although some require registration in order to download the documents. Very few are limited to membership of a specific organisation, or require payment to access them. An initial wider set of documents was collected, primarily as a result of internet searches but also through recommendation from peers in academia and industry. This was reviewed for content, and those which did not fit analysis criteria were culled. A similar approach was taken to that used by Kassem et al. (2015) in their examination of noteworthy BIM publications, but in this case with a specific focus on documents which provide information on roles and responsibilities. Documents excluded were handbooks or guides developed by software providers; superseded editions of more recent documents; non-English resources; and handbooks or guides which considered BIM as a peripheral aspect of another topic, such as Integrated Project Delivery or Lean Construction. Also omitted are standards or guides which define the technical processes or information content of BIM projects, where no attempt is made to delineate roles or responsibilities. The resulting collection consists of 35 documents, which have been organised by publication date, country, developer type, and content. The final list is provided in Appendix B.

3.2.1 Development of BIM handbooks and guides

Little has been published on the development process of the numerous BIM guidelines and handbooks now in existence. Many different approaches can be seen in the types of documents developed, the scope or focus of the guidance, and the developers and their intentions in compiling the advice. A number of handbooks or guidelines can be considered to be seminal documents, in that they have been used as the model for others later developed in different domains or countries. Ongoing modification and revision has led to some current versions diverging considerably from the originating documents, but the initial contribution has been recognised. An example 'family tree' of such documents, in this case stemming from the US Veterans Affairs BIM Guide (VA, 2010), is shown in Figure 3.

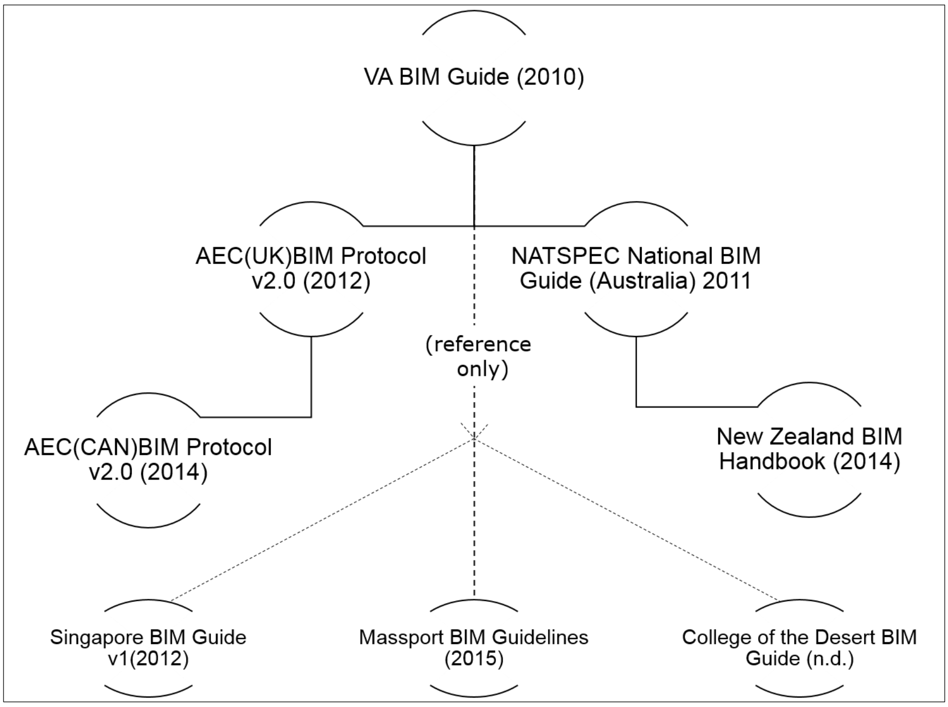

Figure 3 'Family tree' of VA BIM Guide (2010) and selected descendent documents

The VA BIM Guide provides considerable detail in defining key BIM roles and their responsibilities, and outlines supporting roles with the requirement that the project proposal should include "BIM qualifications, experience, and contact information for the following: BIM Manager; Technical Discipline Lead BIM Coordinators for all major disciplines (Architect, Civil, MEP, Structural, *etc.*) …the Construction BIM Manager and Lead Fabrication Modelers for all trades" (VA, 2010, p7-8). More definition of the BIM responsibilities of these roles is also provided. This approach is closely followed in the

AEC(UK)BIM Protocol (AEC (UK), 2015) and the NATSPEC National BIM Guide (NATSPEC, 2016). At the next level of development, however, the example provided by the original source has not been closely adhered to. This process of adaptation from a source is a common theme in diffusion of innovation research. Linderoth (2016) describes the phenomenon of "technology drift", where the differing levels of knowledge, interpretations of needs, or expectations of various participants in the process influence the ways in which adoption and use of the technology may diverge from initial intentions or definitions. In BIM, as with other technological developments, this is as true of roles and relationships around the technology as it is of software and associated processes. Thus each iteration or interpretation based on a standard will result in adjustments or developments that reduce uniformity of practice.

Even where specific identified documents have not been used as a model or development source, the creation of a new guide or manual generally begins with a review of existing documents, with material then tailored to the needs or context of a given environment. However, as Beange and Keenliside (2015, p78) state, "...this process of reviewing, analyzing and drafting guide documents is extremely labor-intensive and often results in paralleled or duplicated efforts that add neither value nor forward achievement in the development of standard procedures or best practices." Although these approaches of progressive adaptation or parallel development both lead to a degree of uniformity in process and advice, each iteration increases the likelihood of changes and variations, and thus inconsistencies and conflicts in the resulting guides.

3.2.2 Document types

Part of the complexity of identifying unified role definitions from the assortment of documents available lies in the variety of names that such documents go by. Guides, guidelines, handbooks, manuals, standards and protocols are all terms used in the title or description of the collected documents; however, even where the same term is used it does not necessarily have a common meaning in the different documents.

The developers and issuers of the documents also vary in their remit and intentions, and in the degree of influence they have within their audience group. Kassem et al. (2013) offer six categories of document issuer: Research body, Governmental department, Community of Practice, Private industry, Industry body, and Local authority. However, these boundaries are not necessarily clear-cut; for example, in many cases where a government department or local authority has developed a BIM guide, it is presented in their capacity as a client rather than as a governing body. This categorization has been loosely adopted, with additional notes where required.

3.3 Guidelines for BIM specialist roles

From each of the BIM guides identified, the sections which discussed roles and responsibilities were extracted, and tabulated according to the key descriptions or definitions of each. These were collated by the significant terms used, in order to identify a consolidated set of roles, and the associated areas of influence or responsibility associated with each. As explained in the Norwegian Home Builders Association BIM User's Manual (BoligBIM, 2012), these are not necessarily expected to be exclusive or self-contained positions within a company or project, and "in some organisations, the same person will be able to play several of the roles" (p19).

3.3.1 Role Definitions

As Barison and Santos (2010) identified from the technical literature, and later found in an analysis of BIM job advertisements (Barison and Santos, 2011), there is a wide variety of job titles which apply to BIM practitioners. More recently, Uhm et al. (2017) identified 35 job types through a similar study of job postings, many of which had overlapping descriptions and requirements. These job types fall into the categories of project roles, with the primary function fitting within a project team; and organisational roles, where the role is primarily performed at the company level. Based on the roles described in the reviewed BIM guides, BIM roles with a project integration aspect fall into two main categories which are relatively uniform in scope and responsibility. These commonly comprise an over-arching project management and coordination role, which is supported by a second tier of specialist managers or BIM coordinators from each of the design and construction teams or technical groupings. Some handbooks also define BIM roles which are concerned with organisation-level BIM processes, and another two categories can be drawn in this area, the organisational BIM manager and the BIM modeller/author. Only 3 out of the 35 handbooks examined defined client, asset or facilities management BIM roles. Table 9 shows the roles described in a selection of the guides reviewed, and indicates the variety of job titles that are used. The following sections expand on the synthesis of role definitions and responsibilities for each of the four BIM roles identified.

Table 9 Role categories identified in BIM guides

	Project roles										Organisational roles			
	BIM manager (project role)						BIM coordinator				BIM modeller			BIM manager (organisational role)
Guide Name	BIM Manager	BIM Facilitator	BIM Coordinator	BIM Project Manager	Design Team / Construction BIM Manager	Information Manager	BIM Coordinator	Discipline / Design BIM Coordinator	Lead BIM Coordinator	Model Manager	BIM Modeller	BIM Users	Model author	BIM Manager
USA - VA (2010)	✓			✓	✓			✓	✓					
USA – AGC (2010)						✓								
UK – CIC (2013)			✓			✓		✓						
UK – AEC (UK) (2015)	✓		✓				✓				✓			✓
Finland – COBIM (2012)			✓					✓						
Hong Kong – HKIBIM (2011)				✓							✓			✓
Singapore – BCA (2013)	✓							✓				✓	✓	
Canada – AEC(CAN) (2014)	✓													
Australia – NATSPEC (2016)	✓			✓	✓			✓	✓					
NZ - NZ BIM Handbook (2016)	✓							✓		✓				

3.3.2 BIM Manager – project role

The most commonly described role is that of project level BIM Manager. The person or persons taking this role can represent the lead designer, the main contractor, and/or a third-party entity acting on behalf of the client. At this level, the BIM Manager is responsible for the development and delivery of the BIM execution plan, and establishing BIM protocols for the project. According to the most common descriptions, quality assurance is also part of the role, as is maintaining oversight over BIM responsibilities and deliverables. Guiding the collaborative process is an important aspect of this role, including organizing BIM project meetings and managing project records. One area of potential ambiguity regarding the BIM Manager project role is the degree of authority held by this person. The role is often described in terms of the project stage, for example the Design BIM Manager, or the Construction BIM Manager. Particularly in documents based on the VA BIM Guide, these roles are expected to report to the Project Manager who has the oversight role.

Information Manager is a role most notably described in the UK in the Construction Industry Council BIM protocol (Construction Industry Council [CIC], 2013) and supported by the PAS1192 suite of documents, and PAS1192-2:2013 in particular (BSI, 2013). Although included here within the category of *BIM Manager – Project role* it potentially sits somewhat outside all four of the BIM-specialist role categories identified from other guides. The Information Manager is employed by the client to have oversight of the information requirements of the entire project. While it is clearly a project-based role, it is not necessarily a BIM role. Before any widespread development of BIM, and with no mention of BIM at all in the description of the role, Froese (2004) identified the Information Manager as a necessary function for successful management of IT solutions in the industry. As described in the CIC documents (CIC, 2013) the Information Manager is responsible for establishing and managing the information processes, protocols and procedures for the project, including aspects such as the common data environment for the project, file management and information exchange. The Information Manager does not get involved in design-related functions such as clash detection or model coordination. Accordingly, the role does not require a knowledge of BIM tools or processes. However, the CIC also add that the Information Manager role is generally expected to form part of a wider set of duties and so may be taken on by a person with other BIM-related duties. As noted by Paterson, Harty and Kouider (2015), in many practical discussions or interpretations of the role this overlap results in it being interpreted in much the same way as a project BIM Manager.

3.3.3 BIM Coordinators – project role

The BIM Coordinator role is described as a secondary role under the leadership of the BIM Manager, representing each individual discipline within the project framework. The BIM

Coordinator is responsible for the exchange of BIM models from their organisation or discipline, including ensuring that models created within their team adhere to the agreed BIM standards and follow exchange protocols. Model coordination and clash detection is often described as falling within the remit of the BIM Coordinator; within a project team the BIM Manager leads the coordination activity, but each BIM Coordinator takes responsibility for the coordination and management of their own model, and any required propagation of changes. Other responsibilities described for the BIM Coordinator role include ensuring that the discipline model conforms to the standards agreed for the project, providing guidelines for the discipline team on agreed project requirements, and communicating data transfer needs and processes to other disciplines. For sub-trades and specialist consultants in particular, the job title often used for this role is Model Manager.

3.3.4 BIM Manager – organisational role

Although almost all of the guides and handbooks reviewed are concerned with the project-level processes involved in BIM implementation, many of them also define a BIM Manager role in terms of organisational as well as project responsibilities. Most commonly, this includes responsibility for training, as well as hardware and software issues. For example, the Hong Kong BIM Project Specification (HKIBIM, 2011) lists training and technical support of modelling staff as roles of the BIM Project Manager. Similarly, in the New York City Department of Design and Construction BIM Guidelines (NYC-DDC, 2012), specification of the BIM Manager role is primarily at a project level and in terms of interaction with NYC-DDC as the client, but it also stipulates the level of proficiency the BIM manager must have in the selected authoring tools, and assigns them the responsibility for coordinating BIM training. In practice, these are not uncommon tasks for a BIM Manager to undertake (Davies, McMeel & Wilkinson, 2014), but they are not project level requirements and thus do not need to be specified by the client in order to achieve successful BIM implementation.

3.3.5 BIM Modeller – organisational role

The BIM Modeller role is described as a production role in developing the BIM model, a role that has a variety of job titles including model author, BIM operator, BIM user or BIM technician. Few of the documents reviewed concern themselves with defining the modeller role, because it is an operational role within an organisation. There are several exceptions, however. Although it does not provide much detail on the responsibilities of those in the role, the Hong Kong BIM Project Specification (2011, p23) specifies that "BIM Modellers (technicians and operators) will have particular discipline experience … with a minimum of 3 years of 3D CAD modelling knowledge." The Singapore BIM Guide (BCA, 2013) uses the term Model Authors to refer to both the party which creates and takes responsibility for a model, and the individuals creating the models for that party. On one hand the role description is concerned with project issues such as information quality and delivery, while on the other it provides advice on organisational concerns including software use and relationships with software vendors.

3.3.6 Skill sets and capabilities

Another approach taken in some of the guides and handbooks is to define roles in terms of the skill sets and capabilities required. Succar, Sher and Williams (2103) divide BIM competencies into abilities, activities and outcomes. All three of these types of competencies are used by the various guidelines to define BIM specialist roles, with some focusing on actions and responsibilities, and others also including abilities or skills requirements. The level of detail in the specification of roles also varies. For example, the Singapore BIM Guide states that the *Design BIM coordinator* is responsible for a given set of tasks: "Define discipline-specific BIM uses including analysis; Coordinate between BIM modellers, design consultants and cost consultant; Coordinate with contractor and subcontractors; Ensure Modelling Quality Control" (BCA, 2013, p25) while for the same role the NATSPEC (2016) guide is much more specific in defining expectations of the role: "These individuals shall have the relevant BIM experience required for the complexity of the project and shall have, as a minimum, the following responsibilities for their discipline: Coordinating technical discipline BIM development, standards, data requirements, etc. as required with the Design Team BIM Manager; Leading the technical discipline BIM team in its documentation and analysis efforts; Coordinating clash detection and resolution activities; Coordinating trade items into the Design BIM (depending on procurement plan)" (NATSPEC, 2016, p7).

Based on the roles identified in Table 9, Table 10 presents a selection of the specified abilities, activities and outcomes, grouped into the focus areas of technical, process, people and strategy. It should be noted, however, that because most of the handbooks and guidelines reviewed are focused on project delivery using BIM, many strategic BIM activities are not commonly included.

Table 10 Expectations of selected BIM roles

Role	Technical	Process	People	Strategy
BIM Manager – project role	Ensure software is installed and operating properly	Lead development of BIM Management Plan/BIM Execution Plan	Provide BIM point of contact with client	
	Determine reference points used for project	Ensure compliance with BIM Management Plan/BIM Execution Plan	Train project staff	
	Analyze model content to ensure it is fit for purpose	Management & quality control of model dissemination; revision management	Facilitate technical meetings with BIM technicians	
	Carry out clash detection & provide clash reports	Coordinate file management processes		
	Assist in preparation of project outputs, such as data drops			
	Assemble composite models			
BIM coordinator	Carry out clash detection & provide clash reports	Provide guidelines for discipline team on agreed project rules	Team contact person in matters connected with BIM	
	Ensure functionality of team contribution to merged models/ integration of design models	Contribute to keeping BIM Management Plan/BIM Execution Plan up-to-date	Allocate and coordinate BIM tasks within own discipline	
		Ensure discipline model complies with BIM Management Plan/BIM Execution Plan	Communicate with other disciplines	
		Manage discipline-based quality assurance, formulation of BIM reports & data management	Represent team at interdisciplinary model coordination meetings	
BIM modeller	Production & modification of information in discipline-specific model			
	Must have appropriate technology skills to produce the model			
BIM manager (Organisational role)	Implement BIM technology	Create company-level BIM processes and workflows	Engage external stakeholders	Formulate corporate BIM objectives
		Develop company-level BIM standards and protocols	Collaborate with partners and internal teams	Plan & manage best practice/ research
			Company-based change management and training	Prepare and manage BIM training strategy

3.4 Implications for practice

The analysis of BIM guides and handbooks raises issues that go beyond a basic definition of roles and responsibilities. The ways in which BIM practice is described in these sources identify some further implications regarding how practitioners are viewed in various parts of the construction industry, and around the use of the guides and handbooks in helping to outline BIM roles.

3.4.1 Moving beyond technical skills

BIM coordination requires an individual (or organisation) with both the technological capabilities with the BIM tools and systems used, and the contractual or financial knowledge and authority to enforce a coordinated process (Merschbrock, 2012). Without these elements, each party to the project follows their own individual processes with little incentive for a unified approach. As a result, the BIM practitioner is also expected to move beyond a purely technical role and must also possess skills in leadership, communication, documentation writing, review and quality assurance procedures, in addition to discipline knowledge and proficiency in model authoring and coordination software.

The widespread and increasing adoption of BIM throughout the construction industry suggests that technological capabilities are now becoming less of a barrier. McGraw Hill (2014) found in an international survey of contractors that almost two-thirds of the organisations surveyed had a high level of engagement with BIM, a finding that is supported by surveys across a variety of regions and industry sectors. However, Eadie, Browne et al. (2013) reported that lack of expertise was still seen as the biggest barrier to successful BIM implementation. Given that technology skills have been reported as adequate or excellent across many organisations in the industry, this implies that the process-focused and collaboration aspects of BIM roles are the factors that present more of a challenge, and attention in these areas are required when establishing roles and defining skills. Although Sacks et al. (2016) identified that technical responsibilities were the primary focus of BIM guides from large construction clients, Table 10 confirms that technical skills are a very small component of the requirements of BIM roles, and are sufficient only for functioning at the production level.

3.4.2 Client influence

BIM development is often driven by client expectations and requirements; consequently, many of the BIM guides and handbooks currently available have been written from a client perspective (Wong, Wong & Nadeem, 2010). The majority of the client authority documents identified in this review have come from the US. In many cases these are from influential government clients, and have become de facto industry standards, in that their use has been applied beyond the initial client domain. Some of these clients have been leaders in developing standard approaches to BIM, and have been influential in the development of other more widely distributed manuals. For example, the US Veterans Affairs guide (VA, 2010) was an early leader in establishing the requirements for project use of BIM, as previously described. The General Services Administration BIM Guide in the US is another similarly influential document (GSA, 2007). However, these two documents take very different approaches. The GSA Guide focuses on the information requirements of the BIM model, with no specification of roles or protocols, while the VA, as previously discussed, provides process definitions that include key roles and responsibilities.

Early leaders in the BIM field tended to take an informational rather than a prescriptive approach in establishing BIM guidelines, and as such have covered the field more broadly than more recent documents. However, this has resulted in the somewhat anomalous situation that, for the majority of client handbooks reviewed, the focus is on the design process and in specifying the workflows and standards of the building delivery up until occupancy. Accordingly, where definitions of roles and responsibilities are given, these tend to be focused on the design and construction teams and not on the client-side representation. If they are to obtain long-term benefit from BIM adoption, clients need to codify the roles and responsibilities for managing BIM data and processes for facilities and asset management, and must develop the information management skills of their own employees, or work with third-party BIM specialists who can deliver this competency (Love et al., 2014). It is curious therefore that very few of the client-developed handbooks do this. It is accepted that clients must clearly identify their information requirements, and the fact that they need to do this as part of a BIM process is set out in almost all guides, regardless of developer type, but the client-side roles are very poorly defined.

It may be that these client organisations have defined in-house roles separately as part of their facilities and asset management processes, instead of within their BIM handbook. If this is the case, there is a risk that where the handbooks form part of their relationship with design or construction teams, the personnel responsible for the end-use of the BIM data are being excluded from the process of developing the information requirements. This can be seen as one of the problems stemming from the separation of capital expenditure and related decision processes, from operational expenditure and ongoing management aspects, as described by Whyte, Lindkvist and Ibrahim (2013).

3.4.3 Differences in discipline

A number of professional bodies internationally have produced guidance documents for their membership. Examples of these include the RICS in the UK, the Norwegian Home Builder's Association, and ASHRAE and the Associated General Contractors of America in the US. Each of these organisations has taken a different approach to how they advise their members on BIM implementation, and in the level of definition provided to their description of roles and responsibilities. The ASHRAE guide, for example, is an introductory document which is more of a deliberation on the changes that BIM introduces to practice, rather than guidance on how to achieve it. Some 'first steps' are articulated, including the advice around roles that suggests the appointment of a *BIM champion*, and the need for a skills inventory and training provision to ensure all staff have an appropriate level of understanding of BIM processes (ASHRAE, 2009). The Norwegian Home Builders' Association's BIM manual, in contrast, is a detailed set of implementation advice that takes a much more prescriptive approach (BoligBIM, 2012). Checklists are provided for the activities of the *Planning manager/BIM coordinator*, as well as for traditional project roles operating in a BIM environment.

Almost all of the guides included in this review consider the BIM specialist roles required for the design side of the process. A much smaller number address the needs of the construction stage. Very few consider BIM roles in the operation and maintenance of a facility. The differences in critical risk factors in BIM projects identified by Chien et al. (2014) suggest that although design and construction teams may both include BIM specialists in roles with similar titles, their areas of concern will be slightly different, with the design side more concerned with BIM standards as a critical risk factor, and the construction team more concerned with interoperability and management processes. Ahn et al. (2016) provides case studies of four construction organisations in which the BIM roles align slightly differently from those described from the design team side. The BIM manager operates as an organisation-level responsibility and handles implementation and software, whereas the BIM coordinator takes the project-level BIM role, which involves interaction with the specialty contractors and coordination of the model.

3.4.4 Diversity and divergence

In the USA particularly, the development of a large number and variety of BIM guides has resulted in diversity rather than standardisation. Many State governments and other authorities have established BIM guides, to support design and construction teams producing buildings where they are the client. Many of these have mandated BIM use on their projects, and so the guides tend to be prescriptive in approach. This client-specific focus has resulted in a proliferation of client guides, with often several different guides in effect within a single state. In New York City, for example, the Department of Design and Construction has published a BIM Guidelines document, specifically for use in their own projects but with the stated aim of standardising the approach to BIM taken by any public agency procuring buildings in New York City (NYC-DDC, 2012). However, the Dormitory Authority of the State of New York (DASNY, 2013) also stipulates a BIM process, as does the Port Authority of New York & New Jersey (PANYNJ, 2017), and the New York City Schools Construction Authority (NYC-SCA, 2014). Each of these takes different approaches to defining BIM processes, and the level of definition of BIM roles is quite diverse, ranging from the brief description in the DASNY Guide of *Design Professional*, which is used to refer to the team member in charge of managing the coordination of the 3D Model in each discipline, through to the more detailed role descriptions of the *BIM Manager* and *Discipline Trade BIM coordinators*; and the *BIM Lead Coordinator*, *BIM coordinators* and *BIM Users*, in the New York DDC BIM Guidelines and the Port Authority of NY & NJ, respectively. This level of repetition and overlap is evident across a wide range of jurisdictions in the USA, and reflects the decentralised nature of standards development in that country, as well as the many levels of government across national, state and local authorities.

3.5 Conclusions

The most obvious conclusion from this review of specialist BIM roles is that while there are a large number of BIM guides and standards, there is little standardisation. A plethora of different labels, terms and job titles are evident across the many documents available. Although many of the documents stem from common sources, the coordination of project roles between guidelines is limited. Multiple interpretations of the same roles and responsibility sets are evident, depending on the guidelines followed in each case. Nonetheless, despite this variety of naming and labelling, the roles defined generally fall into two project roles and two organisational roles—project BIM manager (or information manager) and BIM coordinator as project roles, and internal BIM manager and BIM modeller in the organisational roles. However, there are overlaps in many cases between how the roles are labelled and how they are defined, which may cause confusion for both clients and project teams when establishing project protocols and employing appropriate personnel.

The inclusion of organisational roles as well as project roles in some BIM guides raises concern about their intention and scope. In many cases, these are client-prescribed documents that seek to establish standard approaches to their projects. However, the attention given in some guides to internal BIM roles in project organisations results in clients effectively attempting to mandate a particular allocation of responsibilities even beyond the project environment. Conversely, it is interesting to note that many of these client-driven BIM guides only specify roles and responsibilities in the project team, and neglect to address how the client-side organisation will be managed for the BIM context.

Both of these issues are particularly evident in the USA, where a wide variety of individual organisations have created their own BIM guides for use on their projects. Although these are essentially the same in most of the documents reviewed, each organisation introduces minor—or occasionally significant—differences, which serve to introduce problems when systems are assumed to align but actually do not. This is in contrast with many other countries which have taken a national approach in defining an overall national BIM standard. Such a standard provides a general structure for BIM projects, including roles definitions in the context of information frameworks and wider project requirements. This means that when projects are undertaken, the BIM execution plan (BIM management plan/BIM protocol) is individualised for the client and the project team. This allows for a framework that responds to specific project needs, and not a complete change of requirements depending on what the client has previously defined. As the market for BIM projects increases, this is likely to improve, with greater awareness of the skills and responsibilities of BIM practitioners developing along with increased uptake of the technology and processes. The development of a unified framework for BIM guides, as proposed by buildingSMART, could be useful to avoid repetition of effort, but needs attention so that the issues outlined above can be addressed.

This review highlights that a considerable part of the problem of unifying BIM implementation lies in semantics, rather than technology gaps. Surveys and case studies indicate that, to a large extent, the required tools and skills for successful BIM adoption already exist in industry. However, the adoption of BIM and increased drive for collaboration brings a change in focus and a much greater requirement for alignment in practice, and in how practice is described. Historically, the wider construction industry is made up of individuals and organisations working independently, and often esoterically. The advent of BIM requires that individualised office practices, and the descriptions and definitions of roles and relationships involved, move to a higher degree of consistency.

4 Case studies of early adoption

This chapter is based on the following article:

Davies K., Wilkinson S., & McMeel D. (2017). Baby steps with BIM – learning to walk the talk. In *LC3 2017: Volume 1 – Proceedings of the Joint Conference on Computing in Construction (JC3), July 4-7, 2017,* Heraklion, Greece, pp. 399-406. doi:10.24928/JC3-2017/0253

Chapter summary

In Chapter 4 I provide an illustration of the BIM environment in which BIM specialist roles have emerged and are still developing. Although there is a great deal of enthusiasm reported for companies to adopt BIM for improved project outcomes and industry productivity, the process of developing BIM expertise is not always an easy one. Project teams frequently come together with a very wide range of knowledge and differing levels of enthusiasm for taking on a BIM 'experiment', and do not always find or follow the range of advice available.

This chapter details some of the challenges and pitfalls of the BIM implementation process, as found in two New Zealand projects undertaking BIM with largely inexperienced teams. Interviews were carried out with practitioners involved in the two projects, who held generally positive attitudes towards BIM. Their narratives present an optimistic view of the BIM intentions, while still being realistic about problems that emerged. Warning signs or issues for future consideration are identified. Most revolve around team communication factors and the importance of open and constructive relationships with all the parties, not just those involved in the BIM activities. Specialist BIM practitioners are seen as pivotal, whether as a new, dedicated role within a company, or as additional skill sets required on top of traditional industry roles.

4.1 Introduction

BIM uptake is increasing rapidly worldwide, according to the many surveys carried out in both local and international markets. Predicted uptake in the next few years is high, with the NBS National BIM Survey 2016 in the UK predicting near-universal BIM use within 5 years (NBS, 2016a). The McGraw Hill surveys in North America showed that from 2007 to 2012, BIM adoption increased from 28% up to 71% (McGraw Hill Construction, 2012). In New Zealand, a longitudinal study monitoring 43 companies which are already aware of BIM found that all of the companies had used BIM to some extent in 2016, an increase from 85% in 2015 (EBOSS, 2015, 2016). Internationally some ups and downs in adoption rates have been seen, for example in the UK where progress appeared to reverse in 2015 with a drop from 54% to 48% (NBS, 2015), and similarly in New Zealand, where the EBOSS study noted a decrease in use from 89% in 2014 to 85% in 2015 (EBOSS, 2015). In the UK, some commentators argued that the decline in rates of adoption was itself an indicator of increased awareness about BIM, reasoning that as practitioners became more educated about what constituted 'proper' BIM, they no longer considered themselves to be practicing at the level they had previously assumed (Blackman, 2015). Irrespective of such variations or the reasons for them, the overall trends in awareness and adoption have been consistently upward since the first industry surveys on the topic, with a diverse range of countries also moving towards BIM adoption (NBS, 2016b).

However, the surveys also indicate that there is a considerable number of companies within any market that are slow to get on board with BIM. Most obviously, there is a large push in many developing countries to move towards greater use of ICT in the AEC industry, which includes BIM technology and processes as part of this shift, but many of the companies currently do not have the necessary resources for successful BIM adoption (Bui et al., 2016). Less prominently, in countries that are leading the move towards BIM, there are still many companies which have yet to move to BIM adoption. This is particularly the case for small companies, which in most countries make up the majority of the construction industry (Hosseini et al., 2016).

The commentary about BIM development and uptake tends to focus on the larger and more established companies which are leading the push to innovation, with the assumption that their momentum within the industry will draw the smaller and less technologically savvy companies along in their wake. This effect has taken place to some degree, but not nearly to the level that is required to ensure saturation of the industry with regard to BIM uptake. Some of the acknowledged barriers to BIM adoption include issues such as a lack of knowledge about the technology and process; cost and availability of modelling and associated software, and the hardware to run it on; the degree of change required to company and industry processes; the lack of BIM skills and experience within the industry and the difficulty and expense of hiring suitable staff to implement BIM; and the difficulty of getting buy-in from project partners and working on a level playing field with other project participants (Dainty et al., 2017).

With such barriers reported, it is unsurprising that some companies would prefer not to make the move to a BIM project framework. Many companies, particularly smaller organisations, are still unsure of the benefits of moving to BIM and are afraid of being ‘taken in’ by what is still perceived as a fad within the industry (Dainty et al., 2017). In addition, research often presents the leading edge of BIM adoption, and documents the achievements and benefits that those at the forefront stand to gain. This is not particularly useful to those who have yet to move into the simplest BIM processes, and may in fact serve to daunt them because the perceived gap between their current practice and that illustrated in the research appears so large (Davies & Harty, 2013). As described by Fox (2014), much of the framing of BIM and the innovation it brings to the construction industry is naïve, in that it presents only a selective view of the changes and resulting benefits that are occurring in the industry. Some scepticism and wariness results: that the hype may not measure up to the reality, that BIM may be only appropriate for large, technologically advanced companies, and that it may be suitable just for the major flagship projects that are often presented as case studies. Such questions, and the concerns raised by Smits, van Buiten and Hartmann (2016) about whether enthusiasm and widespread optimism about BIM translates into real and measurable benefit to be gained from BIM adoption, illustrate further the complexity of the argument.

4.2 Case studies

Two case study projects in Auckland, New Zealand, have been examined as a focus to explore the development of BIM processes within a wider industry framework. The first project team, while they would not be considered leaders in an international sense, include some of the front-runners in the BIM movement within the New Zealand environment, who have some previous experience in the BIM process and are moving into a more complete BIM implementation. The second case follows a project team who are just beginning to explore BIM in a project framework and are working within a much more hybrid BIM environment. Both projects were examples of early BIM adoption for the majority of each project team, but also included project partners who were more experienced in BIM use.

Data came predominantly from qualitative interviews with project participants. Representatives from each of the projects (see Table 2) were individually interviewed for 45–90 minutes each. Interviews were designed to be loosely structured and participant-led, which for most participants meant they followed a narrative approach that covered the range of issues of interest to the interviewer, but in the sequence and depth that followed the interests or concerns of the interviewee. Two interviewees were less comfortable following a narrative approach and not as forthcoming with their responses, so a more structured interview format was adopted with increased use of prompts and direct questions, based on the interview structure presented in Appendix C. Topics of interest for all interviews, narrative or otherwise, included roles, relationships, documentation and project administration processes, BIM skills, knowledge and training, reporting and accountability, and preferences and predictions for BIM use in the future.

The case studies are intended to be illustrative rather than representative, and serve to identify and describe approaches and opinions that exist within a developing BIM environment. Quotes from participants have been used to provide context and express the various perspectives about BIM within the two project teams. Even for this relatively small sample, a wide variety of attitudes, beliefs and knowledge is evident.

4.2.1 Case study 1: Large new-build project

Project 1 was a large educational building which followed a previous project for the same client and with predominantly the same project team, which used a partial-BIM process. All of the parties involved had found value in their initial exploration of the technology, particularly in facilitating a complicated services installation in a limited space. As a result, the client requested a more complete BIM implementation with the expectation that further benefits could be realised. The client had no interest in using BIM from a facilities management (FM) or asset management (AM) perspective, citing the sunk cost of the legacy systems currently in use and the substantial investment in new technology that would be required. They also identified that they did not have staff with the appropriate skills to develop and maintain the BIM models for FM or AM use. Their interest in BIM was largely for the reduced project duration and greater degree of certainty that they considered came with a BIM project. There was also an element of future proofing involved, in that they may in the future choose to move to a BIM-based AM or FM system, and want to have models available if they need them.

The architectural practice employed on the project use Revit modelling in the majority of their projects, and have an experienced BIM manager to assist and direct on project BIM implementation. Model exchange and coordination takes place as a matter of course within the practice.

> "As soon as we build our model we shoot it to everyone. They then start using that as the background and populating it with services and structural."
>
> *Architect, Project 1*

The practice has well-established in-house standards and procedures for BIM projects and document exchange, and at the time had just started developing BIM execution plans for some projects, including this one.

Despite the established BIM processes in the practice, the project architect was quite ambivalent about the use of BIM in the design process, and expressed concern about the value it delivers to the designer. His contention was that there was great benefit for the construction team, and the main contractor in particular, but little advantage gained by, or even disadvantage accruing to, the architect when working in a BIM environment. The BIM manager for the architectural practice was more convinced of the potential value of BIM to the project as a whole, but did not feel that it was currently being realised. He was quite critical of the client's approach, and felt that the architect was the main party determining the level of BIM use on the project.

> "I think it's not being driven by the client. When they come asking for a BIM model you can't take it very seriously… [architect] had to actually explain what [a BIM model] means, and ask actually do you want it, is it going to be any benefit, or is it going to sit on a disk and never actually be used. It would only be BIM if we really said it should be."
>
> *Architect's BIM manager, Project 1*

The engineering design was developed by a large multi-disciplinary consultancy, which was responsible for both the structural and services design of the project. Although they had been working to develop BIM expertise for some time, this had been a disjointed and poorly coordinated process. This project, and others they were working on at the same time, were part of a shift in thinking around BIM, a recognition that,

> "it's not actually a delivery tool, it's actually a new way of thinking, a design approach." *Services engineer, Project 1*

The main contractor for the project was in the process of investing heavily in BIM technology and expertise at the time the project started. The previous project with the same client and consultant team had been an exploration of the potential of BIM for the company, and there was a lot of enthusiasm about the advantages of using 3D models and model exchange. The contractor's site manager was positive about the benefits of BIM, although his office was still very heavily paper-based. BIM uses on the project were predominantly based on visualisation within a 3D model, and some clash detection and coordination with specialist trades. One of the main restrictions that the site manager identified regarding the company's use of BIM was the lack of skilled staff, and the reliance of the company on third-party modellers contracted to develop models for use in 4D programming and planning for the construction team.

4.2.2 Case study 2: Extension to existing building

The identification of Project 2 as a BIM project was instigated by the client FM team who were in the process of upgrading their facilities management processes and associated software with a system developed in-house. They were keen to see how an as-built BIM model could feed into their processes and regarded this project as a test-bed which would allow them to observe the BIM process in action and evaluate the outputs against their requirements. This project, a relatively minor extension to an existing educational building, was considered a suitable scale for a test project as it was large enough to require a full consultant team, but not so large that a failed BIM implementation would jeopardise the client's investment. The client team incurred some changes during the course of the project. The project manager, who was part of the FM team, left the client organisation partway through the design stage. He was replaced by a new property manager from capital works rather than operational responsibility, who took over the oversight of the project. There was some friction in the transition, and in the process much of the BIM focus of the project from the client perspective was lost.

The architectural practice for the project had a very tentative approach to BIM, with only half of the practice working in Revit. They had previously used 3D modelling in a number of projects, although mainly for visualisation and presentation purposes, and were starting to transition to a more extensive BIM process. They had not yet established formal project protocols, and were developing practice standards as the project proceeded. This was their first project where the entire documentation process was carried out using Revit. This project was also the first time the project architect had used BIM in the role of lead consultant. Even though they considered themselves to be new to BIM, the architect did not consider the client's expectations to be significantly different from their standard project approach.

> "BIM was a requirement by [the client]. … At one of the early meetings, we did ask them what exactly do they want us to do, because we said, well what we normally do is we use Revit as a 3-dimensional software. We would normally exchange files with other consultants. That's what we normally do, and we asked them, is that what you want? Do you want more than that? Because you can go further, of course. They said, no, just do what you normally do, so that's what we're doing"
>
> *Architect, Project 2*

The engineering firm contracted for the services design had some previous BIM experience within the company, but the engineer coordinating the services for the project had only limited exposure to BIM previously. His role was not hands-on with BIM tools, but he was responsible for coordinating the model development for the services information, and overseeing the coordination process using BIM. Despite the company's past BIM experience, the project was still considered a test development because the individuals involved had used BIM tools for documentation in the past, but had not been significantly exposed to the more thorough collaborative and coordinated approach desired for this project.

> "It's a learning curve for everyone in the project. It's evolved, and many things were added. Going further ahead, we have a clearer picture now. For a test, it's going pretty well. It's a pretty straightforward building. All of the others are at much the same level as us, they are still feeling their way and using this as a test case as well."
>
> *Services engineer, Project 2*

At the changeover from design to construction, the project went to tender and was won by a construction company who were actively developing their BIM capabilities at the time. However, they did not receive the BIM brief that had been produced for the design team, and were unaware of the client's interest in the project as a BIM test case and of the intentions to use the final BIM model as a FM resource. The construction team felt that the design BIM model was largely unsuitable for their needs, and proceeded to develop their own BIM model for the construction stage of the project. Much of the modelling work was outsourced to a third-party modelling company offshore. The construction team used BIM for programming, resource allocation, site planning and Health and Safety inductions, amongst other purposes. 3D and 4D modelling was extensively used to support the contractor's needs.

4.3 Findings and Discussion

The two case studies provide an insight into a range of issues affecting early BIM practice in the New Zealand context. International surveys indicate that while New Zealand is not a leader in BIM, neither is it significantly different in rate of adoption or process from many other countries currently involved in BIM development (McGraw-Hill Construction, 2014a; NBS, 2014). Furthermore, although the case studies are concerned with the introductory stages of BIM implementation within a country with low BIM maturity, the lessons learned are also relevant to companies that are new to BIM but within a more mature BIM environment. Key findings and areas of interest are highlighted in the following sections.

4.3.1 BIM understanding and expectations

The various parties had differing perceptions of the expertise and capabilities of others within the project teams. For example, the clients in these projects saw themselves as driving BIM adoption, and felt that they had a good understanding of the BIM process. However, the architects in both cases considered that the clients were naïve in their perception of BIM, and potential uses and opportunities offered by BIM adoption were not achieved.

Similarly, the contractors felt that the standard of the architectural models limited the uses available to the construction team. Criticisms included the level of detail included in the architectural model, as well as the architects' organisation and management of the model.

> "Design-wise I don't think they really get into it; to the detail you need on site. They don't think they need to throw in that much detail either. They're also managing their time versus output. It needs more time than what they're doing to actually build it. I don't know if design-wise it's worth spending more time on it

> and saving the time for the builder. I don't think that'll ever happen because they'll always be risk averse. 'Not my job. Detail to be resolved on the site.'"
>
> *Site Manager, Project 1*

The range of uses to which the model was applied was quite limited. This was acknowledged by several of the participants, and was justified by the argument that they were developing trust in the system and were still exploring its capabilities. For example, on Project 1, sections of the structure were constructed in a full-scale mock up in order to establish whether they were constructible as designed. A detailed 3D model of the sections had been prepared by the engineers, but the construction team was not prepared to rely on the model for such a crucial element. This need for a physical as well as digital representation of the construction process was observed by Whyte (2013), who noted that this transition from one medium to another prior to committing to actual construction is a valuable practice for examining assumptions, as it adds an additional and tangible check to the construction process.

The BIM requirements were not explicit in the contractual expectations in either case study. The client team for Case Study 2 produced a BIM brief for the project, but it was concerned with technology issues such as establishing common software platforms and exchange formats. In both projects, the BIM capability of the design teams was a consideration in the procurement process, but apart from requiring handover of a 3D model at the end of the design process, the clients' expectations with regards to BIM were not made part of the contractual obligations of the project team. This lack can be seen to stem from two causes. First, the inexperience of the clients and project teams meant that there was no real understanding of what was involved in the process and how it might play out within the framework of a traditional contractual framework. Second, at the time of these projects there were no local guidelines available to provide a template or model for the teams to follow in their dealings around the BIM processes.

Rather than a BIM problem, however, these issues can be interpreted more broadly as flaws in the wider communication process. As a result of their inexperience with BIM, the parties did not establish clear expectations and handover points at the outset, so each came to the process with different views of what their roles and expected outputs were. In addition, project deliverables were primarily paper-based, with a traditional drawing set as the principal part of the contract documents. This meant that although BIM was used in the production process, the BIM outputs were treated almost as an afterthought by the project teams.

4.3.2 Operations vs. capital works

The original driver for BIM use on Case Study 2 came from the operations side of the client organisation. This seems to be a somewhat unusual situation. In the UK, Eadie, Browne et al. (2013) identified that BIM has not yet been well integrated into building operational and life cycle considerations, and so these aspects take a low priority for BIM users. However, while this case study may be ahead of the curve in this regard, it also provides an example of the tensions which are often present between capital works and operational responsibilities within a client organisation. The two parties operated from different budget lines and had very different concerns for the outcome of the project. Between the two areas of interest, potential BIM uses for the project such as quantity take-off or optimisation of materials and components during the design stage, or planning for future uses such as building performance monitoring or operation were overlooked. The capital works manager was concerned with the up-front cost of design and direct return on investment, and was not convinced that BIM delivered any real value from a capital management perspective.

> "Right now, as long as it's not increasing the bottom line of my projects… Can industry guarantee a benefit in kind further on down the track? Then no skin off my nose, I'd take a punt. But not only do I have to set out that capital up front for an unknown return, I might as well go to the dogs and put it on number 8."
>
> *Capital Works Manager, Project 2*

In contrast, the facilities manager was interested in the practical applications that the BIM model could deliver for the operation of the building. These may not necessarily have a quantifiable financial outcome, but facilitate the day-to-day management of the building.

> "We want to use BIM to help workflow for maintenance – we can run the Helpdesk, driven by BIM-info, extracted from the BIM model, for generating work orders and checking off jobs done, then update the model for an as-built record. It's not even for the complicated elements like services, necessarily, but simple things like a change of flooring." *Facilities Manager, Project 2*

This difference of emphasis may lead to problems in the project definition and delivery. The two contrasting priorities of quantitative versus qualitative considerations of BIM adoption: the up-front cost and return on investment for the client of requiring (and managing) a BIM model, versus the benefit the model offers in supporting the ongoing operational decisions and processes of the building management, are a result of the separation of processes described by Whyte et al. (2013). As with many elements in the BIM process, the answer is not in any technical solution but in a greater understanding of the requirements of the other parties in the process and the constraints they are operating under. Again, in common with many other challenges and benefits of BIM, this is not unique to the BIM process, but the clarity that 3D modelling offers to the construction and operation of a building, plus the attention that it attracts to the process, means that BIM adoption becomes a catalyst for identifying and resolving issues of this nature.

4.3.3 BIM expertise and skills development

The need for staff with BIM skills suitable for implementing a BIM process was a common theme throughout the two case studies. There were two clear strands to this issue. The first complaint was the lack of people skilled in BIM available to the project team. This limited the value of the BIM process because no one was able to either develop the model for desired simulations or to interrogate the model for more complex analyses. Many of those with BIM specialist skills were seen as more focused on the technology than the process, with poor understanding of design constraints and construction methodology;

> "…a real concern is that you find that a lot of time, too much time, gets spent trying to work out how to build the Revit model as opposed to how you would actually build the building." *Architect, Project 1*

Third-party modellers were used by the construction teams in both case study projects, to varying levels of success. The site manager for Project 1 suggested that his company was being "held to ransom" by third-party modellers who were contracted to deliver specialised modelling functions, but did not have sufficient experience to understand what the company needed from the model. In particular, third-party expertise was contracted to add 4D capability to the models (linking the 3D model with time- or programme-related information). Although the third-party modellers were skilled in use of the technology required, they did not have the required level of discipline knowledge of the construction methodology and processes to make the model useful as a programming tool. Both construction companies were in the process of developing greater in-house capability, to reduce the reliance on outsourcing this function.

A related but distinct issue was the interviewees' concerns about their own personal BIM knowledge and capabilities. Apart from the BIM manager/Revit modellers on the two teams, the interviewees were not BIM specialists and had no particular mandate within their respective companies to take any additional responsibility with regard to BIM. It was simply expected that they stay up to date with project delivery tools as part of their normal roles, and in this case BIM was part of the package. A big challenge was the amount of time required to learn to use the necessary tools, and the difficulty of maintaining some degree of aptitude, when they only need to be hands-on very occasionally.

> "I had good intentions of learning how to use it… it's just the time. It's one of those things, you need to be doing it regularly, at least to a certain period of time. You know, I've been shown a couple of times how to do certain things. You sort of sit down for half an hour with the BIM manager in the office and they show you how to do it, but 3 weeks later when you haven't done it again, you can't. You miss one little step, everything is out the window." *Architect, Project 1*

The lack of personal capability in using the tools was described as a frustration by most of the interviewees, but was only really felt to be a negative factor in the use of BIM when there was a lack of in-house capability as described by the site manager on Project 1 or the BIM manager in Project 2.

Most of the interviewees were in positions of responsibility and coordinated wider teams within the BIM process. Several described similar challenges for their staff in upskilling to the different ways of working and understanding of the tools used.

> "They had some issues, it was mentioned in the meeting a couple of weeks ago, where if you have anything in the ceiling like a light fitting, it's almost like a clash with the ceiling grid. They quickly learned that there is a way to say that this was a known, not actually a clash. Those are the things that are coming up now, and slowly getting smoothed out." *Services engineer, Project 2*

Most of the issues described are a product of inexperience and unfamiliarity in the process, and not a fundamental shortcoming in the education or knowledge of the team members. Despite this, the lack of familiarity is a barrier to the project team's ability to capitalise on the potential benefits offered by the BIM environment. Although the team leaders do not need to be fully BIM capable, with knowledge or competence in all of the various software tools, they do need to be aware of what tools their teams are using and what can reasonably be expected.

4.3.4 Changes to the process

The project participants all stated that BIM did not require any significant changes in their design and delivery process. However, their explanations of how the projects played out included some aspects that were clearly different because of the use of BIM. The frequency of information exchange was increased through the use of the BIM model, as identified by the Project 2 services engineer:

> "In terms of liaising with the architect, we would constantly ask the architect, if you do any changes please keep sending us the updated models so that we are up-to-date. So we can be more aware of the changes. There were handover points agreed but we realised that even though they would say it's still a draft model, we would still love to have it. They were happy to give to us."
>
> *Services engineer, Project 2*

The conversation around design decisions and project progress was more open between members of the project team, although as the architect for Project 1 described this was more a project team decision rather than driven by the use of BIM:

> "We've always detailed things and resolved things pretty well…We don't simply stop at the ceiling and leave them to it. A lot of the work we do, we're quite happy to expose services and structure, so we are quite interested in what they're doing. I guess from our point of view we were always looking to coordinate all that, it was just happening in a 2D environment, as it has done for hundreds of years."
>
> *Architect, Project 1*

Again, this illustrates that the changes resulting from BIM use on the two projects are less an outcome of the introduction of BIM technology and systems, and more from the communication process that was developed alongside those. A similar process could be implemented using more traditional project delivery approach, but the introduction of BIM provides a demarcation point where other related process changes can be adopted. Claiming that these advantages accrue from BIM is stretching the point somewhat, but it is unarguable that for many companies and project teams these more collaborative and integrated approaches to information sharing were not in practice before the advent of BIM.

Most participants felt that BIM was the new way of working and were simply accepting of any change it caused in their working processes. The Project 1 architect was the only respondent who did not speak in positive terms about the changes that BIM brought to the project processes, but his criticisms were more that it provided shortcuts or 'cheat' techniques to carry out functions that were normally part of a 'good' architect's role, rather than any negative implications of BIM as a process. Others mostly described it as a different way of working rather than identifying specific improvements that BIM delivered. The two most enthusiastic were the Project 2 architect, and the Project 1 site manager, both of whom were experiencing their first BIM project in the cases examined. For the Project 2 architect, the most beneficial change lay in the way changes could be propagated through a 3D model and from there to the documentation set, so that there was no need to continue updating information in multiple locations – the idea of a 'single point of truth.'

> "If you change something or you mark something it's changed and it's updated. The whole thing, the whole model is updated. You don't need to worry, has the elevation been done, or a section, it just happens. That's fantastic, but also with coordination with other consultants, it's just made it so much easier and quicker."
>
> *Architect, Project 2*

The site manager on Project 1 was still coming to grips with the changes in information flows, and frank in describing his low capability in BIM. He also described some difficulty with working with a third-party BIM modeller for this project, that was proving to be an ineffective undertaking. Despite this, he was enthusiastic about the level of information and control that BIM offered the construction team. In particular, he appreciated the way they were able to prototype approaches to construction in the model, to plan out the most appropriate strategy.

> "There were some pretty horrible ceiling corners and things that just had everything going through them, and if you didn't know who was first, you would have been forever pulling the thing down." *Site Manager, Project 1*

The architect for Case Study 1, who remained sceptical about the value of BIM to the design team, did not consider that it added value, but also did not feel that there was any disadvantage to using the 3D approach and associated information modelling capabilities in the design and construction process. His main criticism was that from his perspective it was a change for the sake of change, where the existing processes served the purpose equally as well.

> "You still need to do the old-fashioned things like meet once a fortnight and sit down with a pen and paper and … you know? What height are you having that beam and what clearance do you need under there for the duct work and … it's not as if the model kind of solves any of that for you." *Architect, Project 1*

In addition, he considered that the lack of modelling skills within the company created a barrier between the design and documentation elements of the architectural process. In contrast, the services engineer on Project 2 considered that the use of BIM offered little change to the design but delivered an advantage because of the quality control stages it added into the process. In his view, the fact that the engineer did not have the BIM skills became an advantage purely because they did not have the skills to work directly in the modelling tools.

> "Having to do it on a paper and giving it to another person to look at the paper and draw it, it's almost like a QA. He's checking my work, so if we skip that that means we lose another channel of checking. I think it is more heavily policed when it comes to a BIM project because it does go out in 3D… It has to make a lot of sense. Everyone is carrying responsibility. If it's a hydraulics, he would make sure that all the pipes are connected and it doesn't look like it's in the air or something like that." *Services engineer, Project 2*

Disadvantages identified were largely in the area of skills, as previously described, but also related to being effectively the frontrunners within the local industry and having to make it up as they went along, with little to guide in local experience. For the architects on Project 1 particularly, where this was the first real BIM project they had been involved with, this was felt quite keenly:

> "We are like the pioneers here in our office. We can't really learn from others in the office, so we do need to look outside the office for more knowledge and these theories." *Architect, Project 2*

Several respondents identified that the time commitment in the case study projects was greater as a result of the BIM framework, though all except the architect on Case Study 1 acknowledged that this was a result of the experimental nature of their BIM implementation to date and likely to improve as they became more familiar and experienced in the software tools and associated processes in a BIM environment.

> "In general terms it takes a lot longer to build the model and it's a little more unwieldy I suppose." *Architect, Project 1*

The architect on Project 1 was generally the most negative of all the participants and this was evident in his evaluation of the time commitment also.

4.3.5 Benefits

When describing some of the site operations during the interview, the site manager for Project 1 abandoned the computer model that he had been demonstrating, and resorted to finding specific drawings within the large hanging file for the project. Despite being clearly inexperienced in using the model and having ingrained patterns of reliance on paper documentation, the site manager was very enthusiastic about the advantages that BIM delivered on the project. He emphasised that he was unable to quantify any benefits that had accrued on the project, but felt that the increased amount of information that was accessible to him was the main advantage—that decisions could be made with greater confidence due to more knowledge.

Again, the architect on Project 1 was the only participant who was more sceptical about the value of BIM for his own purposes, but he recognised that other project participants benefited from BIM.

> "I don't think we necessarily would get a better outcome, architecturally. … the practice I work for; they've been going for something like 25 years. Obviously, there's lots of people who were producing good architecture before that without BIM. I don't know that architecturally it helps. I think the people who are most enthusiastic about it and who are finding the most value in it is probably the contractors." *Architect, Project 1*

4.3.6 Challenges

The main challenges arising on both projects were to do with agreeing project norms and establishing the baseline details for managing the information and exchange processes. Some of the difficulties described are quite fundamental issues. For example, the services engineer on Project 2 described a degree of confusion early on in the project because of different versions of software in use between the engineers and the architects.

> "At the moment it's all new, everyone's still getting used to it. We had initially some problems where the architecturals were all on different versions of the software and we were on different versions of software. All these things we had to go around in circles and get our versions. It's early days."
>
> *Services engineer, Project 2*

Project 1 was effectively a follow-up to a previous project involving most of the same project partners, on which a limited BIM implementation was used. The benefits of learning from that first project were described by most of the participants, and included aspects such as the software issues raised by Project 2 participants, and other basics such as identifying a common project datum, and others. It is clear from this that experience is important, but that such experience could be transferred in a form such as a simple checklist that could be used at the outset of any project to resolve such basic issues. The project partners also transferred experience between members of the project team, with the more experienced helping to guide those who had little or no previous BIM knowledge.

Several months after these projects had commenced, the New Zealand BIM Handbook (BCPP, 2014) was released. The more structured process described by that document provides a basis for establishing project norms and clarifying the expectations and responsibilities of the various parties. Many of the challenges described in both case study projects would have been simplified or avoided altogether through the use of a client BIM brief and BIM execution plans.

4.3.7 Effects on individuals

The personal and professional responses to BIM described by the case study participants were in many cases difficult to disentangle from project or organisational outcomes. The architect on Project 2 gave the most specific example of individual benefit. She was very positive about BIM in the case study project, and one of the advantages she described was that she was "more relaxed" as a result of the BIM. The more collaborative coordination process "feels like less of a responsibility on myself as a person." She believed that it still gave her the same connection with the design, but that the "whole process is just easier and quicker and more painless, in a way." In a complete contrast, the architect on Project 1 was using BIM only because the architectural practice and client required it, and did not have any personal desire to become a BIM practitioner. He did not see any clear argument for adopting BIM, nor any advantage to be gained in doing so. His response was a classic example of habitual resistance to change:

> "The practice I work for, they've been going for 25, something like that, 25 years. Obviously there's lots of people who were producing good architecture before that without BIM. I don't know that architecturally it helps. I wouldn't say that it's an obvious choice." *Architect, Project 1*

The greater engagement between the consultants in the process was described as a stimulating aspect of the BIM process by several participants. This was a source of personal satisfaction and seen as one of the central advantages of BIM adoption on the projects.

> "It's forcing some really robust conversations. I love the fact that it forces conversations externally to say this is what's important and why."
>
> *Services engineer, Project 1*

Most of the impacts described were a mixture of professional role and project implications; for example, simplifying or speeding up normal professional responsibilities. As well as the impact on project tasks and activities, there were also expressions of enjoyment afforded by the changes brought about by BIM use:

> "I'm in here spinning this thing [the model] around and playing to see how things look. I quite like just going in and seeing details. This has got all the design models together. Great for the architectural look, so I can see what the architect's intentions are. That's nice and easy compared to looking at a 2D picture of these."
>
> *Site manager, Project 1*

These responses indicate that as well as providing advantages to the project processes and outcomes, personal benefits and consequences also accrue to the individuals involved in BIM implementation. These are not always positive, but illustrate some of the more subjective motivation factors that contribute to progress in the development of a BIM environment.

4.3.8 The role of BIM practitioners

The BIM specialists, in this case the architects' BIM manager and BIM manager/Revit modeller in the two case study projects, tended to take a leadership role in the adoption process and transition to BIM. They were central in directing the BIM process, with an emphasis on model creation and BIM process, but they also had the responsibility of guiding the collaboration and team in each case. For the BIM manager/modeller in Project 1, this was very much a process of just-in-time learning, where they were expected to take a coaching role for others in the team, but did not know very much more than those they were guiding. The BIM manager on Project 2 was more established in the role and had experience in teaching others within the organisation. For the collaborative aspect of the project, both found themselves having to stay one step ahead of the rest of the team in setting up processes and managing project protocols around model exchanges and coordination meetings.

The strength of BIM development was seen to be enhanced where BIM roles were held in-house, as opposed to reliance on external expertise. All of the parties involved were developing their own understanding of the modelling, exchange and coordination processes as they progressed, and involving third-party modellers in that process meant that the knowledge was not gained within the organisation. As expressed by the services engineer on Project 2, the BIM process is just beginning and there is a lot more to be learnt, but with greater industry knowledge the progress will increase and the challenges will become more manageable.

> “It's just an evolution. It will take time and it will get there as more people pick up on it. One thing that worries me is by the time we have got everything in the system, there will be new products, processes, we'll be chasing the tail. But at least we'll be further enough along to make it work.” *Services engineer, Project 2*

4.4 Conclusions

Both cases are remarkably similar from a BIM perspective, despite the differences in experience, scale of project, and size of the organisations involved. Both teams freely acknowledge the shortcomings of their BIM processes and the distance they have yet to travel before they reach what might be considered an optimal BIM implementation, but they also recognise the improvements that BIM—even in a limited implementation—offers to their individual roles with a project team, and to their projects overall.

Both cases illustrate that it is not necessary to adopt BIM in an ‘all or nothing’ fashion, but that it is possible to use BIM tools and processes to incrementally improve various aspects of project performance. It is also clear that while skills and knowledge of project participants is important, it is not necessary to transition everyone to a full working knowledge of BIM. For many within the project, context awareness of what BIM does, rather than how to use it, is sufficient.

The main challenges seen in both of these projects are not unique to the use of BIM. Issues such as communication, early agreement and involvement of parties, exchange of information, and clearly defined project expectations and responsibilities are all issues on any construction project. Participants in both projects were developing relationships in a BIM context within their own organisations and between project partners, and learning the best ways to manage agreements and spheres of responsibility. Most participants asserted that the connections they had with project partners were still the same as they would have been on a traditional project, but also acknowledged that model exchange had been taking place prior to the move to more complete BIM adoption and that changes had been occurring gradually with that process.

Most of the challenges identified in these case studies are less about BIM but are instead about fundamental communication processes and project relationships within the project team. There seemed to be an expectation, from the client particularly, that the adoption of BIM was a magic wand that would automatically deliver superior performance and outcomes. In fact, the processes followed in both case study projects were essentially traditional project delivery pathways.

The benefits that BIM offers to the individuals in the projects are entangled with project and practice benefits. However, participants indicate that BIM offers the potential for personal enjoyment and satisfaction, as well as improved professional interactions and outcomes.

5 Hybrid practice in BIM

This chapter is based on the following article:

Davies, K., McMeel, D. & Wilkinson, S. (2017) Making friends with Frankenstein: Hybrid practice in BIM. *Engineering, Construction and Architectural Management*, 24(1), 78-93. doi:10.1108/ECAM-04-2015-0061

Chapter summary

This chapter explores the factors that lead to hybrid practice in BIM across disciplines or project stages, and accommodations that must be reached within BIM project frameworks to allow for it. In the previous chapter, I provided a view of an immature BIM environment, where the lack of structure and definition of the roles and processes were perhaps expected. In Chapter 5 I go on to illustrate that similar scenarios can be found even in experienced BIM teams and established environments, and very few projects operate a wholly BIM approach. Hybrid practice in BIM is shown to be a common experience for practitioners, particularly during the management of transitional stages of BIM implementation. It is presented as a valid model of BIM adoption, not simply a development stage in the process towards more complete BIM implementation.

The published version of this paper was based on the first stage of data collection for this project, from New Zealand and Australia. An assumption made on the basis of this early data was that hybrid BIM environments were a characteristic of immature BIM markets. However, as interviews with practitioners in the Netherlands, UK and US were added to the data, it became evident that this was not exclusively the case. Although hybrid BIM appears to be more of an issue in the first stages of BIM practice, it is common throughout BIM practice in all of the countries included in this study. The published paper has thus been amended in this chapter to reflect that.

5.1 Introduction

The potential benefits of an integrated information management system for construction projects have been widely reported since the early enthusiasm which greeted the concept. These include better visualisation and communication for all parties to a project; increased collaboration and coordination throughout the design stage; greater predictability and control, reduced time and cost in construction processes; through to enhanced management of assets and facilities throughout the building's life cycle (Bryde et al., 2013).

All of the reported activity and developments around BIM paints a picture of a new era of efficiency, productivity and quality in which BIM, as a putative disruptive technology (Eastman et al., 2011) first disrupts, and then completely replaces, existing technologies. The reality, however, is that the construction industry is slow to change. While BIM uptake has undoubtedly been increasing, use of BIM is not universal, neither within projects nor even within companies. Very few organisations have the resources or knowledge to move fully into a BIM environment, and smaller companies in particular struggle to justify the investment required. Many companies adopt BIM on an in-house or 'solo' basis, where a 3D model and associated BIM tools and processes are used within a project for internal development and design, but all documentation and exchange processes take place in a more traditional 2D or hard copy format. This may result from scepticism of the benefits of more integrated use of BIM, where some companies or disciplines see little relevance of working in a BIM environment at all and so are content to maintain existing CAD practices (Gardiner, 2014). Other reasons include fears around legal issues or loss of intellectual property (Arensman & Ozbek, 2012), or that project partners are simply not BIM-capable. As a result, the majority of projects, even some of those hailed as flagship BIM projects, combine some elements of BIM practice integrated with, or tolerant of, more established processes.

Common representations of BIM in the literature, including case studies and best practice guidelines, tend to suggest that BIM implementation requires complete or immersive adoption. Slow or partial uptake of BIM by organisations or individuals has been widely characterised to stem from either resistance to change, or failure to recognise the benefits of BIM (e.g., Bernstein & Pittman, 2004; Khosrowshahi & Arayici, 2012). In contrast, Fox (2014) challenges the rhetoric that has developed around BIM and suggests that many of the claimed benefits are over-simplistic and based on hype. He characterises the underlying assertion of improved productivity and industry transformation resulting from BIM as an example of a nirvana fallacy, which presents an all-encompassing positive view and ignores opposing views or other approaches. Poor decision-making and uncertainty are the result. Miettinen and Paavola (2014) similarly suggest that the claims and assertions surrounding BIM benefits and adoption processes are not realistic, and that an evolutionary approach is required that is more responsive to the needs and abilities of specific companies and projects.

Whyte (2011) introduced the concept of hybrid practice to describe a mixed mode of working which combines the adoption of digital technologies with more traditional 2D CAD or manual practice. As she comments, the transformations that occur in the course of an innovation becoming established are often underrepresented in research. As a result, the mutations and modifications that develop in practice are presented as less significant than the 'pure' form of the innovation. However, as Rice and Rogers (1980) assert, such reinventions are typical of a large number of adoption cases.

> Typically, diffusion studies assume the existence of technical experts who ultimately make the decision to adopt or reject a monolithic, prepackaged innovation. In fact, there may be a fair amount of groping for a solution by concerned individuals, leading to alterations of and later corrections to, the original innovation. (p501)

To use the terminology of Rice and Rogers further, although BIM is commonly presented as a monolithic innovation, it can in fact be viewed as a loosely connected bundle of sub-innovations that offers the potential to be unbundled, and adopted and adapted piecemeal to suit the needs of the adopting individual or organisation. Thus a variety of hybrid adoption paths are possible.

The combination of project and organisation cultures represented by hybrid project processes, and the reasons they occur, can often introduce an element of tension into the wider project team. Expectations can vary considerably between practitioners following more traditional processes and those adopting BIM tenets and philosophy. The BIM practitioner is often called on to act as translator and intermediary, to negotiate the differences and deliver a BIM project. This introduces another element of hybridisation, in the definition of the BIM practitioner's role. Depending on the organisational environment, specific discipline, and skills and aptitude of the individual, this role may encompass a variety of technical, process and strategic requirements. It may also involve responsibilities beyond the BIM space and into practice management, design or project management more generally (Davies et al., 2014).

5.2 Generating factors of hybrid environments

Even though BIM can no longer be regarded as a new development in the AEC industry, there is still a lot of uncertainty around what a BIM project entails, and a variety of implementation approaches are evident in practice. As a result, the majority of projects are to some degree hybrid in form and execution, rather than 'pure BIM' projects with all project partners working in a BIM environment. Although all of the interviewees in this sample were considered BIM experts by their peers, and many of their companies are seen as leaders both nationally and internationally in BIM, much of their experience as they describe it has been working in hybrid projects, and none work consistently within an all-BIM context, although several consider they come close. The interview data suggests that the reasons for hybrid practice in BIM vary considerably, and multiple reasons may apply within a single project. The implementation configurations that result present a variety of problems and challenges. The following subsections probe some of the different contributing factors that are evident in the emergence of hybrid implementations, and associated justifications that are apparent in the interview data.

5.2.1 Tentative implementation

BIM for most early adopters, which includes many of the companies that interviewees worked for, tends to begin with 'solo' implementation, where an individual company chooses to explore the possibilities of BIM in isolation, with little or no discussion or interaction with industry partners. Thus projects are carried out that may have multiple solo models, with each consultant creating their own in-house representation of the building, or parts of the building, without any model-based exchange or coordination taking place (Dossick & Neff, 2010). In such cases, the hybrid process is commonly not far removed from a traditional 2D process, with document-based exchange and coordination and little or no collaboration (Neff et al., 2010). BIM uses are focused around visualisation, documentation, and, in some cases, design simulations or calculations.

Adoption is often spurred by a BIM champion within the company. Despite the call in the literature for champions to come from senior management roles in order to provide resources and leadership for BIM adoption (Ho & Rajabifard, 2016), champions instead are frequently drawn from technical roles. They tend to be self-identified rather than appointed by the company, when an individual develops an enthusiasm for the new technology and persuades their company leadership to support them to move ahead with it. At least half of the interviewees describe themselves as a technical champion, although several have since moved into more strategic roles. In a minority of instances, interviewees hold a top-level champion role within the company, and take a strategic view of BIM and its value to the company. Typically, these people do not have a technical knowledge of BIM, but see their role as providing support and resources for staff development.

Such tentative 'solo' implementation is commonly seen to be a stepping stone to more integrated use of BIM within project teams. However, in many cases it has taken (or is still taking) quite some time for this shift to take place, even when it is led from a senior position within a company. Although most interviewees identified resistance to change as a primary reason for the slow uptake, it was also suggested that this is less a result of direct resistance but because of a lack of definition of what BIM entails or how best to move into the BIM space.

> "In the traditional way everybody knows what to do. It's an inefficient process, but it's clear what somebody does from his own work. Now in the new situation with BIM, it's a lot of unclearness, what he has to do. So we call it BIM, and everybody has his own ideas about it, but it's very unclear what is somebody to do in that specific part." *Interview 45—The Netherlands, BIM consultancy*

Overcoming this uncertainty is seen as an incremental process that involves both education and demonstration, and is often considered a central part of a BIM practitioner's role. Hence the view is that, as BIM becomes more widely understood, and skills and uses develop further, the hybrid environment in this instance will be outgrown by companies. Thus, the use of hybrid practice is viewed as a phase in BIM implementation, rather than an established structure.

5.2.2 Skills of project partners

The adoption of a hybrid approach to BIM may be a pragmatic response to the available level of skills and resources available, particularly when smaller companies are involved as project partners. For small specialist companies, the investment costs of BIM are seen as difficult hurdles to greater integration of BIM in the supply chain.

> "We have guys who do the landscaping, nice company, a guy and his wife with five vans and a little yard somewhere, do a fantastic job on your landscaping. But if I... ask them to create a model? They don't have the software, they probably don't have the money to pay to get Revit, or the training, and what they've got, works."
>
> *Interview 48—UK, Construction company*

The lack of availability of project partners with appropriate skills is less of an issue in the main centres, where BIM practitioners feel more secure in the BIM abilities of their supply chains. However, in other areas, finding project partners with the appropriate level of BIM knowledge can be a significant challenge, resulting in the need to reach some accommodation to manage the resulting hybrid environment.

> "With trades and subcontractors we try to select based on their skills with BIM, but sometimes I have that chance, sometimes I don't. If I'm going to the market where there's nobody, what do I do then? Some skills you can get, some skills you can't, so it's a battle. Definitely not easy." *Interview 71—US, construction company*

Even where companies with BIM skills are available, they are not always the best option for a project from a purely commercial perspective. BIM practitioners in all five of the surveyed countries noted that BIM skills were preferred if a cost advantage to the project could be demonstrated, but in their experience it is not a determining factor in selection of suppliers or project partners.

5.2.3 In-house skills development

In the opinion of many of the design-side BIM practitioners interviewed, adopting a BIM approach for the design process takes more time and resources than traditional approaches, with one engineering BIM manager suggesting that for a coordinated MEP deliverable the increase is up to three times that of the traditional process. As such, very few companies are willing to take the risk of transferring all their project delivery staff onto BIM processes, particularly since projects where BIM is required by the client still make up only a small proportion of the total project numbers. This situation was also noted by Singh and Holmström (2015) in a comparison of BIM adoption in Australia and Finland, where they observed that short-term project goals tend to override the longer-term requirements of BIM adoption. One result of this partial adoption within an organisation is that if multiple BIM projects operate at one time, there is a shortage of staff with the required capability.

For companies looking to employ BIM-capable staff, there is also a problem finding people with appropriate skills. In New Zealand and Australia, local graduates are generally not considered to have the skills or experience required to take up BIM roles. However, this is not limited to less developed BIM markets. Similar concerns were identified by Eadie, Browne et al. (2013) in the more mature UK market, where it was identified that lack of expertise was the main reason that BIM was not more widely adopted. A number of the BIM practitioners interviewed have developed their skills in an international context. In some cases, this came about through internal development, where a multinational company used overseas-based company experts who made visits to provide training and were available on-line for support. In other cases, the interviewees have worked in other countries, and shared skills developed in other markets. In New Zealand and Australia, cross-Tasman and UK experience is common, whereas in the UK and the Netherlands, several interviewees described time working in large companies in the USA or Middle East. All who had been involved in international work experience considered that doing so accelerated their development of BIM skills.

5.2.4 BIM sceptics

Hybrid environments can result from scepticism about BIM and its benefits, whether through widespread scepticism in a company preventing the adoption of BIM at all, or from individuals or groups within a company limiting the extent to which BIM implementation can take place. One of the main reasons identified for scepticism around BIM is a feeling that the reality of BIM can not measure up to the widespread hype evident in industry media and events. As Fox (2014) describes, promises of better information, coordinated design processes and improved productivity as a result of BIM adoption are common and have been around for some time, but for many companies the predicted benefits have not been realised or have been slow in coming. Early bad experiences with BIM have left some companies disbelieving such claims and unwilling to take the next step into BIM implementation.

> "I think a lot of firms, a lot of people's first experience, were epic fails that cost a lot of money, and I think that that's something they have not been able to shake."
>
> *Interview 14—Australia, Multi-disciplinary design practice*

Interviewees suggested two main reasons for the incidence of over-promising and under-delivery, though they were often found in combination. Clients were often described as uneducated, often asking for a 'BIM project' with little or no understanding of what functions are required from the BIM model, or what a BIM process entails. As a result, there is no unifying use-case for BIM on the project and no alignment in the way the participating organisations approach the development and production of the model and associated documentation. In some organisations senior managers were criticised for their poor understanding of the BIM process, and their lack of recognition of the capabilities of their staff. They are believed to be caught up in the BIM hype, and often agree to products or processes that the staff responsible for producing them had no capacity to deliver. In both scenarios, unmanaged hybrid approaches meant that,

> "the deliverable ends up being Frankenstein BIM that's no use to anyone."
> *Interview 13—Australia, Architectural practice*

Internal divisions were identified as an issue that many companies have to contend with, where despite BIM adoption in some parts of a company, other elements remain persistently BIM-free, thus creating hybrid environments internally. Although this is seen as a particular issue for multi-disciplinary companies where different disciplines have conflicting attitudes towards BIM, it exists in a variety of companies, from small architectural practices through to global multi-disciplinary consultancies. It was also suggested that for contractors, cultural differences between office and site workers has a similar outcome, with site workers dubious that any change implemented from head office could be beneficial to their work:

> "Most of the big construction companies have got modelling teams on board… but they pour a lot of time and effort into it and it never actually seems to go anywhere, because once you get out of the head office onto site, the guys out there just won't touch it." *Interview 4—NZ, Architectural practice*

For companies or individuals who do not believe that the potential benefits will materialise, it makes better sense to them to wait to see how the early adopters fare before committing resources to BIM implementation. They continue to work in a more traditional fashion, even when other project participants have moved into BIM use, necessitating a hybrid project environment.

The effect of an aging workforce was also seen by several interviewees as a cultural factor that contributes to the influence of BIM sceptics. Although younger staff are considered keen to embrace the technology, and are coming through their training programmes with a greater level of knowledge and appropriate skills, older staff in general are believed to be resistant to BIM adoption and more sceptical of its necessity or value.

> "We have people from 35 who just don't get it. They don't want it. They are very afraid for their job. 'When new things come along, then what am I going to do.' It's the change of process...they do their job, most of them are pretty good at doing their job, like they've done for the past 15 years. When it has to be something new, they're afraid that they can't do it or they don't want to do it or they just don't see the new process." *Interview 43—The Netherlands, Construction company*

While these quotes suggest that there are various reasons for companies and individuals to be sceptical about BIM adoption, the outcome in all cases is the same. A unified BIM environment is not possible where members of the project team do not have BIM capability, and so a hybrid project process is necessary and will remain so until the sceptics perceive that BIM delivers on the productivity gains and other promised benefits.

5.2.5 Protective environments

Protective environments limit BIM and require hybrid implementation in a similar way to scepticism, but are more closely focused on legal issues such as intellectual property, liability and contractual requirements. They adopt hybrid practice as a means to control the amount of information that is released, and the way in which that information can be used.

With regard to intellectual property, a protective hybrid environment commonly entails conversion from a 3D model to 2D documentation in order to strip out material that is considered to have commercial value. This stems from a concern around repurposing of model components, as described by Arensman & Ozbek (2012). Interviewees gave numerous descriptions of situations where it was known that a project partner had created a BIM model for internal use, but where only printed drawings would be released for coordination. Other instances reported described attempts to avoid this issue by releasing electronic documents only in 2D, or in a 2D/3D hybrid model:

> "For 5 or 10 years [the architects] built their own library of stuff and refused to share it, so they'd send a building model out and it wouldn't have anything in there because they'd strip out all the stuff. Well, that's crazy, crazy! How are you

supposed to co-ordinate something that is basically an architectural shell, and you go inside the building and everything is flattened into .dwgs, on the floor?!"

Interview 8—NZ, Engineering consultancy

From a legal perspective, traditional contracts are still widely used even for projects where the client has expressed the desire for a BIM-enabled process. As a result, the BIM model is only rarely a contract document, which leads to printed documentation being issued, even where a high degree of model-based collaboration has taken place.

> "In a contract they are still 2D drawings and as reference it's BIM, but actually it should be the other way around. We are now in this transition phase and for the roles it's difficult. If you put all the focus on the BIM model but then the contract will describe the 2D drawings as leading, then you have to be looking in two different directions at once." *Interview 45—The Netherlands, BIM consultancy*

Some interviewees identified that they had experienced project participants using this as a reason to refuse to accept a model for use in coordination or for resolving project queries, and to operate on a paper-only basis.

Some of the interviewees expressed a degree of concern about intellectual property, and others noted contractual and other issues, but most described solutions that their own company uses to manage such concerns. More commonly they spoke of project partners who use such concerns as a reason for refusing greater integration on projects and for maintaining highly hybrid processes to protect themselves. From these responses, it appears that less advanced BIM users are more likely to operate hybrid environments from a protective perspective, and that greater awareness of appropriate project processes and protocols reduces the protective stance.

5.2.6 Defensive attitudes

Some non-BIM practitioners seem to be actively working against the movement towards BIM adoption across the industry. Several interviewees reported exchanges with colleagues or project partners who feel that BIM is directly threatening their professional roles or the way in which they choose to work. This was noted particularly in the case of architects, where there appear to be fears that BIM takes over the design process, or makes it too mechanical. One interviewee reported that architects are happy to use the visualisation and documentation elements of the BIM tools, but that it is often difficult to get them to engage with coordination and model exchange:

> "… they choose to make themselves very exclusive, 'I am an architect, I only deal with pretty things, that's too technical for me.'"
>
> *Interview 2—NZ, Multi-disciplinary consultancy*

Attitudes such as that expressed in this quote are not new, as evidenced in Kiviniemi and Fischer (2009). Professionals may perceive that BIM adoption puts their role under threat and creates role competition (Davies, McMeel & Wilkinson, 2013). However, this is not limited to architects, with examples of similar defensive attitudes from project managers (Sebastian, 2011) and structural engineers (Porwal & Hewage, 2013) also documented in the literature.

Another defensive attitude reported by interviewees is closely related to scepticism, and is the result of practitioners, often senior management, having already decided at some past occasion that BIM was not a viable option for their firm. These people often have quite fixed ideas on what can be done with BIM, and challenging that view is not an easy task.

> "As I explored the technical aspects, I found that it became… a political football, because suddenly I was undermining people's positions on something that five years ago they said was stupid or not possible."
>
> *Interview 8—NZ, Engineering consultancy*

A defensive attitude, where people are defending either their perception of their role, or a stance that they have taken that reflects on their professional reputation, can act to limit the extent to which BIM can be implemented at a company level or within a project. In such cases, a hybrid environment is required because project participants will only engage in certain BIM-enabled processes and not others, or because some partners will not engage at all.

5.3 Management of hybrid environments

Within a hybrid BIM environment, BIM practitioners tend to take responsibility for both making the necessary compromises work as efficiently as possible within the present situation, and for working towards a more integrated BIM environment in the future. The following subsections explore some of the elements of the responsibilities taken on by BIM practitioners, the resulting relationships, and the effects on the BIM specialist role.

5.3.1 Pragmatism

A key characteristic identified throughout the interviews was a strong thread of pragmatism. Although almost all of the BIM practitioners interviewed describe themselves as champions or enthusiasts of BIM, that did not stop them from recognising the limitations of the technology or processes in practice, or from acknowledging the barriers that exist within the industry. The realities of hybrid practice are well-known, and interviewees accept that there is still a lot of work to be done to improve performance. Many 'work-arounds' were described where non-BIM processes are adapted so BIM can be implemented at the highest level practicable. The most common practice sees BIM-enabled companies developing 3D models based on project partners' 2D documentation, so that 3D coordination can take place.

Another approach is the use of a third-party documentation company to coordinate the development of the model. This was mentioned with respect to several large-scale projects where a number of the participants had no BIM capacity, or in one case where project participants all had solo BIM models for in-house use, but there was no expertise available to integrate these into a project model. As described by an interviewee who worked for such a company, their role included:

> "Creating an integrated model from all of the different consultants, doing clash detection work, coordination, running coordination meetings using the model… specific model audits and checks…" *Interview 5—NZ, Documentation company*

Despite the double handling and inefficiencies of these project approaches, the advantages of BIM-based coordination and documentation are seen as sufficient to outweigh the additional time and cost involved. This is supported by a study by Bryde et al. (2013) which examined a variety of documented case studies and concluded that despite the generating factors of hybrid BIM environments identified here—issues with agreeing on IT platforms, cooperating to share BIM models and data, and attempts to protect ownership and intellectual property rights—the benefits of BIM adoption were clear. There was evidence as well that this level of control over the process is only necessary as an intermediate stage before project partners become more BIM literate, and that more efficient use of skills and resources will evolve as experience and understanding increases.

> "It is always more expensive to do it yourself. You have more influence, but it takes a lot of hours and things, that's the latest experience … If you asked me the same

> question a year ago or one and a half years ago maybe I would have told you that it's better to do it yourself, but at the moment it's going the other way. The companies are getting better at what they do, they listen to us better."
>
> *Interview 43—The Netherlands, Construction company*

As such, whether considered as a level of adoption that companies are comfortable with on an ongoing basis, or as a temporary stage in the process towards full BIM implementation, hybrid practices are seen to have value, no matter how much they fall short of the ideal of a fully BIM-enabled industry.

5.3.2 Multi-role specialists

Many of the interviewees have job titles that revealed the hybrid approach that their company takes to BIM, most commonly seen as CAD/BIM Manager. However, the label 'Manager' hides further hybridisation, as most BIM practitioners are required to take on a wide variety of roles. As illustrated in Figure 4, a BIM approach requires three main spheres of activity, with numerous tasks and activities within and connected to each.

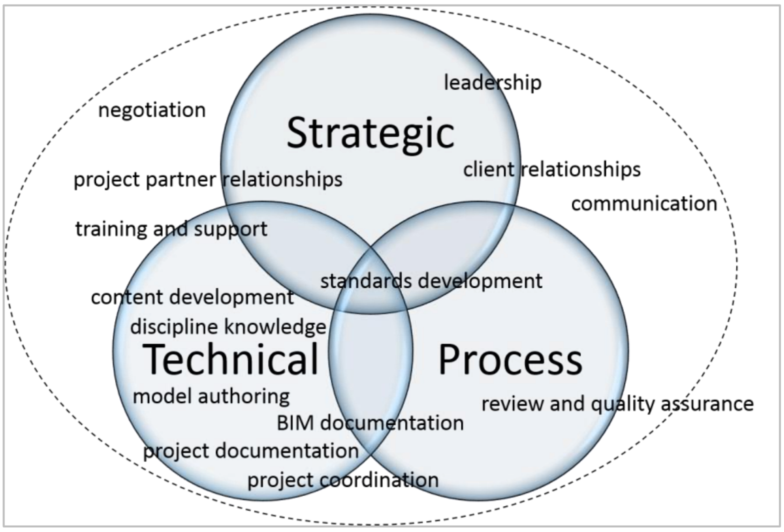

Figure 4 Spheres of BIM activity

One third of the BIM practitioners interviewed are in strategic positions, with little or no technical role, though most are also involved in process-focused activity. The other two-thirds of interviewees take on elements of all three spheres of activity, although usually concentrated on technical and process aspects. Almost all of those interviewed have some direct involvement in project delivery; for only three participants this involvement was described as minimal, and their focus is principally at an organisational rather than project level. The remainder have significant project involvement.

The demands of the multiple roles have resulted in frustration for many BIM practitioners that they are unable to advance the BIM practice in their organisation, because they have become too overwhelmed with maintaining the status quo. The lack of skilled staff available also has led to many stepping back into a hands-on technical role involving modelling and project documentation.

5.3.3 Collaboration, demonstration, education and mentoring

The BIM practitioners interviewed universally considered that they have a responsibility towards the wider industry to demonstrate good BIM practice to the best of their capability. It was suggested by many that the best way to make progress with BIM adoption is through practical demonstration that it works. By collaborating as much as they can with other companies within hybrid environments, they feel they are able to advance the understanding of BIM capabilities, and move their project partners further along the path towards embracing more integrated BIM,

> "…particularly if clients are continually doing projects that have the same team, yes they might have it on the shelf for the first project, but for the second project they might actually use it and by the third project they're able to successfully use it in an integrated and coordinated way."
>
> *Interview 5—NZ, documentation specialist*

Demonstration of the benefits of BIM use through case study projects, and representation of practice through industry fora and publications were other approaches that interviewees had been involved in. While many expressed some disappointment that they were still not able to demonstrate a 'pure BIM' project, the importance of showing the advantages of hybrid practice as an entry path into BIM was well-recognised.

Almost all of the BIM specialists interviewed are involved quite substantially in training and mentoring within their own companies. Some go beyond this into active involvement in organising and coordinating industry fora and training events, and also take part in structured mentoring of colleagues from other companies, whether collaborators or competitors. There were different opinions regarding the intellectual property issues raised by this level of collaboration and sharing of knowledge. One interviewee considered it to be necessary for the company and the wider industry, but describes it as a balancing act:

> "We try to avoid disclosing the core competitiveness, but… you have to collaborate with the wider industry…we're wary of that, to protect our investment, obviously, but for survival in the commercial environment you need to get success with the project and you need to deliver for the client, so if they fail the whole project fails…"
>
> *Interview 7—NZ, Engineering consultancy*

Another view was that there is little risk for the industry leaders, since there is such a wide discrepancy between those who have BIM capability and those who do not:

> "It's better to share the information, otherwise you're holding everyone back including ourselves… if we keep running, nobody can catch up with us – you want our IP, you want to be always copying what we're doing, fine, but we're going to be doing the next thing and the next thing and the next thing, and we've got a long way to go before we take this thing as far as it can go. If you're learning from me, you're behind me!" *Interview 34—NZ, Engineering consultancy*

Interviewees stressed the importance of education and knowledge-sharing to overcome the sceptical, defensive and protective approaches that are limiting wider adoption of BIM. More information and exposure to successful hybrid BIM implementations is considered necessary to help move the industry beyond these negative factors that inhibit BIM adoption at even a hybrid level, and move forward into tentative implementation and onward to greater integration and industry involvement in BIM practice.

5.3.4 Project protocols/execution plans

BIM execution plans (also described as project protocols, BIM planning guides, or BIM management plans) were developed for use in integrated BIM projects, but they were also described as vital for use in hybrid practice. By establishing the level of BIM capability of project partners at the outset of the project, an execution plan helps to articulate each party's expectations, and helps to avoid misunderstandings that may arise around what is expected in a BIM project, especially for newcomers to BIM. Some of the problems encountered by interviewees are fundamental to the use of BIM on a project, and require a bit more exploration of capabilities rather than a simple statement of expectations. For example:

> "On one occasion we… specified Revit as well, and we got this, it was a 3D dwg, inserted into Revit. So it was a full mechanical, all in 3D, but there was no data associated to it, you couldn't pick any of the objects. So in later contracts we tried

> to get agreement, agreed that we would follow the [company] best practice in BIM and tried to be a bit more specific." *Interview 5—NZ, Documentation specialist*

One respondent went further and is also pushing for the adoption of execution plans as an internal process for improving understanding about capabilities and expectations within his own company:

> "It makes sense. If we've got our BIM teams who are adept at making models, and then the project leaders, project managers and project directors don't know really what a BIM is, you've got to treat those guys as internal customers so they can give you a really clear scope of what they want. They may just want a big pile of drawings like they used to have. But they are the guys that are facing the client and taking the brief and understanding what the client's trying to get. So even if the client won't give us an execution plan, we should be able to get an execution plan from project leaders, and we can use that to deliver stuff internally."
>
> *Interview 8—NZ, Engineering consultancy*

There was widespread agreement that the standardisation of practice that was promoted by handbooks or BIM protocols is definitely an improvement on previous ad hoc approaches. Interviewees feel that instituting the handbooks' recommendations and using the associated protocols will assist with clarifying hybrid practice and help shift the industry towards more integrated BIM use.

5.4 Discussion

This examination of the underlying factors of hybrid practice and some of the approaches to managing it, suggests some further reflections on how hybrid practice needs to be viewed as a central element of the drive towards integrated BIM practice across the construction industry. Governments internationally have set goals of improved communication, more collaborative processes, and increased productivity through the sharing of building information across projects. In the UK and the Netherlands, mandates have been introduced for government projects. In the US, many state and central government clients and other large clients such as universities, have also introduced their own form of mandate. In New Zealand and Australia there are no formal mandates in place, but clients have started to introduce BIM capability as a qualifying factor when calling for expressions of interest for major construction projects, and for BIM models as a required product alongside the built facility. As a result, these findings can be seen to contribute to better understanding of routes towards BIM uptake.

5.4.1 The validity of hybrid practice

Despite the emphasis on negative causes in the evidence, the predominance of hybrid practice in project environments is a positive finding. It shows that even without reaching the ambitious and widely-touted aspiration of fully integrated BIM projects and organisations, practitioners are still able to use BIM processes and technology to help the industry take manageable steps to improve processes and outcomes. This is supported by previous research that investigates modes of BIM implementation. For example, Whyte (2011) suggests that any process of innovation will involve improvisation that balances established practices with the changes required of the new systems or processes. She argues that while the solutions that practitioners improvise for BIM adoption may differ significantly from recommended BIM standards, they nonetheless provide valid modes of adoption that meet project and organisational needs. Hartmann et al. (2012) demonstrate the successful adoption of BIM in the face of initially sceptical professionals, through alignment of the BIM tools with existing work practices with the adopting organisations. Although the level of BIM practice documented in their study was at a higher level than that described by many of the participants in this study, the conclusions nonetheless reflect a similar need for organisations to use the technology in a manner which fits naturally with their own processes in order to derive the benefits from it.

Thus it can be argued that hybrid practice is a valid end in itself, which allows industry participants to connect with BIM to a greater or lesser degree, according to their organisational abilities, and thereby achieve some of the efficiencies that the technology and processes facilitate. For some organisations, this may well be sufficient. If they do not have the resources or the need to become more fully involved with BIM, hybrid practice allows occasional and limited engagement and does not exclude less developed parties from industry participation.

This does not mean that hybrid practice should become the 'Frankenstein BIM' that interviewees described, which develops in an unstructured and uncontrolled manner and greatly reduces the opportunity for sharing information and facilitating project processes. Many of the complaints and criticisms of poor BIM practice revolve around issues with what can essentially be seen as traditional design management practice. The introduction of 3D modelling, exchange of model files, shared project repositories and other elements of BIM may drive different patterns of working and introduce additional factors for planning. It in no way replaces the need for clear definition of project expectations and responsibilities, establishment of communication channels and oversight of design and coordination activities that design management entails.

5.4.2 Moving from hybrid practice into integrated BIM

The second implication of these findings is the value of hybrid practice as a staging point in the process of increasing BIM capability across the industry. As organisations engage with BIM even to a limited extent, they are able to accrue some of the benefits and identify their own areas of advantage from the new modes of working. This is expressed well by Miettinen and Paavola (2014), who recognise the iterative nature of the adoption process, and the needs of practitioners to find workable solutions that are appropriate to their stage of progress. The many different varieties of hybrid practice are not barriers to effective BIM, but a pragmatic solution for companies and project teams to make gains where they can, and progress towards an improved BIM outcome. Further, Berente and Lee (2014) make the case for the potential of small, incremental process improvements to open the way for significant and radical innovation. This gradual process is seen in practice as a way to overcome resistance to change.

> "In the beginning, there are loads of people that are very hesitating and very resistant to change. And they say, "Look at these crazy idiots; I'm never going to do that. I've been doing this for 30 years using just drawings, so don't bother me, I'm not going to do it." But it gets harder for them every project to say that, because the group of people that actually does it using BIM is growing and sees, "Oh, wow, this is awesome! It's faster. It's better." Better communication, etc., all the advantages of using BIM. For the people that are very resistant, it gets harder and harder. As they become a minority… it changes."
>
> *Interview 42—The Netherlands, Construction company*

The use of a hybrid process can therefore be seen as an exploratory activity which allows companies to build knowledge and explore possibilities as they move toward more substantial changes.

Although BIM is commonly framed as a technological innovation, many of the gains it delivers lie in the collaborative environment that develops alongside the modelling and data exchange mechanisms. Hybrid practice can equally be used as a test-bed for BIM practitioners to explore such collaboration, following established protocols around project set up and management in a BIM context. Any benefits accrued may then lead to greater confidence in a more integrated BIM implementation. As Holzer (2011) explains, the impediments to successful BIM, meaning 'fully BIM' projects, lie much more in the cultural and political situation within organisations, and not with limitations of software and associated technology. A hybrid adoption process offers the potential for the issues with culture or management to be worked through in a less challenging setting.

5.5 Conclusions

A positive framing of hybrid practice can help to avoid unstructured and uncontrolled processes which result in the 'Frankenstein BIM' described by one participant. Viewing BIM practice as an evolutionary process, rather than a paradigm shift in the industry, may help to make potential gains more accessible. Some of the factors that necessitate hybrid project environments can be seen to impede more integrated BIM implementation, but it is argued that despite these negative causes, hybrid practice is a beneficial process in the development of BIM capacity across the industry. It can be viewed from two perspectives. First, it may be a valid implementation goal in its own right. Within organisations that do not have the resources or capability to engage more fully with BIM, or who do not consider that a fuller implementation will deliver any more benefit, hybrid practice allows BIM practitioners to realise some improvements from information exchange and collaborative processes, without requiring the company to make significant investment. Second, for organisations who do believe that increasing participation in BIM will deliver further improvements and improved returns, hybrid practice provides an incremental approach for exploring their capabilities, and allows BIM practitioners to develop more complex skills and processes as they progress towards a fully-integrated BIM environment.

From a practitioner perspective, accepting hybrid practice allows those taking a lead in BIM implementation to take a measured approach in developing their own skills and those of their colleagues, without expecting unrealistic outcomes. Not every organisation will progress beyond hybrid practice, but very few will achieve capability in an integrated BIM environment without providing the opportunity for practitioners to work within some hybrid projects along the way.

Part 2

6 Identity work in BIM practice

Chapter summary

In the international discourse around BIM, a variety of beliefs of what it means to be a BIM professional are evident. These include different interpretations of the purpose and practice of BIM which may not necessarily be reflected in actual practice but can be discerned in practitioners' perceptions and representations of themselves in a professional context. In Chapter 6 I focus on how BIM practitioners express their conceptualisation of BIM as part of their professional identity. By looking at where BIM sits within practitioners' professional narratives, I explore the different parts that BIM can play in the role identities of architects, engineers, technologists, contractors and other professionals, as well as those who primarily identify as a specialist BIM practitioner.

This examination of identity includes how BIM contributes to the ways practitioners view their professional selves, roles and associated activities; how this aligns with their organisational identity; and how they perceive BIM and their own involvement in the wider industry context. Different perspectives are offered of how BIM fits into the professional imaginary of the AEC industry, which provide insights into the effect of BIM practitioners on industry, organisation and project-level adoption and implementation efforts.

6.1 Introduction

The various transformations in technology and process that BIM introduces inevitably lead to associated changes in professional roles and relationships. Traditional role delineations shift and refocus within a BIM environment, and new roles emerge. Within the theoretical contexts of institutional work and organisational change, it is recognised that changes in processes, particularly including the introduction of new technologies, often result in transformations in professional and organisational configurations. These commonly involve the creation of new roles and evolution or reorganisation of existing roles and relationships (Labatut, Aggeri & Girard, 2012; Suddaby & Viale, 2011). For most of the BIM practitioners involved in this study, their roles and relationships have had to evolve through the process of 'being' BIM in their organisation, and taking responsibility for developing BIM practice, as there was no prior model for what a BIM role entailed or what sort of person should do it. This is an example of i*dentity work,* defined by Alvesson and Willmott (2002, p626) as "forming, repairing, maintaining, strengthening or revising the constructions that are productive of a precarious sense of coherence and distinctiveness." Identity work in the professional context is particularly important at times of work transition, to allow practitioners to develop a new professional identity that will allow them to attach meaning, develop coherence and establish legitimacy in their new role (Ibarra & Barbulescu, 2010).

Identity work is not a one-off undertaking, but an ongoing process of reflection and sensemaking that takes place at multiple levels (Lepisto, Crosina & Pratt, 2015). Different expressions of identity in a work environment include display aspects such as personal clothing and decoration of work spaces, as well as behavioural aspects such as demeanour and language choice (Ibarra, 1999), but is primarily concerned with expressions of how an individual prioritises their knowledge and skill within their work activities (Caza & Creary, 2016). Identity work in a professional context is relational, in that it commonly takes place in response to pressure and expectations of others; for example, direction from managers, examples provided by industry or professional leaders or other role-models, or defined models of behaviour established by professional memberships. Professionals must negotiate the value and importance of these various relationships with respect to the developing identity, in order to establish legitimacy in the role that they are claiming.

Although research in business and management has long paid considerable attention to issues of professional and organisational identity, construction management research has traditionally avoided aligning with mainstream management thinking (Bresnen & Marshall, 2001), and this area is no exception. More recently however, this has begun to change, and a number of studies of identity have been conducted within the construction environment. Gluch (2009) explored the identity of environmental professionals in a construction project context, and called for further research on the emergence of new professional roles in construction and their relationship with traditional roles and professional expertise. Identity of site-based construction workers has been examined from the perspective of quality (Styhre, 2012) and safety (Andersen, Karlsen, Kines, Joensson & Nielsen, 2015), both studies concluding that practitioners' identity can be influential in shaping organisational and project outcomes in relation to practice. Other studies exploring the professional identities of project managers (Hodgson & Paton, 2016), construction managers (Brown & Phua, 2011), and architects (Cohen, Wilkinson, Arnold & Finn, 2005; Ahuja, Nikolova & Clegg, 2017) also suggest that identity studies provide insights into practice, and argue the need for further research into identity work in professions in relation to the potentially conflicting demands of social, organisational and industry expectations.

This exploration of the identity work of BIM practitioners examines the narrative construction of identity (Ibarra & Barbulescu, 2010); that is, the ways in which the interviewees describe and explain their personal characteristics in relationship to their role, and their organisational and industry context. The next sections provide a brief introduction to the theoretical framework of personal, organisational, and industry identity used to examine the practitioners' narratives. Following this, the various ways in which practitioners accept or reject a BIM identity are explored. Two additional narratives are then presented which impact on practitioners' identity, and have implications for organisations and wider industry with respect to how BIM roles develop and are enacted.

6.1.1 Professional identity at a personal level

Professional role identity refers to an individual's self-perception in terms of the type of work they do and the organisation they work within. Wenger (1998) describes it as a 'nexus of multimembership' which requires an ongoing process of negotiation or reconciliation across multiple demands. Professional identity shapes and is shaped by the interactions and conflicts experienced by the individual (Lamb & Davidson, 2005), and encompasses a person's conscious or unconscious attachment to their view of their self to the expectations, ethics and experiences of their profession.

Identity is concerned with how individuals and groups behave within a professional environment. Identities are constructed and altered progressively through both self-reflection and observation, and interaction with others. Power structures in teams and organisations require individuals to negotiate and adjust their roles and areas of influence. One way that practitioners delineate their professional identity is in how they view other professional groups. Stereotypes and in- and out-groups are used to create definition of self and other, and establish frameworks for interaction (Loosemore & Tan, 2000).

The professional identity of the practitioners involved in BIM adoption and implementation will in turn affect the BIM environment they are associated with, particularly in situations where they take a leading role in establishing the organisational culture with respect to BIM.

6.1.2 Organisational identity

Organisational identity is another level of identity within the professional sphere, and relates to how strongly an individual feels association or alignment with their employing organisation, and how significant that association is to their self-perception (He & Brown, 2013). Although professional identity is not organisation-specific, organisational identity can affect how professional identity develops. Relevant aspects include how much practitioners feel they are empowered by the organisation to perform their role, the extent that organisations impose specific identity expectations on individuals, and what level of influence practitioners feel they have on the overall performance of the organisation. From such interactions between organisational and professional expectations, individuals substantiate their roles and practice, and develop a sense of who they are in a professional context.

6.1.3 Industry identity and professional imaginaries

The construction industry—commonly abbreviated as AEC (Architecture, Engineering and Construction), or further, as AECFM, with the addition of facilities management—is often referred to as though it were a single entity with uniform characteristics and goals. Despite the clear distinctions conveyed in these abbreviations, the disciplinary differences are not articulated, presenting an underlying assumption that the various sectors operate within a collective practice.

Conversely, many critiques of industry practice and analyses of barriers to innovation refer to the fragmented and disjointed nature of the industry, at both an organisational level and in terms of the overall construction market. Types of fragmentation described include the differences in practice across the domains of infrastructure and building construction. Within the buildings domain specifically, further differences include construction scale and the diverse specialisations required across and between commercial, industrial, residential, educational and medical construction. Further differences come into play with the division into roles in designing, constructing and operating the buildings, and further divisions again within each of those role sets.

These two opposing perspectives of the construction industry—a collective endeavour with a common goal, and a fragmented and disjointed collection of specialisations and purposes—are both examples of professional imaginaries that exist within the industry. *Professional imaginary* is a refocusing of the term *social imaginary*, which according to Taylor (2004), encompasses,

> ...the ways people imagine their social existence, how they fit together with others, how things go on between them and their fellows, the expectations that are normally met, and the deeper normative notions and images that underlie these expectations. (p23)

Considering professional imaginaries provides a view of the ways in which practitioners collectively interpret changes and developments in a profession, over and above evidence from practice. This can help reveal how professional roles are evolving as a result of perspectives or pressures on the industry. This is again drawn from within the literature on social imaginaries, where Taylor explains,

> What is originally just an idealization grows into a complex imaginary through being taken up and associated with social practices, in part traditional ones but ones often transformed by the contact. (Taylor, 2004, p29)

Professional imaginaries are thus concerned with the thoughts, beliefs, understandings and expectations that are held around a particular professional context. Imaginaries are not grounded in the everyday experiences and interactions of people involved in specific tasks and roles, but derive from narratives and visions created in order to contextualise practitioners' experience, or promulgated about and within the wider profession. The concept of professional imaginaries is used here as a means to understand and connect the practical and obvious manifestations of public and private life with the implicit and unspoken beliefs that also shape people's experience of their professional practice.

Changes in practice and the associated narratives around professional identity are thus interrelated with the professional imaginaries or collective understandings of the profession and industry context in their impact on evolution of roles and responsibilities. However, personal and professional narratives do not necessarily coincide, which can cause divergence in the professional imaginaries within a professional group.

6.2 Claiming a BIM identity

The opportunity that most interviewees had to develop their own conceptualisation and implementation of the BIM practitioner role has produced a wide range of identity narratives. In order to analyse and theorise practitioner identities, an iterative approach has been used to draw out themes related to professional practice, BIM experience and motivation, based on statements made by practitioners that claim or reject views of their identity in relation to BIM. These have been grouped to classify practitioners' identity work and its impact on their professional perspective and practice. This is subsequently connected to participants' narratives of how they perform their BIM roles, and how they see themselves connecting from their professional level with organisational and industry-level identities.

The interviewed practitioners participate in a wide range of activities, and are active across a range of BIM, BIM-hybrid and non-BIM projects. Most are involved in elements of almost every role related to their discipline, from top level management and coordination through to model authoring and modelling application expertise.

Table 11 provides examples of responses that expressed various claims related to BIM practitioner identity. Each example is drawn from the transcript of one interview, but conveys a particular type of attitude or experience that recurs across multiple respondents; these examples are referred to as exemplar narratives and the recurring patterns that they illustrate are identified as themes. A similar range of responses came from all of the countries included, and from across the range of disciplines and participant types. Not all expressions of identity are distinct, hence the brackets in Table 11 overlap where narratives include elements of adjacent themes.

Table 11 Identity claiming of BIM roles

Exemplar narrative	Theme	Identity claim
"I don't see BIM as part of my career plan specifically, only as a tool. I see BIM as a part of the QS role... The strategic role that I'm taking at the moment is kind of a temporary, well, semi-temporary role." *Interview 12—NZ, Cost and planning consultancy*	BIM as a tool to get the work done	
"I don't want to be the BIM manager, I want to be the project leader using BIM to do my job; I don't want to get into the BIM manager role as that will just detract me away from doing my job, from the interesting stuff." *Interview 22—Australia, Architectural practice*		Refused identity: 'Not a BIM practitioner'
"It's all a kind of new territory really... My impression is that it's still in its infancy here in New Zealand, the whole BIM thing... We've been talking about it for years really; since the first time we heard the word BIM, there's a big talk about it but in reality... I personally don't know anyone who's really implementing it as per the book." *Interview 25—NZ, Architectural practice*	Not really working in BIM	
"The problem is we're still using AutoCAD, we're still using other systems out there that aren't BIM, and I'm still supporting those... For me it's hard, and I would struggle to, I'd challenge anyone who says they're BIM managers, to actually prove that they're BIM managers and not just a software manager." *Interview 6—NZ, Engineering consultancy*		Tentative identity: 'BIM practitioner, but...'
"I only do the basic things, but we have an expression in the Netherlands, when you're in a country with people with only one eye, if you have two eyes you're ahead. It's a bit like that. ... If you know a little bit about what you're talking about and you have some skills and some knowledge from four or five years working with BIM, most of the time you turn out to be somebody at the table who knows most of it or almost most of it." *Interview 60—The Netherlands, Project management consultancy*	Lack of depth in BIM knowledge/ expertise	
"I guess I am in a project leader-slash-BIM manager for the office, sort of role. That said, I don't have enough time to do either role, so one part gets more priority. Obviously the project leader role takes precedence, because we have to look at resources and very short time frames to get stuff done." *Interview 20—Australia, Architectural practice*	Tension between BIM role and project role	
"Generally my role at the moment is, 'Hey you're on the project, can you take care of the coordination but you're also going to do these 50 drawings and design these things' which, that suits me. It's fine, but, that's probably a risk as well, because I'm a jack of all trades, master of none, I've got to try and cover all sorts of things." *Interview 35—NZ, Architectural practice*		Balanced identity: 'BIM practitioner, and...'
"I deliberately have tried to lose this horrible term 'BIM manager'... To me, BIM manager is a bit restricted to model-type stuff and I do much more than that in terms of what I do." *Interview 50—UK, Architectural practice*	Risk of being restricted by the identification with BIM	
"There's a risk of being pigeonholed as the BIM guy; whether I see that as a risk or an advantage I don't know." *Interview 35—NZ, architectural practice*		
"Trained, mastered, set up systems, sold; I think everything that one person could possibly do, I did... Now it's kind of seeing that in action, and getting excited and helping people get people excited about what they're doing, it's pretty good!" *Interview 16—Australia, Multi-disciplinary consultancy*	Engagement in variety of tasks with a BIM focus	Accepted identity: 'BIM practitioner"
I do things in projects, I have a little bit overview over colleagues, I help them with things they have to do, for meetings with subcontractors, and help them with presentations, and all these things. BIM manager has been the official function on my contract since last summer, but, unofficially I think I have been doing it for 2 years, 2 or 3 years, now." *Interview 43—The Netherlands, Construction company*		

6.2.1 Refused identity: 'Not a BIM practitioner'

Not all of the practitioners are comfortable in claiming a BIM practitioner identity, or accepting the 'BIM specialist' label that they have been given by their peers. Although they have come to be associated with BIM, these practitioners either do not see it as part of their professional identity, or are not confident that they have the necessary skill or commitment to claim a BIM practitioner identity.

The identity work for the practitioners who refuse the BIM identity outright commonly downplays the BIM component and focuses on their discipline role. They often identify very strongly with a traditional industry role, and see BIM as just one of a range of tools or skills that are useful in achieving their primary goals. Respondents in this category included architects, an architectural draughtsperson, and a quantity surveyor. All agreed that BIM was a central part of how they do their work, and that they are interested and engaged in using BIM as well as developing and sharing their BIM knowledge. Despite their level of involvement, however, BIM is not just incidental to their professional identity but is actively rejected in their narratives.

One BIM manager illustrated the need for caution in ascribing a BIM identity to practitioners on the basis of expertise in BIM, when that was not the way they perceived their role:

> "You know the saying 'cursing in the church'? If you call a BIM engineer a BIM modeler he's going to get very angry. 'I'm not a modeller,' he says. 'I'm an engineer, I engineer buildings.'" *Interview 40—The Netherlands, Construction company*

Others who rejected the BIM identity did so not because of a prior identity or focus on the product rather than the process, but because they do not feel they have sufficient expertise to claim it. In some cases, as illustrated in Table 11, this lack of BIM knowledge is seen as an industry-wide failing, while others consider themselves to be novices in BIM practice and therefore not yet ready to assert the 'BIM specialist' label that peers have ascribed to them. Practitioners in this latter class often bridge the gap between rejection and tentative acceptance of a BIM identity.

6.2.2 Tentative identity: 'BIM practitioner, but…'

Tentative acceptance of the identity came from several practitioners who are interested and willing to develop a BIM identity based on their level of interest and knowledge in

BIM, but with the caveat that currently they aren't 'really' involved in BIM. Their identity work asserts the value that BIM has to them personally, but ascribes their status as a 'BIM specialist' less to their own expertise per se, and more to the slight advantage they hold over the general level of ignorance in the wider industry. One reason cited for low awareness of BIM is the attitude of clients, and their lack of interest or willingness to require BIM adoption on their projects.

> "The clients I'm talking to, they're not bothered… we're pushing it big-time at the minute. The amount of software we're buying, spending money on, we've massive investment at the minute. I'm getting every single person in my region, everybody, trained. I've got a BIM appreciation course, which is basically a four-hour thing which is being run out. Everyone goes on that, without exception… I just need the opportunity. I need a client." *Interview 48—UK, Construction company*

There is also an element of cautiousness with many practitioners in claiming solo or hybrid BIM use as 'real BIM'. The low level of BIM knowledge in the industry is both blamed for restricting the use of BIM, and credited for elevating the interviewees, with what they consider their incomplete or insufficient BIM skills, to the status of BIM specialists.

Another source of hesitation in claiming BIM identity lies in the lack of definition of BIM roles. Practitioners in many cases observed that their status within their organisation and project teams is unclear, to others and even to themselves.

> "The roles are not defined very well. It's a very unusual kind of way of working, and it's what you make it as well. You get people screaming at you from some perspectives, and other perspectives are like 'I don't know what you do, I don't even know why you work here, I don't know what your role is.' It's probably something that I think sometimes too!"
>
> *Interview 14—Australia, Multi-disciplinary design practice*

Because of this lack of clarity regarding their role, practitioners are open to challenge from colleagues, and unsure of their authority or ability to act. While they may be willing to accept a professional BIM identity based on their own knowledge and skill, the absence of identity in relation to the organisation and wider industry leaves them in a tentative position.

6.2.3 Balanced identity: 'BIM practitioner, and…'

More widespread were the practitioners who claim BIM as part of their professional identity, but who emphasise that it is just one aspect of their role alongside other business functions or more traditional role definitions. In some cases, this situation was due to necessity in that their organisation lacked staff with the appropriate skills or experience or was not of a size to have a dedicated BIM role, and so they were required to take on multiple roles. In other cases, it was the preference of the practitioner to not be involved exclusively in BIM but to maintain a connection with other aspects of practice. Peer recognition of a BIM practitioner role is one of the challenges for a number of the participants, who consider that their contribution is often considered secondary, suggesting that "there is sometimes that tendency [to see you as] just the technician" (*Interview 2—NZ, Multi-disciplinary consultancy*), even when their qualifications and experience are equal to those of their peers. This seems particularly prevalent in the engineering field, where a clear distinction is maintained between designers and draughters (Whyte, 2011). In contrast, the practice in architecture is much more integrated, with one practitioner noting that,

> "Obviously, there are some team members who are more to do with the administration and office work, but everyone is essentially an architect or working to become an architect. The whole thing of technicians from an architecture point of view finished a while ago, I think." *Interview 55—UK, Architectural practice*

Nonetheless, many practitioners in architectural practices were often at pains to make clear that their identity does not solely lie in being a BIM practitioner, but that they have design skills and involvement as well. Similarly, in construction companies, practitioners often emphasised their breadth of experience, to illustrate that they are not 'just' BIM practitioners.

> "I've done lots of engineering stuff, I'm very technical-minded. One of the criticisms of most people in BIM is that they're not, there's not much commercial focus there." *Interview 57—UK, Construction company*

A sense of risk is expressed in the narratives of a number of interviewees who balance BIM identity alongside another professional alignment; a concern that BIM may become a dead-end path rather than offering the prospect of a new career direction. One interviewee described the BIM direction as people having "deviated away from their careers" (

Interview 46—UK, Multi-disciplinary consultancy), and indicated that in future he may switch back to his previous design-focused role. In this case, despite his successful career and rapid promotion to a senior BIM role, such a comment indicates that 'BIM practitioner' is not a core part of this practitioner's professional identity.

For others, however, the evolving role is not seen as a conflict, but as an opportunity to develop additional skills and add or extend parts of their role that they enjoy. Being identified as a BIM practitioner, in this mindset, is an opportunity to test out a new professional identity, without having to commit fully to one or the other.

> They call me a BIM specialist. It's a big word! Three years ago, the manager asked me to come and work here because they wanted to do BIM. He didn't know what BIM was, but he heard BIM is hot so we had to do BIM. I had a little experience in introducing BIM in an organisation. He asked me, will you do the same here. I'm still a cost engineer. I come from within the projects and I like estimating the cost, just digging deep in the project. But I also like to talk with people, let them know what they're doing right and what they can do better. So I'm also the BIM manager at some projects. *Interview 44—The Netherlands, Cost consultancy*

Expressions used to describe this diversification from an intended career path included "another string to my bow", having "different hats if I want them". Other interviewees see it the other way around, and identified that having an architecture or construction background could be 'a safety net' to revert back to if it became evident that their current role was only necessary in a transitional stage of BIM adoption.

6.2.4 Accepted identity: 'BIM practitioner'

A minority of participants accept a BIM identity fully, and do not qualify their BIM identity with 'but', 'and' or 'almost'. To these individuals, the sum of their experience and the range of tasks and activities they are involved with do not detract or sit alongside their BIM identity, but contribute to the characteristics of the role they have constructed. In this case, the identity work asserts the practitioners' holistic professional identity, claiming all the varied aspects of their job as part of the BIM role.

Several of these participants are in strategic roles within their organisation, and are working to develop a more integrated view of BIM at an organisational level, as well as for their own role and those of their staff.

> "Our vision of what BIM is, it's changed… BIM was first very 3D oriented. Since the beginning of this year, I became responsible for the complete project information management within [company]. Also, for document management, also for requirements management, also for process management, also for scheduling. We get a lot of applications we use in our projects and the reason is that we say, 'Okay, all these applications, together with 3D and GIS, are BIM, if we integrate it.'"
>
> *Interview 39—The Netherlands, Engineering and management consultancy*

At an operations level, the identity work of those claiming a BIM identity is oriented around the diversity of the role, as illustrated by the 'Refused identity' exemplar narratives in Table 11. At both operational and organisational levels, integration and connection are key elements of the narratives.

These different identity claims reflect changing patterns regarding careers and employment, not just within the construction industry but in society more broadly. Career patterns are generally shifting away from traditional models where professionals focus on roles which build on their background education and existing skills. Practitioners who expressed the '*not BIM*' perspective of the 'Refused identity' claim are examples of this older approach. Practitioners who expressed 'Balanced identity' or 'Accepted identity' perspectives are representative of the increasingly popular 'protean' approach to career development, where professionals are more flexible, adaptable and willing to diversify in response to opportunities (Clarke, 2009).

6.3 Identity and practice

These various expressions of BIM identity convey how practitioners position themselves in relation to BIM, but also provide insights into how they see the implementation of BIM within their own and partner organisations, and in the industry as a whole. Two aspects that affect practitioners' development of a BIM identity have been highlighted in the following discussion. First, findings show that tensions between BIM and project practice are a central influence in how a practitioner's BIM identity develops. Similarly, further tensions exist around the nature of the design process and its place in the technology-centred environment that BIM use often generates.

6.3.1 Balancing BIM role against project focus

Many of the practitioners expressed a feeling of constant struggle to carve out the time required to adequately perform their BIM role. Because they are identified as BIM specialists, they are expected to develop and disseminate BIM skills as well as implement practice standards and processes for appropriate BIM use within their organisation. Set against this is the need for them to be 'hands-on' with BIM in project delivery, commonly because of a lack of other staff with the necessary BIM skills. For many, this means their BIM role is less about management of the virtual project within the BIM framework, which they see as a priority, and more about producing the deliverables for the physical project which is a priority to other project participants. The necessary reframing of processes and relationships to enable effective BIM use is thus constantly undermined by the lack of resourcing and the prioritisation of traditional project roles over performing a BIM identity.

> "I'm trying to get the office up to speed, get all the systems in place, but I've only got maybe an hour or two a week to do it. It's going to need a lot more than that! I'd be 90 percent project work and 10 percent my other [BIM] role, if that. I'd rather 50 percent—when I joined they sold it as being half and half, but that's definitely not happening." *Interview 20—Australia, Architectural practice*

Despite the BIM practitioners' assertions about the value of their strategic and process-centred BIM activities to their organisation and project teams, the cues they receive from their environment are contradictory and frequently relegate BIM to a technical delivery role. In such a situation, the practitioner's BIM identity is jeopardised by a fundamental misalignment between the individual's assertion of the importance of BIM and the changes it brings, against existing work practices and the established institutional logic (Linderoth, 2016).

The overriding influence in the conflict between establishing longer term, more fundamental standards, and immediate project needs, is the established professional imaginary of the primacy of project requirements (Jacobsson & Linderoth, 2010). However, this need not be the case. Merschbrock and Munkvold (2015) describe an attempt to counter this where the client took a very different approach, engaging in a project with the explicitly stated goal of increasing the BIM competency of the project team and providing access to skills and knowledge that could be transferred to other projects in the future. A significant site-based training programme was structured to develop the skills of all participants, though to different levels of expertise as required by their roles. By neutralising the traditional expectation of project demands in this way, practitioners are provided the space to develop their BIM identity, which is accorded significance as a legitimate project outcome.

6.3.2 Technology/design conflict

Similar tension is evident in the relationship between BIM and the design process. For practitioners with a background in design, the development of a BIM practitioner identity can be challenged by perceptions that BIM is technocentric and not aligned with the creative processes of design. This has been a concern of designers regarding IT generally, but has become more prevalent with the advent of BIM. Barrow (2004) considered the role of the traditional architect in the face of 'cybernetic architecture'. He noted key changes in practice, with the digital model taking a central role in the design process, along with a much-extended design team with collaboration from a range of contributors. Although he presents both dilemmas and opportunities resulting from the challenge of IT in the design profession, Barrow appears to take the position that IT (and BIM) provides scope for new roles—but that those who pursue them can not necessarily be considered architects. This interpretation was echoed by some interviewees who suggested that taking a BIM path meant no longer being an architect.

> "I was an architect for 10 years, so I graduated and had my own office for 10 years … I started looking at what kind of work I would like to do because I wasn't interested to just keep doing what I was doing as an architect. Because you know, as an architect you have different options, and I was like 'wow, I did that for 10 years, I have 25 more to go until I retire. Do I really want to do the same again and again and again?' … I started looking at BIM and started to really think that BIM is changing the construction industry, and I wanted to be part of the change."
>
> *Interview 47—UK, Fit-out designer and manufacturer*

While many of the engineering or construction discipline practitioners conveyed a sense of balancing their identity as a BIM practitioner alongside their more traditional discipline roles, the narratives from most of the architects expressed the choice of being either a BIM practitioner or an architect. For these participants, developing as a BIM practitioner was risky because it meant letting go of a previously held identity. For some, this conflict between the two roles was a disincentive to adopting a BIM identity, because of the investment of time and effort, not to mention the expense of studying, that had already gone into the identity of being an architect.

> "It's uncomfortable in the fact that I spent five years training as an architect… so it's a lot of time that I've spent training in different areas, where I haven't actually applied it fully. There's a bit of frustration involved with that."
>
> *Interview 17—Australia, Architectural practice*

For others, developing their identity as an architect had already become problematic because they found that the practice of architecture did not match the conceptualisation or expectations that they had held for their career (Ahuja et al., 2017). Pursuing a BIM role in this case offered an alternative path that made use of previous architectural training and experience, while providing the opportunity to develop a new professional identity.

> "I went into industry and decided to not finish my degree, I realised very quickly that I didn't actually want to be an architect, that the reality of what it was wasn't what I thought it was. I didn't have the patience to spend the next 20 years doing someone's draughting. The potential to be the yellowtrace director while someone else does the work, the reality for me, my personal experience, the actual reality of the job was something quite mundane."
>
> *Interview 13—Australia, Architectural practice*

Architects who were more successful aligning a BIM identity with their traditional role tended to be involved in BIM at a strategic level rather than at an operational level. They were generally in a senior position and knew enough about BIM to provide the resources required to enable others to take on the practical work of BIM implementation, but not to engage in using BIM tools themselves. Their BIM identity was much more in the mould of BIM champion (Ho & Rajabifard, 2016) rather than BIM practitioner.

> "I'm not a user… I can just normally stand over somebody's shoulder, but I quite enjoy getting the best out of it because I've found that my role is one of, I can spend the money, so I can make certain things happen. Also I sort of try and suss out where I can get the best out of them." *Interview 32—NZ, Architectural practice*

Comments from practitioners in other disciplines were often critical of how architects made use of BIM. Although the architectural profession was recognised as an early leader in BIM adoption, many participants, including architects themselves, thought that this lead had been lost. Main criticisms included a lack of depth in BIM use, resulting in a focus on geometry, 3D tools and presentation, rather than the management of information in the model.

> "Our profession are just not on the page when it comes to the data side. The thing with architects is they've been in the world of geometry for a long time, they've been doing visualizations and so on, using Revit for ten years. Everyone is like, 'You know BIM,' 'Yeah, we know, we've been using Revit.' Well, BIM is not Revit... Someone Tweeted to me recently, they were saying, 'What is it about empty models?' I was thinking, 'Empty models? What the hell are they talking about?' Then I realised that was a model where it was all geometry and no data in it."
>
> *Interview 64—UK, Multi-disciplinary consultancy*

Again, the development of a BIM identity is stymied by a professional imaginary, in this case an established perception of the architect's identity as centred on creativity, individuality and aesthetics (Cohen et al., 2005). Such a representation of the architect's role is not only at odds with the need for architects' participation in BIM practice, it does not align with architectural practice more generally (Ahuja et al., 2017). Challenging the accepted vision of the architect in the professional imaginary is a difficult task but one that may be required of educators and professional bodies in order to allow a more diverse representation of the roles an architect may play. With a more diverse professional identity, architects would have greater freedom to achieve a balanced BIM practitioner identity.

6.4 Supplementary narratives

A number of repeating narratives were evident across the interviews that revealed facets of the professional imaginary that introduce challenges to practitioners' identity work. Four of these supplementary narratives were notable for their frequency, and have been expanded on here with a consideration of their implications for BIM identity. Two of the common narratives are related to the hype around BIM as a transformational force in the industry, the idea of BIM as a 'magic wand' that will transform the industry, and the view of BIM as a 'Trojan Horse' for industry change. The associated rhetoric of BIM as a revolution within the industry is another challenging narrative that has underlying influences and assumptions about developing a professional identity in BIM. Finally, a widespread focus on age and generational factors is also examined.

6.4.1 BIM as a magic wand

A challenge for organisations in achieving the progress that BM practitioners may need to support their BIM identity is the extent of improvement that is possible within a single organisation, without support and buy-in from project partners and other industry participants. A narrative that appears to be becoming part of the professional imaginary around BIM was characterised by interviewees variously as seeing BIM as a 'magic wand' or a 'silver bullet'. This narrative suggests that introducing BIM will solve many of the problems faced by the construction industry, such as fragmented workflows, a lack of collaboration, and wasteful and unproductive practices. Government pronouncements around construction industry reforms, including BIM, appear to be the source of this belief. Such statements also often include an expectation of cost reductions (ACIF & APCC, 2017; Cabinet Office, 2011; MBIE, 2013). Because the most evident changes and drives in the industry are often the moves towards BIM, this gives the impression that the savings touted will result from BIM alone.

> "I've had other clients who want a twenty percent cut on the job because they've read somewhere that BIM saves twenty percent. So, I've got this ten million pound job and it's only eight million now." *Interview 48 – UK, Construction company*

Such misinterpretations of the value of BIM were not limited to clients. Practitioners related the experience that within some companies, the idea was simplified to the level that simply buying Revit was considered enough to start a new programme of efficiency and cost benefits. The wider context, that a reduction in costs is related to changes made possible by better information management through the use of a BIM model in operations and management and the extended building life cycle, was not recognised.

While some of the BIM practitioners reported this professional imaginary as a challenge that they faced in establishing effective BIM practice and meeting the expectations of others, a number of the practitioners themselves supported this narrative and had adopted it into their professional identity. They saw themselves as champions of the industry, with the power to create substantial change through their own practice. This leads to a risk of over-promising and under-delivering, that leads to disillusionment and risk aversion.

> "One of the things that slowed the BIM process down a lot, is that a lot of people promised things they couldn't actually deliver, fairly early on…and that sort of thing sets up a lot of bad blood, and people tend to hear of it and think, nah I'm not going to get anywhere down that path."
>
> *Interview 4—NZ, architectural practice*

Unrealistic expectations, whether on the part of practitioners themselves or others in their working environment, are likely to pose a challenge to the developing BIM identities of practitioners, and thus to successful BIM adoption and implementation.

6.4.2 The Trojan Horse myth

The Trojan Horse narrative is an aspirational view of the change that BIM can bring to the industry, that goes well beyond the boundaries of traditional definitions of BIM. In the traditional Greek story, the Trojan horse was a deception to get soldiers through the gates of Troy to conquer the city; in the BIM context, BIM is seen as a 'trick' to allow industry leaders to bring in solutions to overcoming many of the problems that the industry faces. In this view, BIM provides a vehicle for change, with an expectation of much greater impact than the core ideas of information quality and management that are the purported reasons for introducing it. For example, better work practices introduced by BIM can be used to 'piggyback' improvements in working conditions and hours (Poirier, Staub-French & Forgues, 2015). As the change to working in BIM starts to come into effect, it drives a climate of change which allows for additional and unrelated strategies to be attached to the movement—such as improved education and training for the industry; more inclusive hiring practices; reduced use of carbon and better environmental outcomes; and ultimately delivering a better built environment, with benefits to society as a whole.

The main tellers of this narrative tend to be practitioners involved in organisational BIM strategy, and leadership in roles beyond their own organisation; of the 22 interviewees who expressed the Trojan Horse narrative, 18 identified that they had responsibility for strategic decision-making in some form. This included all of the participants in a primarily strategic role, and six who had no direct involvement in BIM strategy for their organisation but had wider industry influence through industry forums or other networks. A further four respondents who had no strategic involvement also supported this narrative. This suggests that those with responsibility for enacting change beyond the immediate BIM process and technical level are frustrated with the state of the industry in a broader sense, and feel that BIM may be a way to energise the movement for change. Interviewees spoke with enthusiasm about how BIM adoption and implementation had the potential to provide the impetus for wider industry and societal change. The narrative tapped into the overarching identity driver of improvement that was expressed by many of the practitioners.

> "I talk about making a difference. With whatever I do, from personal life through to work life, it's about making a difference, so if I'm in this industry I'm here to make a difference." *Interview 16—Australia, Multi-disciplinary consultancy*

The Trojan Horse narrative was common in the UK, which is unsurprising given that their industry leaders have used this metaphor in various forums, and declared this indirect movement for change as an intention of the UK Government's BIM mandate (e.g., "David Philp on mandate day: BIM is the 'Trojan Horse' that gave industry a kick", 2016).

A more pragmatic view of the Trojan horse approach was that it provided a means of demonstrating some straightforward and distinct improvements that could be then used to leverage implementation of more abstract or complicated change.

> "[Supply chain management] is hard to improve… If I would have started with this, then all of my colleagues would have said, 'You're crazy, man!' Because it's too abstract. Lean also, continuous improvement… analyzing your processes and basically saying, 'Okay, we can cut this out, this out, this out' … too abstract. But if I look at BIM, which is basically a 3D model, then it's actually very logical. Engineers, they like logical. And they recognise it and they say, 'Oh! It's a building! I totally understand that!'" *Interview 42—The Netherlands, Construction company*

From BIM specialists at a technical or implementation level there can be a degree of wariness about what this rhetoric will mean for their roles. While there is also a lot of positivity about the changes that could be brought about, there is often concern about the time and effort required to keep abreast of all the initiatives involved. There are fears that the focus of their work may become too broad, and the practical company and project-specific gains that BIM can deliver in the short term become lost in the profusion of diffuse possibilities and hopes that people have attached to it. There is also an associated risk that the enthusiasm of the leaders and champions will wane as the changes that motivate them are slow to eventuate or lost in other initiatives. Training and support for specialist roles needs to be very extensive and wide ranging if individuals are expected to cover such a wide range of capabilities that extend much further than discipline and technical knowledge. In addition, BIM practitioners will be working on so many levels that they will become the 'Jack of all trades, master of none'; a problem already identified as common in the role, even within the core practice of BIM.

> "You're a bit of everything, but you're not core skills in any one thing… I think that's why the quality is not there. People are too far stretched, to be a bit of everything." *Interview 14—Australia, Multi-disciplinary design practice*

Furthermore, time spent on side issues such as diversity, education and image building is time that is not related to projects and outputs, and so is difficult for companies to fund. BIM specialists already describe a tension between project-based and practice-based activities, and a resistance by companies to fund BIM activity as an overhead. Additional overhead requirements can only put further pressure on the role.

6.4.3 The BIM revolution

The 'slogan' that the change to BIM is 'a revolution, not an evolution' was repeated by many interviewees, and the idea that they were helping bring about a change to established practice was a popular element in practitioners' BIM identities. However, even though the concept of BIM driving radical change was present in many interviews, it was not actually supported by the surrounding narratives about practice, which tended to focus on achieving transformation through incremental, evolutionary change. Even interviewees who specifically used the phrase 'revolution, not evolution' described wider experiences with BIM that did not correspond to that narrative.

> "The dissemination of information is quite slow. We're still, I suppose, making the transition from flatland to information-rich 3D. Where a lot of the traditional disciplines have been delivered in 2D, actually delivering in 3D is quite a challenge." *Interview 8—NZ, Engineering consultancy*

Several interviewees used the phrase 'revolution, not evolution', alongside a quote attributed to Charles Darwin, to illustrate the paradigm shift that they perceive BIM brings to the industry: 'It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is most adaptable to change' – an ironic choice given that Darwin is known as the 'Father of Evolution.' This apparent cognitive dissonance is an example of the influence that narratives have on both professional identity and the professional imaginary, and is an illustration of the hype that has characterised BIM development (Fox, 2014). Adoption and acceptance of BIM has been shown to be more successful when it does not disrupt existing work practices (Hartmann et al., 2012, Davies & Harty, 2013), so the described practice has support as an appropriate approach in effecting change. However, once hype perceptions such as this narrative take hold, they have the potential to override the experience and earned knowledge of those in the industry.

Another negative aspect to the revolution narrative is that it portrays the change as a violent one, which is contrary to the message of BIM as a driver for better communication, less adversarial practice and greater transparency between industry participants. The idea that they were fighting for a new way of working was popular with several practitioners, who used metaphors of war and battle, as well as revolution, to express their desire for change.

> "This should be revolution. It should be a totally different way where we're working and we're communicating, but revolution, that will happen from one day to another, it's overnight, and this definitely is not going to happen overnight. It's not a revolution, this is a real long war. It's still not bloody enough!"
>
> *Interview 66—The Netherlands, Building information specialist*

The risk of such beliefs becoming part of the professional imaginary is that if practitioners hear that BIM adoption should happen as a single sweeping change, particularly an aggressive change, they may be put off from even attempting it as they shy away from the image of revolution. They may believe they do not have the ability or resources to make such a substantial transition, or they will attempt to move into BIM with this expectation and be disappointed to find that the reality of their process is much less dynamic and more hesitant than anticipated (Dainty et al., 2017). This frustration was evident in several of the interviewees, who had been trying to bring about the 'revolution' but found they were making only incremental gains.

> "It's been 7 years, and I've been pushing this boat now for 7 years, I suppose I'm a little bit, what's the word? Gun-shy? You can only push it for so long and get nowhere, you get a bit disillusioned with it."
>
> *Interview 30—NZ, Architectural practice*

By integrating the 'revolutionary' aspect into their professional identity, practitioners can find themselves caught in a paradox as their identity comes into conflict with the realities of practice (Ahuja et al., 2017). This may constrain their personal development in their role, and can lead to dissatisfaction, cynicism or outright rejection of the identity or the organisation (Kira & Balkin, 2014). Such a situation demonstrates the need for BIM rhetoric to be more grounded in practice (Miettinen & Paavola, 2014).

6.4.4 The generation gap

As argued by Čuš Babič and Rebolj (2016), there is a great deal of personal, organisational, and industry investment in maintaining existing patterns of work and relationships within an accepted framework, so it is a slow and difficult process to make changes to established practice. Many participants considered that BIM requires a generational shift, asserting that significant changes in BIM practice will not be realised until the current generation of senior staff and managers move on. Their argument is that because BIM is so technology focused, the new generation of graduates and employees are the ones who will be fully adapted to the process and accepting of its use. Underpinning this narrative is an assumption that young people are 'digital natives', therefore it is natural to them to be using computers in their everyday work and they would be surprised if they were not. This 'generational shift' narrative formed part of the identity of almost all the practitioners under 30, but was common across all age-groups. Older participants, despite being acknowledged as BIM specialists themselves, and often engaged in the active use of BIM and other computing technologies, still considered that it was too hard to expect older people to be able to adapt to the more immersive technological environment that BIM demands. In almost all cases where an age delineation was given, 35 was stated as the oldest age at which it could be taken for granted that practitioners could adapt to computer use as an integral part of their role. Several reasons were given for this rather simplistic demarcation. The most common explanation was that anyone older than this had not had the experience of being immersed in technology throughout their education. Although computer use would have been commonplace in their working life, exposure to technology from a young age was perceived as more important. Another explanation was that generational attitude was the dominant factor, rather than technology use. Previous generations were described as unwilling to challenge the status quo, whereas the current generation is seen as less accepting, demanding to know why things are done in a particular way. Another view was that it was not generational differences that were important, but stage of life. People were considered to find change more difficult as they age, and to prioritise maintaining status and job security rather than take on new training and work practices. Other practitioners advised caution about accepting this 'generation gap" narrative, because it undermined the importance of the discipline-based skills.

> "What we must be aware of, pulling in all young people, is demolishing your engineering knowledge. So we have to find a balance between engineering and BIM." *Interview 40—The Netherlands, Construction company*

An effect of the widespread acceptance of this narrative was evident in the career progression of several of the younger people interviewed, who commented that they had progressed much faster in their role, into more senior positions or with greater responsibility than their peers, because they had chosen to focus on BIM practice.

> "There was such a huge lack of individuals within the construction sector that have good knowledge of this stuff, so it is giving young guys like myself opportunity to take really senior business roles, because the senior business guys have no knowledge of it. I'm probably the youngest person [on the company Board] by twenty years at least, probably twenty-five years."
>
> *Interview 46—UK, Multi-disciplinary consultancy*

Despite their relative lack of experience, these practitioners are involved in more significant and influential positions because of their knowledge of technology and the power of new computing approaches. Arguably, they are thus able to make a greater contribution than if they had followed a more traditional discipline-based path. A significant risk within this narrative, however, is that companies may believe that that young practitioners have the necessary skills to operate in a BIM environment, or even to lead a BIM adoption process, simply by virtue of youth. Without a critical awareness of the requirements of BIM implementation and knowledge of the specific skill-set and experience of individual BIM practitioners, relying on age as a determining factor is unlikely to deliver successful outcomes.

6.5 Conclusions

Clearly, BIM practitioners are including BIM as an aspect of their professional identity in some way, although some of the practitioners interviewed expressed it in terms of ambivalence or outright rejection. The most common approach was '*BIM, and…*', adding BIM to the professional identity but maintaining an association and strong connection to traditional roles, with assertions of skills and experience beyond BIM. This also indicated that there was often a negative attachment to being 'just BIM'. Many of the practitioners had become involved in a BIM identity by default, through others labelling them as the

‘BIM guy’, and some were concerned that such a label brought a risk of being pigeonholed in a particular role, or side-lined from more central project involvement.

AEC careers tend to follow established pathways with relatively well-defined roles. BIM practice appears to require practitioners to cross or at least blur some of the lines between traditional roles, which can be problematic in terms of professional identity and career progression. More flexible career approaches that enable practitioners to cross between areas of interest would allow BIM expertise to flourish alongside traditional discipline roles. Patterns of career development that accommodate a less-defined career model would support BIM identity. Companies that embrace this approach would benefit through attracting and retaining skilled practitioners who are passionate about developing innovative practice. Currently BIM identity tends not to be associated with the specific organisation that a practitioner works for, but to personal skills development and to the industry as a whole.

The relationship between professional identity and the imaginaries of the professional context is significant with regard to how people position themselves within the industry, and frame their practice and career aspirations. Practitioners’ narratives reveal a number of important messages of relevance to both practitioners and organisations involved in BIM practice. There is often a conflict between the project-centred focus of organisations against the BIM requirements of many of the practitioners’ roles, which challenges the validity or value of a BIM identity by asserting the dominance of project deliverables and deadlines over longer term development of BIM standards and processes. Other professional imaginaries can also conflict with individuals’ professional identity, which sets up tensions between the expectations of the BIM role and the realities of practice that challenge those expectations.

Where BIM has caught the attention of the wider industry, it has generally suffered by being over-inflated through hype or under-valued as a technical fix. BIM practitioners have often bought into this ‘crusader’ view BIM and express frustration that their efforts are not achieving the degree of change that they believe should be possible. BIM practitioners are not immune to hype, and experience does not necessarily override idealism or the desire for the industry to perform better. While the intentions the narratives embody are optimistic, they add further performance challenges for practitioners and organisations that may already be overwhelmed by the degree of change required to implement BIM.

Widespread shifts in the industry's understanding and interpretation of BIM roles are needed, to allow better alignment between roles and expectations, for BIM practitioners as well as industry participants more generally. For many practitioners, BIM is not yet a substantial part of their professional identity, so if misalignment results in frustration or disillusion, they may abandon their BIM identity as a distraction from their 'real' career path. This would leave the transition to BIM practice incomplete for their organisation and the industry.

7 Performance of BIM identity

Chapter summary

Performance is an essential element of any professional identity. The roles which BIM practitioners perform are diverse, and take place within projects, organisations and the wider industry. In Chapter 7, I discuss further the elements of BIM identity expressed in interviewees' narratives, focusing on their descriptions of what is involved in the performance of their roles. As well as describing tasks and activities, the narratives of performance also include expectations on BIM practitioners, and aspects of aptitude, motivation and experience, as well as some of the influencing factors that affect how BIM identity is performed, and by whom. Different ways of viewing identity in the professional context include a focus on definition, in terms of the requirements and prescribed actions assigned to particular roles, or alternatively an emphasis on motivation and purpose that is more personal to the individual carrying out the role. These different views of identity can act in synergy, to embed practitioners in their roles, or in opposition to one another, which introduces role conflict.

7.1 Introduction

Identity work, as discussed in Chapter 6, is not simply a matter of developing a sense of self. A professional identity provides an individual with a framework for both 'being' and 'doing', within their professional environment (Lepisto et al., 2015). Performance, and the narratives developed around the actions and drivers of performing, are therefore important aspects in practitioners' representation of their professional identity. Furthermore, narratives are central to the formulation of identity as they provide practitioners with the opportunity for reflection on their practice; as described by Styhre (2012, p635), "'saying' and 'doing' are thus what construct identities". Narratives of performance provide a conscious interpretation of actions and behaviour, which can be considered a constructed or 'curated' perspective of how a speaker wants to be perceived, rather than an impartial representation of what they do. Despite this, interviews are not incompatible with developing an understanding of performance. As expressed by Atkinson, Coffey and Delamont (2003), interviewees may show bias or distortion in their retelling of their behaviour and activities, but interviews provide a valid approach to understanding their perspective, in that their narrative reveals "how they chronicle facts and evidence; how they represent their own motives and feelings; how they attribute motives to others; how they display the rationality of their own and others' actions." (p132)

The following analysis presents two central representations of performance of BIM identity. First, based on participants' descriptions of what their roles involve, a set of roles is defined. This is aligned with roles outlined in the literature, and with formal descriptions from BIM guides and handbooks, as discussed in Chapter 3. Second, drawing on practitioners' self-concepts expressed in their narratives, an alternative division of BIM performance is explored, centred on alignments between work and identities. Additionally, four supplementary narratives are included, two of which consider stated descriptions of performance requirements in terms of skills and knowledge. The other two narratives do not explicitly address performance expectations, but imply attitudes regarding practice and practitioners that may challenge BIM identity development. These different descriptions and narratives are then considered in a wider context, in terms of the impact that roles and role performance have on BIM practice.

7.2 Roles by description

As they were appointed or moved into a new role within an organisation that often had little or no experience of BIM practice, the BIM practitioners interviewed frequently had a significant influence on setting the direction of BIM practice within the organisation. Many noted that they were employed in their current role for the specific purpose of implementing BIM for their company. Even where an organisation already had a BIM framework in place, it was common for interviewees to state that they had no specific job description, and often that they did not have a formal position in the company structure or hierarchy. Individuals were in many cases responsible for determining the scope and requirements of their own position.

> "My task isn't on paper what I should do, so I just make things myself. I have to make my own function, I still have to make it, my job description. I have to figure out for myself what it is." *Interview 43—The Netherlands, Construction company*

As a result, practitioners often had considerable latitude in determining both their own role and how they enacted BIM practice within organisations and project teams.

As previously described in Chapter 5, a BIM approach requires three main spheres of activity, involving strategy, process and technical roles. Each of these spheres involves numerous activities and relationships, many of them interconnected. As a result, 'the BIM practitioner' is often not framed within a single role but spans a tiered structure of different BIM interests, at different levels of authority within an organisation. These are not always independent roles, and many of the participants embody a number of different BIM roles, as well as additional project and organisational roles outside of their BIM remit. A range of factors contribute to the way practitioners' have developed their roles, in particular the leadership and knowledge within their organisation; the level they have been appointed into within the organisation; the amount of exposure they have had to national and international practice, research and development; and their own personal areas of interest.

Five BIM role definitions have been identified, based on alignment between participants' descriptions of their roles and activities, and formal BIM roles identified in BIM guides and handbooks (as presented in Chapter 3), and from descriptions in the literature. These are shown in Table 12, with exemplar narratives and associated coding of key elements which illustrate the range of experience and expertise included in the study participants.

Table 12 Role description narratives

Role definition	Exemplar narratives	Key elements
Management level	"I think every single firm within the construction sector needs someone to lead BIM within that firm…To understand the impact of it and to really use it as a tool to grow a business, or to allow a business to survive, allow a business to keep existing clients, it needs somebody who will lead and can be this type of talisman for the company." *Interview 46—UK, Multi-disciplinary consultancy*	Leadership and direction for company; understand business impact of BIM
	"Too often, we think on a project level, but I think we have to think on other levels as well. Of course, we work from project level but what we did as well, based on experiences and the problems we have, we say okay, we need to think out this or we have to develop this and this… you also have the company level to get experience back, use it in the next project, and maybe based on these experiences, you also start a new development project to make some things more efficient or better." *Interview 39—The Netherlands, Engineering and management consultancy*	Overview of practice; connecting what is learnt from projects into company strategy and policies
Project–level BIM manager	"My role usually comes in at the beginning of a project… it's more about establishing the ground rules, for things like coordinate systems, making sure that things like all the datums we use all have the same datum system…, making sure that all the files are clean, well put together, they all overlay each other, they've all got the latest information. Anything that anybody needs to know or find out, that's where I usually jump in, and help just initially to set things up, the concept level." *Interview 3—NZ, Architectural practice*	Establishing project standards; quality control of files and systems
	"My activities are managing all the stakeholders. We get together, I control, before BIM I looked at the quality of the drawings, now I do the models. I do the clash detection, I give advice to make things more buildable. That's in a shortcut what I do." *Interview 41—The Netherlands, Construction company*	Project management; design management; coordination
Practice–level BIM manager	"As BIM manager I'm mostly working with the work preparers, spreading my knowledge to the people who do all the checks of the drawings and what has to be built, we have about 6 or 7 of them in the company, and that's what I'm mostly involved with, explaining to them how they should best do it, supporting them in their daily things." *Interview 43—The Netherlands, Construction company*	Support role, educating and informing project participants
	"My role and I guess now what I focus on more, is development, testing new systems and figuring out whether they're right or do they need training. Setting up training plans, essentially trying to progress [company] into new areas and advance their skill, I guess. Whereas, these guys as the BIM coordinators and technicians, are on the day to day project work. That's the rough plan." *Interview 38—NZ, Construction company*	Outside of project work but supporting it with training and company systems
	"I am basically providing support, training, make sure that the plans are being met, that we have proper plans, that we are meeting the schedules and deadlines, and that we are not overlooking something that should be happening, and that we have a proper staffing for a project. Making sure we have enough people on a project to support the tasks that are happening on the project… I am helping also with the technology in general, making sure that project teams have a proper technological support, both on the software and the hardware side" *Interview 71—US, Construction company*	Oversight of all project roles;

Table 12 Role description narratives(continued)

Role definition	Exemplar narratives	Key elements
BIM modeller	"I interpret that design and I put the model together and I produce the drawing. I haven't in the last, I don't know, five or six years, been instructed to construct the building or detail the building in a certain way or to produce documentation the way the architect says, that always is left up to me." *Interview 22—Australia, Architectural practice*	Model development; documentation production
	"I have more responsibility for coordination, if I am updating the model and see clashes or something not in the right place I pass on that information and we look at it together, but before I would just hand over the drawings and it wouldn't be my part to work on the solution. It's more challenging and more interesting." *Interview 26—NZ, Architectural practice*	BIM offers opportunity to go beyond just documentation
Traditional roles	"I'm a generalist with specific skillsets in contract law, BIM, design management and programming. Those are my areas of specialty in a general role." *Interview 31—NZ, Project management consultancy*	BIM one part of an industry skillset
	"I'm the services coordinator. I will be working with that guy who is doing the entire model. If he sees anything wrong, or that needs tweaks, he will be coming to me… I either solve things if I can solve them or go back to the originator. I will also be the one contacting the architect, now we need this sort of space for this area, you know, to accommodate this or that. At project meetings I'm representing the team." *Interview 36—NZ, Engineering consultancy*	Not a BIM user but work with the BIM people; manage and coordinate project requirements

Ahn et al. (2016) identified from an analysis of four case study companies that two to three BIM expert levels were required. The first was characterised as the BIM coordinator, with project interests that encompass two of the roles identified in Chapter 3, the BIM coordinator and the project-level BIM manager. The organisation-level BIM manager described by some of the reviewed BIM handbooks aligns with the second level in Ahn et al.'s description of the BIM manager, who "confidently handles all different types of BIM implementation and software" (Ahn et al., 2016; p 15005-8). The third level which Ahn et al. (2016) identified goes beyond the roles covered by the BIM handbooks, and addresses the leadership or strategic level of BIM management, including aspects such as decision-making on investment in hardware, software, staff development and recruitment; how an organisation positions and markets itself as BIM-capable; organisational structures; project team partner and client relationships.

Given the general description of 'BIM specialist' used in seeking participants for this study, the BIM practitioners interviewed come from a wide variety of background disciplines, and represent company roles from technician level through to senior management. Consequently, the work they perform includes many different combinations of strategic, process and technical responsibilities, providing a broad representation of the spectrum of roles in which BIM practitioners are employed, and the types of skill sets aligned with those roles. As well as the three roles identified by Ahn et al. (2016), two further categories are evident in role descriptions from the practitioners interviewed. BIM modellers (model authors) have been included, because although they are considered to be a technical role and at a relatively low level by more advanced BIM practitioners, they are often viewed as BIM specialists by others in their networks and can have a significant influence on BIM implementation in their companies. This was also a role identified in Chapter 3 from the review of BIM handbooks. Further to this, a less-easily defined role is that of practitioners who are primarily operating in traditional industry roles. Although they are not necessarily BIM specialists in their own practice, their engagement with and involvement in BIM projects has led to them being regarded as influential in BIM implementation.

A third of the BIM practitioners interviewed were currently in strategic positions, with little or no technical role, though most also performed process-focused activity such as developing or applying standards and guidelines, or managing quality of models or information exchange, whether at an organisation or project level. The other two-thirds of interviewees performed elements of all three spheres of activity, although usually concentrated on technical and process aspects. All of those interviewed had some direct involvement in project delivery; for only three interviewees this involvement was described as minimal, and their primary focus was at an organisational rather than project level. The remainder performed significant project activities.

The five categories, illustrated in the narratives of Table 12, are further described below:

1) *Management level:* At the most senior level are the directors or senior managers who have responsibility for determining the direction of BIM practice within their company. These people are generally established practitioners, and thus well versed in their discipline, as a result of substantial practice experience. Management activities are also clearly a significant element of their role. More long-standing managers in this position do not necessarily have experience or skill with using BIM themselves, but are enthusiastic about the use of BIM within their companies and strongly support their staff in developing such skills. Managers who have more recently moved into this role have often come to it from advanced study which has focused on BIM management and business strategy. Practitioners in this

role see themselves as leaders in BIM, both within their own organisation and in the wider industry. The role they perform is focused on the strategic level.

2) *Project–level BIM manager:* The second group are BIM managers and coordinators who manage BIM processes at a project level. They tend to have a discipline-based background and hold a mid-level position within their company. Their responsibilities are across BIM process setup and execution for projects, coordination and quality assurance within project models and model exchanges, ensuring that models produced are fit for purpose and managing consistency of models from different parties. Their strength tends to lie in their knowledge of their discipline and the wider industry, though most have advanced BIM software and process skills to manage the task required, and good interpersonal skills for managing the people and processes involved in the project. Process-related activities are at the centre of the role, but it commonly also involves technical responsibilities. The role may also involve strategic issues around the application of BIM to the specific project.
3) *Practice–level BIM manager:* The third group of BIM practitioners are the BIM managers who have a primarily practice-based role. They develop and implement BIM processes and standards within their company, often manage in-house training, and are the first point of call for trouble-shooting technical problems faced by others. Those in this role are often from a technical background, and their strongest skillset lies in BIM software and processes. However, they also require interpersonal skills, especially for the training aspect of the role, and usually have developed construction knowledge through their project experience. Again, process activities are central to the role, but practitioners at this level are often expected to take a strategic perspective in the implementation and application of BIM in their organisations, and may also perform a technical role because of their background.
4) *BIM modellers:* The fourth group have a strong BIM-technical focus, and work primarily in model creation. In companies that are new to BIM adoption these people are often expected to move into the practice-based BIM manager role. They may lack discipline experience or have limited management and interpersonal skills, and are likely to have been employed based on their knowledge of BIM software and standards. In some cases, these people have come from a broader

construction background and have been diverted into a specific BIM role due to their proficiency with the software. This role is almost entirely technical, although in organisations where the BIM modeler is the BIM champion, strategic and process activities may also be performed.

5) *Traditional roles:* The fifth group exists alongside these BIM-specific roles in the more traditional industry roles, such as architects, engineers, and contractors, who are also required to operate within a BIM environment. Interviewees in this category do not usually consider themselves to be BIM specialists, but were identified by others as BIM leaders in their company because of their experience of working on BIM-mediated projects. Their strength is primarily in discipline-specific skills, and interpersonal skills for managing projects and project interactions are also required. The role may involve strategic, process and technical elements but is most likely to focus on strategic issues of using BIM within the project context.

Two thirds of the participants held multiple roles. Figure 5 presents the distribution of respondents across these five categories, with a breakdown of the distribution of secondary roles held by participants in each primary role.

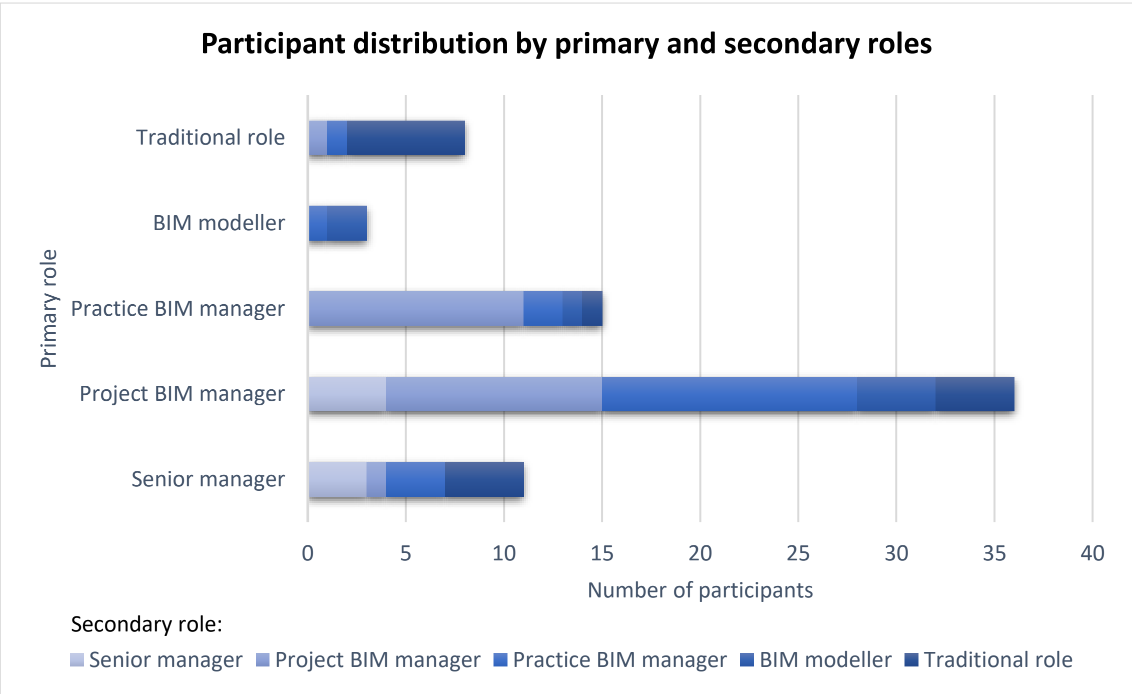

Figure 5 Participant distribution by primary and secondary roles

7.3 Roles by identity

Beyond the descriptions of tasks and activities, narratives in which participants describe their expectations, motivations and ambitions in relation to their role have been analysed, to determine how they articulate their professional identity in relation to performance. This follows the approach used by Stein, Galliers and Marcus (2013) of using professional self-narratives to explore the role of technology in construction of professional identity. Whereas Stein et al. (2013) focused on descriptions of identity from a material perspective in terms of interactions with IT artifacts, this study has instead centred on self-narratives that present participants' emotional responses to their professional roles (Kira & Balkin, 2014). Key phrases sought within the narratives communicate individuals' character, personality and passion with respect to their professional identity, such as "I'm the type of person that…", "What really interests me is…", "I love it when…" and similar expressions.

Traditional diffusion of innovation theory divides adopter categories into five ideal types: innovators, early adopters, early majority, later majority and laggards (Rogers, 2003). Because of the relatively recent development of BIM in the AEC industry, BIM practitioners can be perceived as predominantly innovators and early adopters, with some newcomers to the field falling within the early majority. Innovators are characterised as venturesome, comfortable with uncertainty and risk, and competent with technical knowledge. Early adopters are seen as opinion leaders or 'mavens', who adopt the new idea and then influence others in their networks to follow suit. The early majority are more deliberate in their adoption process and evaluate the outcomes from the innovation through their connections with the innovator and early adopter groups (Rogers, 2003). Moore (2013) uses slightly different descriptions, and positions innovators firmly as technology enthusiasts, perhaps as much interested in 'playing' with the new technology as in achieving specific outcomes through its use. Early adopters in contrast are characterised as visionaries, who see the value of the innovation for a particular goal and are likely to view implementing the new product or approach as a project in itself. The early majority are considered to be pragmatic, and are often focused on standardisation (Moore, 2013). Moore (2013) further characterises innovators and early adopters as having horizontal communication networks, communicating with others with similar enthusiasms regardless of background or context. The pragmatists in the early majority, in contrast, are more likely to communicate with others in similar roles within their own organisation and industry.

While these descriptions of adopter characteristics include many qualities that are evident in the practitioner narratives, there are many overlaps between them. An individual practitioner may express, for example, enthusiasm for the technology, a desire for improvements to benefit to the industry, and concern for how those improvements are implemented. Many other aspects of the narratives go beyond the characteristics identified by Rogers (2003) and Moore (2013). As such, the distinctions between innovator, early adopter and early majority are not sufficient to define BIM practitioner identity. Instead, five core types of practitioner identity were categorised that reveal the different enthusiasms that practitioners bring to their role, and approaches they take to their BIM practice. These identity types are not fixed or exclusive, and some practitioners describe adapting their persona to deliver the outcomes they see as necessary at a particular time.

This sense of balancing identity across multiple roles corresponds with the debate from industry over whether BIM generalists are more valuable, given the range of work that BIM practitioners might be expected to carry out, or whether the depth of knowledge required to effectively deliver BIM within a particular discipline means that specialists are necessary (Wu and Issa, 2013). Accordingly, these identity types are not intended to be exclusive, but to provide a framework for discussing the ways in which practitioners express BIM identities in their professional narratives, and for exploring the implications of those expressions of identity on their practice. Participants describe their roles in terms that include elements of most, if not all, of these identities, but tend to emphasise or express a particular identity type that they feel most closely represents themselves—their personality, aptitude, performance, and preferred ways of working. The identity types are not simply *what* people do in a BIM role, but *why* they do it; the motivation and drivers for their BIM interest and involvement.

The following five types of BIM performance identity have been drawn from the narratives:

1. *Implementer* – "*I'm the kind of person who will work it out, and make it work*"; pragmatic, task focused, using BIM to provide value.
2. *Interpreter* – "*I can find out things that are better for another person than he could decide or find out by himself*"; interface between people and technology, translating technology into industry context.
3. *Instructor* – "*There would always be myself falling into a training role to teach them how to do things*"; supporting others in skills development, teaching people how to make better use of BIM.

4. *Inquirer* – "*I'm always looking into why. It's a very important question in my life.*"; not satisfied with following a process, has a need to know all of the angles.
5. *Innovator* – "*A kind of person… that needs to be a couple of steps ahead*"; sees BIM as a stage in an improvement process, more connected to finding the next thing that the industry needs than to BIM.

Exemplar narratives and indicative analysis are provided in a more extended form in Table **13**, and detailed in the following subsections.

Table 13 BIM identity narratives

Expressed identity types	Exemplar narratives	Performance of personal identity	Positioning of others/industry
Type 1. Implementer	"I really want to see it happening and seeing it working. I'm the kind of person who will work it out, and make it work, and take a lot of enjoyment out of doing that." *Interview 34—NZ, Engineering consultancy* "I've got a great passion for buildings, for building technology, and basically I am, where my interest lies is in figuring out how to do it, you know, getting it done." *Interview 4—NZ, Architectural practice*	Satisfaction in making things work; problem solving; practical	BIM currently not working in industry
Type 2. Interpreter	"My mindset, brain works in more technical way, 'how do you apply this stuff', but I know how the architects think. Having been part of the process, I understand those guys in our office who are kind of the extremes, if you can satisfy these two ends of the extremes then you win." *Interview 50—UK, Architectural practice*	Understanding of different perspectives; finding solutions	Dichotomy between design view and technical view
	"My main goal is making processes better. It's what I did at my previous company, and what I'm doing here. It's what I like. My fun in working, for me, is to let someone else see that I can find out things that are better for him than he could decide or find out by himself." *Interview 59—The Netherlands, Construction company*	Improvement driver; want to be seen as better, more knowledgeable than others.	Processes require improvement
Type 3. Instructor	"I decide who needs training and when and what it should be. Sometimes I give training sessions myself, sometimes I organise a company that comes and gives the training. … We put in advance the people we think should be educated and want to be educated." *Interview 43—The Netherlands, Construction company*	Oversight of training process; making decisions and judging who is ready and willing for training.	Not all practitioners want or need to be educated.
	"It was a natural fit for me, in terms of whenever I went into an office or when I was working with other students at university there would always be myself falling into a training role to teach them how to do things." *Interview 17—Australia, Architectural practice*	Training as an innate skill	

Table 13 BIM identity narratives (continued)

Expressed identity types	Exemplar narratives	Performance of personal identity	Positioning of others/industry
Type 4. Inquirer	"My thing is I need to know how they do it, so I can figure out what I need them to do to help me. So I've gone into that a little bit, talking to the design consultants, seeing them do a bit of drawing. I have to do a lot more of that to really understand how it works, which can then mean I know how I can get them to make it work for me." *Interview 12*—NZ, *Cost and planning consultancy*	Looking at a bigger picture than individual role	Others don't understand or don't do BIM BIM requires interconnection with other non-BIM roles
	"If I'm going to tell others, 'You have to do this,' then I have to understand why. I'm always looking into why. It's a very important question in my life. I actually read a report card from, I think it's fourth grade, my teacher wrote, 'You're never satisfied with the answer, you always ask, 'Why? Why?' Always.' I was six years old then, so that hasn't changed." *Interview 42—The Netherlands, Construction company*	Personal satisfaction; BIM for personal enjoyment and growth	
Type 5. Innovator	"The innovations go rapidly, so very fast. You have to have at least one guy like me in the company that looks ahead, sees the future... So I go to events and I say 'Ah, that works for us'. Then I test it, then I roll it out in our company...we have to test it and we have to know what's in it for us, what's in it for our guys outside ... I think there's always a kind of person in the company that needs to be a couple of steps ahead, in the innovation." *Interview 40—The Netherlands, Construction company*	Pragmatic; innovation necessary because it delivers, 'what's in it for us'	Constant process of change and development in industry.
	"There is the whole area of digital construction that sits on top [of BIM] ...we're in a time now where more or less we can test anything, in construction. It just takes a bit of will, and embracing that way of thinking... that's the area that seems to spike the imagination of people more. The BIM side of it I find people get a bit turned off of it because it's quite dry, it can be quite dry as a topic." *Interview 51—UK, Construction company*	Motivating; innovation used to spike people's imagination	BIM seen as an evolution of existing organisational processes. Requires shift in thinking to see bigger picture, potential beyond BIM

7.3.1 Implementer

Most of the BIM practitioners interviewed have come into BIM via a technical orientation. An interest or aptitude for CAD or BIM tools, or for IT and computing more broadly, led to their identification as a technical leader within their company, which often then became a BIM champion role because they knew more about the software and technology process than anyone else. Although this may have led to the technical aspect of their work being overtaken by other elements of the BIM role, the practical implementation aspect, generally focused around technology, has remained a core element of practice for many, and 'making things work' is a central part of their identity narrative. From an organisational and industry perspective, the implication of this emphasis on making things work is that currently things don't work, that there is a need for practical people to take charge to get BIM happening and on track.

A more specialised form of the implementer narrative is seen with four participants who identified a computer science background that allowed them to move into BIM work and take some control over the technology. They all noted how useful their computing knowledge had been in understanding and developing BIM as they progressed within a BIM role, and identified situations where being able to modify and customise the software gave their implementation role a creative aspect. However, none of the four are currently active in actually developing the technology.

> "I should do a bit more because there's a lot of programming and stuff which we need as a company… It's not worked out that way. If you can see the trends of the industry now, programming is a huge part of it, developing apps and things like that. I would really like to start progressing in that area a bit more, but it's going to take some time to do it." *Interview 53—UK, BIM consultancy*

Several practitioners in the implementer type identified that their motivation does not come from using BIM as a tool or technology, but is based more on the appreciation that BIM enables them to contribute in a meaningful way to the final product, i.e., the built environment that results from their efforts. In this sense the implementer role may also have a creative impetus that contributes to the motivation of the practitioners.

> "It's one of the things that drives me, that satisfaction of achieving a building, you hear that from a lot of people who have been in the construction industry for a long time, they love driving by a building and saying, 'I worked on that.'"
> *Interview 70—US, Construction company*

As such, implementer narratives were evident not just with regard to technology, but also applied to process and workflow, and communication and collaboration aspects of BIM. For some practitioners, the desire to make things work is not so much about doing it themselves but in enabling others to work more effectively. Practitioners whose BIM identity is more other-centred than self-centred have been labelled *Interpreter.*

7.3.2 Interpreter

In an interpreter role, the practitioner sees themselves as a bridge between BIM and those using it. This identity is based on understanding the different and potentially conflicting needs of different project partners or industry parties, and being able to act as a broker to enable BIM adoption and implementation.

Practitioners with an interpreter identity often express a need for variety and challenge in their role. For these individuals, this comes not just from making things work, as for the implementer identity, but from coming up with new approaches or processes that address specific problems that other practitioners may be facing. The work to interpret or interface between users and the necessary technology and processes is commonly underpinned by a desire for improvement, enhancement or simplification of existing practices.

The interpreter tends to be a process-focused role, but also contains a strong element of working to develop and upskill other practitioners.

> "One thing I've always had is three or four people, up to 12 people, that I work with, share the basic skills and coach people through things. I'm better at that than independent work… If there's a problem that needs to be solved, I can solve the problem, say 'this is how you solve it', but not necessarily doing the leg work, turning the handle after that… Hence why working with a team works for me because I know where my weaknesses are, so I know the people I need to target to help fill that gap." *Interview 57—UK, Construction company*

Where this aspect of sharing skills and knowledge dominates over the problem-solving aspect, the professional identity has been labelled the *Instructor*.

7.3.3 Instructor

The need for BIM practitioners to take a leading role in educating other members of their organisation and supply chain has been identified in the literature (Succar et al., 2013) and is evident in job advertisements for BIM roles (Uhm et al., 2017). Thus it was not unexpected that peer-to-peer teaching, organisational training, and industry coaching and education was noted by almost all participants as a significant component of their role. For some interviewees, however, the instructor role is their motivating purpose as a central element of their BIM practitioner identity. Several noted that they had tended to fall into a teaching role, often informally, during their studies or in previous positions, and relished the opportunity that BIM provided to continue that work.

For these practitioners, because their enthusiasm for BIM is based around the opportunity to teach others, their personal development in BIM ability is often driven by wanting to understand more about the technology and process in order to teach others more effectively. In some cases, however, the drive to understand all of the various roles and requirements in the BIM environment comes more from a personal quest for knowledge; this professional identity has been labelled the *Inquirer*.

7.3.4 Inquirer

Very few of these practitioners have stepped into well-defined roles or established BIM practice. As a consequence, they have had to be largely self-directed in developing their capabilities and finding sources of information to learn from. For practitioners who fit the inquirer type, this opportunity to drive their own learning within an embryonic field is a central attraction of the role. They are often passionate, self-declared 'BIM evangelists', who take every opportunity to learn and share their knowledge.

> "It's interesting stuff, so you're driven to learn, driven to talk to people, to meet with different software vendors, to meet with different industry peers, just different, just cross-pollination I suppose, with respect to exposure... I'm the sort of person who, you need to be personally interested in something for it to be worthwhile, so you want to invest your time and your efforts in it, and then you look for opportunities where you can start. Talk to anybody in our business and you'll say [*Interview 15*] and they go, 'oh yeah, him. Who's going to talk to him? Just start talking about BIM, he'll be talking for hours!'"
>
> *Interview 15—Australia, Property development and management company*

Several practitioners expressed frustration at the lack of training and upskilling opportunities available to them. While they recognised that they did not have all the answers and wanted additional skills and knowledge to enable them to perform more effectively, their drive to learn and develop was hampered by the low level of courses offered.

> "There's still not so much education, but there are some companies that give education on BIM manager, and I did it. But I could have given that class, I was

> already beyond it. That was maybe a year and half, two years ago, after just a year of working on it myself. There wasn't much new that I learned there."
>
> *Interview 43—The Netherlands, Construction company*

Understanding BIM practice for practitioners in this type is often about developing a better knowledge of wider industry connections and the roles played by others in the BIM process. For some practitioners, however, BIM technology, roles and practice may be seen as a current interest that is just one element of a wider quest for knowledge and new ideas. These have been labelled the *Innovator* type.

7.3.5 Innovator

Ahn et al. (2016) identified that BIM experts often go beyond the current implementation role to a more research and development focus to identify potential advancements in practice that could be adopted by their project team or organisation. This was evident in some of the companies with more advanced BIM practice, in that the BIM practitioners interviewed had, in addition to their BIM role, a specific responsibility to identify and evaluate potential applications of new technology that would benefit the company or its clients. As one interviewee noted, this was not necessarily an aspect of BIM practice, but "BIM is the easy term, people understand that", whereas the role was much broader in scope:

> "…trying to figure out, what are those next things that are coming down the pipe from industry, what are our competitors doing, what are we doing in the company that need to get bubbled up to the greater good."
>
> *Interview 73—USA, Multi-disciplinary consultancy*

Specific innovations described included lean construction, supply chain management, big data, use of drones and virtual reality. In this respect, BIM was often seen as an enabler, with the adoption of BIM opening the door to many more applications and innovations. Further, many of the BIM practitioners expressed keen interest in technology and so their diversion into other uses of technology is often driven by that enthusiasm.

7.3.6 Progression of identity performance

The five types can be seen in one sense as a progression or process that practitioners move through to find the identity that best fits their own preferences and characteristics. As Figure 6 depicts, there is a flow from one to the next, and the later identity types in the progression incorporate many elements of the previous types.

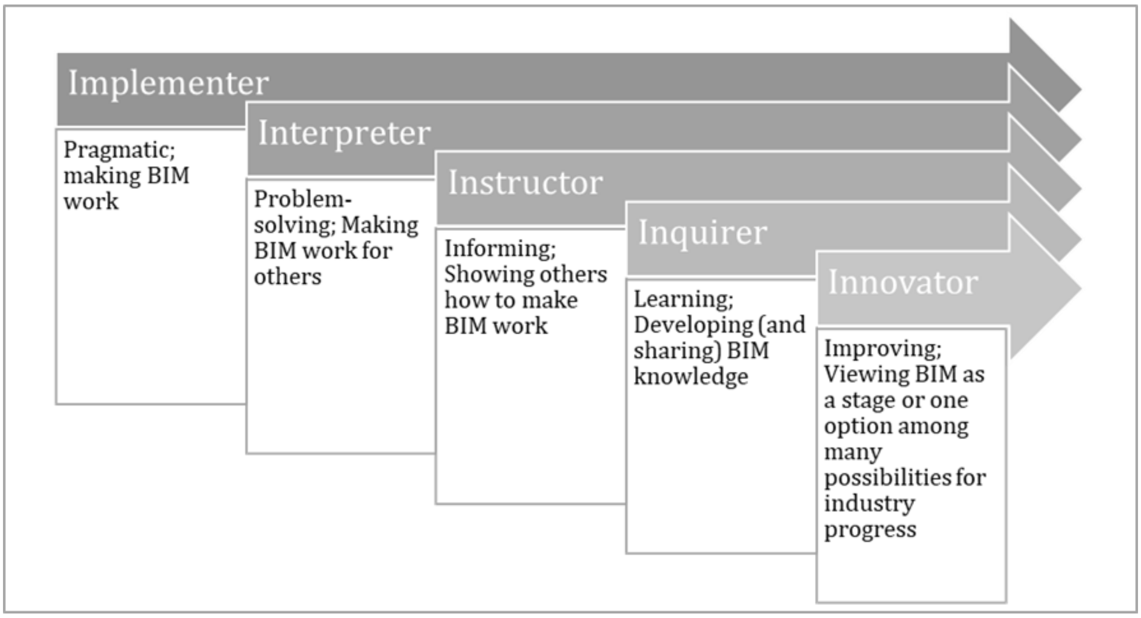

Figure 6 Progression of BIM identity

Of course, this view is a simplification, and individuals may not align to all of the preceding types. Practitioners may also adapt their identity to suit different situations that they face (Gluch, 2009), and given the lack of formal role definitions and established practice expectations there is a great deal of freedom to do this. In some cases, the practitioner in a later type may not have worked through the preceding types but instead manages others who fulfil those roles. Nonetheless, the value of describing the types as a progression is to emphasise the multiple layers of performance that are entailed within a particular BIM role, and to illustrate the connection between the different identities that practitioners construct. From an organisation's perspective, these types provide a way of considering the expected function of a practitioner, and whether they are the right person, with access to the necessary resources, to fulfil that function.

The overall motivation for most practitioners across all types is the idea of improvement. They see BIM, and therefore their own activities, as a positive force in changing the way the industry works.

> "They're passionate about what they do, they're not just here for the 9 to 5, they really love what they do, and development is something that is new and innovative, and they feel like they're making a difference."
>
> *Interview 21—Australia, Engineering consultancy*

At the same time there is commonly an element of pragmatism in the drive for improvement. BIM is not just an ideology, but a business decision that is expected to deliver a benefit to the projects and organisations involved.

> "There's quite a few touch points, if you like, for BIM across our business. [My role] I guess is trying to decide which bits of that are value and which bits of that are nice to have but not really adding huge value, they're just cool. There's a bit of playing in BIM and there's what is BIM doing to make the boat go faster and make us more money, basically." *Interview 9—NZ, Construction company*

The identity types described here might be considered to some extent to relate to the idea of 'playing in BIM', in that almost all practitioners expressed some aspect of BIM practice that brought them enjoyment or interest in their roles. However the more pragmatic drive to 'make the boat go faster' was often integral to this; they recognised the enhancements to practice that BIM could deliver, and it was often an additional source of satisfaction.

7.4 Identity and practice

The analysis of performance of BIM identity provides insights into the expected place of BIM practitioners within organisational and project roles, and also into the motivations and interests that have led them to those positions. Further to this, however, it also suggests aspects of identity that go beyond individual significance and have implications for BIM implementation and practice.

7.4.1 Role transition and transformation

BIM adoption and implementation, particularly within less advanced BIM markets, is not an established process but develops within a constantly shifting environment. BIM practice is evolving and adapting as practitioners, project teams and organisations become better informed and more experienced in how to manage BIM processes to deliver more successful outcomes. Practice changes result in role changes, and essential functions or elements of a role at one stage of adoption may become less significant or even redundant as the experience levels of practitioners change (Akintola et al., 2017). Conversely, currently underutilised activities or skill sets may take on greater levels of importance as the use of BIM increases (Gustafsson et al., 2015).

Changes in role descriptions are therefore expected (Succar et al., 2013), so the labelling of roles, whether through examination of practice or definitions in guides and handbooks, is only of short-term relevance. Of greater importance, however, is the extent to which such changes may result in practitioners' roles losing the aspects that currently determine or contribute to their BIM identity. For example, where a practitioner is largely technology-focused, their expertise is only significant while it is a new skill in the industry. Once core professionals increase their BIM proficiency, technical BIM skills will lose their prominence (Akintola et al., 2017).

> "I've got a few younger technician guys here. They're all architecturally trained, but now BIM is the thing for them—but it's the software and technology end of it that's the thing for them… But hold on, that's not a career, if you just do software you stay as you are, only you become less relevant as everyone else learns how to do it." *Interview 56—UK, Multi-disciplinary consultancy*

This also applies to practitioners whose involvement and enjoyment is centred on developing processes and frameworks to enable other practitioners to engage with BIM practice. As BIM becomes more and more mainstream, practice at an organisational level and especially at a project level will become more well-defined and standardised. The increasing development and acceptance of national and international BIM frameworks (Kassem et al., 2015) reduces the influence and importance of the Interpreter role type.

BIM practitioners currently have a leading role in building awareness generally, as well as training other participants to meet project and organisational BIM needs. Most of the interviewees are directly involved in delivering information content to other staff, and this part of the role is a core motivation for many, as described in the Instructor identity type. Some participants described that their training responsibility had become more involved with coordination and oversight, rather than carrying out in-person training themselves. As BIM awareness across the industry increases, this shift is likely to continue, and training roles will become more focused on evaluation and monitoring of training levels.

BIM practitioners whose BIM identity is embedded in activities that are no longer required will face decreased role satisfaction, and potentially also limited career opportunities as their strengths have much less prominence in practice. Ashforth and Schinoff (2016, p124) identify five possible responses when an individual's identity is not validated;

> (a) modifying the claim to be more in accord with others' perceptions, (b) striving harder to present a persuasive claim (e.g., redoubling efforts to display positive indicators), (c) abandoning the claim and presenting an alternative (e.g.,

> emphasizing one's social skills rather than technical skills), (d) seeking validation from a secondary audience (e.g., abandoning attempts to impress senior coworkers and pursuing validation from junior coworkers), or (e) tolerating the discrepancy between claim and denial.

The progression of identity performance may thus provide a framework for practitioners opting for one of the first three responses, who could consider shifting the focus of their claimed identity, or adjusting their area of interest and personal alignment to other aspects of their role. This may not necessary require a significant change in their range of activities, but simply a reframing of the dominant elements of their role. Another answer is for practitioners to prioritise their established identity, and seek an alternative (rather than secondary) audience, through a change of organisation;

> "I think there's loads of other companies that need this exact same approach."
>
> *Interview 42—The Netherlands, Construction company*

7.4.2 Role ambiguity and role conflict

Pearce (1981) advances two types of role ambiguity, labelling them 'unpredictability' and 'information deficiency'. Unpredictability is described as a situation where the likely consequences of performing a specific role are unknown. Information deficiency is a lack of role requirements or guidance for carrying out the role, or a feedback gap where practitioners receive insufficient feedback to affirm or reject their actions as appropriate to the role. As described in the narratives, the way in which a specific BIM role develops is often at the discretion of the practitioner taking on the role. For some, the line of authority and reporting expectations were also undefined, and there was no clear guidance in terms of how BIM was expected to fit in relation to existing practice and roles. This freedom may be a positive feature of the role for practitioners with a clear vision and a drive to lead and improve. Role ambiguity has the potential to improve creativity, as long as it does not negatively influence the practitioner's job satisfaction (Tang & Chang, 2010), so the ability to be self-determining in establishing a BIM role may allow more flexibility and opportunities for innovation in developing BIM practice. For those unprepared or unwilling to take such a leadership role, however, role ambiguity has a negative aspect and may lead to role conflict and stress.

Role conflict occurs when a practitioner is required to take on multiple roles simultaneously, where the demands of the roles are incompatible (Tang & Chang, 2010), or when the requirements of the role are at odds with the identity and capabilities of the practitioner. Gluch (2009) expressed the difficulties faced by environmental professionals who have to deal with simultaneously performing both generalist and specialist roles within projects. Similarly, Georg and Tryggestad (2009) found that project managers have to balance and negotiate between information-based and cultural perspectives. BIM practitioners also frequently expressed the feeling that they filled at least a dual role, balancing the specific BIM expertise that they were expected to deliver, alongside the more general role of project delivery. Additional expectations which introduced conflict included having to do more than expected in less time, and taking on wider responsibilities to become involved with decision-making on levels that were not anticipated.

> "There's not much support vision-wise. I would have expected a lot more. There's none. It's up to me to drive it… I don't think I should be the one making the strategic decisions." *Interview 42—The Netherlands, Construction company*

BIM practitioners also identified that their reporting expectations and position in the organisational hierarchy are commonly undefined, and they often deal with multiple lines of authority. Such situations have been identified as leading to role conflict and job dissatisfaction, as well a loss of organisational efficiency and effectiveness (Rizzo et al, 1970). Again, some practitioners find it stressful and difficult to adapt to that degree of looseness in their environment, whereas others are comfortable working without a formal status within the team.

> "In one way you could put me right at the bottom, because I have to respond to even graduates' requests. But then again, I turn round sometimes and tell them off for doing something, sometimes directors as well… it's a real shifting job and I think you've got to be quite comfortable with a) dealing with management, but also b) being told what to do by graduates. Because you've got that massive scope, and you've just got to not take it personally."
>
> *Interview 3—NZ, Architectural practice*

As BIM practice becomes more widely accepted and standardised, some of the factors contributing to role ambiguity and role conflict will reduce. Some are intrinsic to the environment, however, and many BIM roles will continue to challenge practitioners who have a low tolerance of ambiguity and uncertainty. Companies may find it necessary to include consideration of this characteristic in their recruitment processes, or implement training and personnel development approaches to help practitioners improve their response to ambiguity (Tang & Chang, 2010).

7.5 Conclusions

Practitioners' performance of BIM identity can be considered at two different levels. The first and most straightforward is through role descriptions in terms of tasks and activities. These are common in literature and BIM documentation, and provide a framework for practitioners to negotiate their place in organisations and project teams. However, such descriptions are not definitive, nor are they exclusive. The majority of practitioners interviewed operated within at least two of the roles identified, and several had three or more functions. Multiple roles and requirements can cause role ambiguity and conflict, which may lead to dissatisfaction and stress for some practitioners. Others thrive on the challenge and welcome the flexibility to put their own stamp on the way that BIM practice develops.

The second angle on BIM identity performance lies in a more personal perspective, considering the aspects of practice that practitioners take enjoyment and satisfaction in. This view can help organisations to ensure that roles are created or modified to suit the motivating factors of the practitioners involved, in order to retain skilled staff. The different areas of performance can also be useful to practitioners needing to adjust or reinvent their practice, if progress in BIM implementation should make their previous area of interest less relevant.

8 Choosing a BIM career

This chapter includes material from the following publication:

Davies, K., McMeel, D. & Wilkinson, S. (2015). Soft skills requirements in a BIM project team, In J. Beetz, L. van Berlo, T. Hartmann, & R. Amor (Eds.) *Proceedings of the 32nd CIB W78 Conference 2015*, Eindhoven, The Netherlands. pp 108-117. Retrieved from http://itc.scix.net/cgi-bin/works/Show?w78-2015-paper-011

Chapter summary

The preceding chapters have presented a diverse set of findings looking at a variety of elements pertaining to BIM practice, particularly from the perspective of BIM practitioners. In Chapter 8, I provide a synthesis of these elements to consider the various aspects encompassed, through an interpretation of BIM practitioner roles as a career choice. Implementation of BIM throughout the construction industry has led to the establishment of new professional roles, based on a range of technical, discipline-based, and interpersonal skills. As introduction to the place of these roles in current practice, I have used interviewee's descriptions of the qualities and character traits that they consider to be necessary for a practitioner in a BIM role, or what they would look for if employing a BIM practitioner.

Different aspects of and approaches to BIM adoption and implementation have an impact on the way BIM practice may develop as a career, and I explore a number of these factors which emerged from practitioners' narratives. I connect these career factors to a wider perspective of BIM maturity in the industry, and to the idea of a professional life cycle: as BIM practice continues to change and mature, the career possibilities and needs within the BIM field also evolve. Practitioners' expectations, as well as what is expected of them, are influenced accordingly.

8.1 Introduction

Development of any professional role is a dynamic process, and there is no determined transition when a profession can be considered to exist or not. Instead there is a cycle of development as skills, expectations, and specialisations evolve and are modified to suit the changing environment. Hence, the current multiplicity of views has developed regarding the status of BIM as a professional role. As shown in Chapter 2, these range from assertions that new BIM roles are required in order to achieve BIM implementation (Gu & London, 2010), that they will proceed from the development of BIM practice (Turk, 2016), or that they are merely a transitionary stage and will end up as a technician role in support of traditional practitioners who will add BIM to their current skill-set (Akintola et al., 2017).

A further complication, as established in Chapter 3, is that BIM roles currently have little uniformity in titles or expectations. Individualised practice from early BIM development has led to diverse descriptions of roles and associated practices, and BIM handbooks and guidelines both within national markets and internationally contain overlaps and discrepancies in how various roles are named and defined. Nonetheless, while this may lead to misunderstandings about areas of responsibility and authority on project teams, there is still an overall consensus regarding the roles that are required at both an organisational and project level.

Despite these uncertainties, it is clear that currently and for at least the near future, BIM practice necessitates the introduction of specialist BIM practitioners, and also requires traditional practitioners to take a leadership role in BIM which takes them beyond their established positions. In addition, senior management support is required to enable the investment in resourcing not just BIM software and hardware, but also the training, additional time, and changes to processes and practice required. Chapters 4 and 5 demonstrated the need for these various roles in implementing BIM, both in early stages of adoption and as BIM becomes more embedded in practice.

The lack of clarity regarding BIM professional roles and opportunities is a contributing factor in the shortage of skilled practitioners (Gu & London, 2010), and is thus a barrier to improving BIM adoption. Many universities are now attempting to address the skills shortage by introducing programmes to develop BIM skills in their graduates (Abdirad & Dossick, 2016). However, education and training providers require definition of professional expectations and standards so that their offerings are suitable to meet the needs of industry (Bravenboer & Lester, 2016). Practitioners currently in the industry also need similar guidance to be able to upskill themselves into BIM positions. Equally, without such information, graduates and current practitioners are likely to be less interested in pursuing opportunities in BIM as the direction and outcomes are unknown.

To contribute to understanding of BIM as a professional path, BIM practitioners' views are presented regarding the skills and attributes that they consider necessary for current and future BIM practice, including the importance of knowledge sharing in skills development. Related issues are then presented around different ways that BIM implementation approaches might interact with the decision to adopt a BIM career. The subsequent discussion considers more overarching aspects of BIM practice which may influence practitioners' decision to embrace or reject BIM as a career choice, including the potential development of roles within a professional life cycle framework.

8.2 Skills and attributes for a BIM career

The competencies and skills expectations of BIM practitioners has been thoroughly addressed elsewhere, most notably by Succar et al. (2012, 2013). That work provides a framework for defining, assessing and managing competencies for BIM practice, and does not need to be duplicated here. Instead, this section presents practitioners' perceptions of the relative importance of different skills. As part of their description of their own roles, interviewees often described what they considered to be the qualities and character traits that were necessary for a practitioner in a BIM role. Many also outlined what they would look for if employing a BIM practitioner.

Skills and attributes discussed by practitioners have been grouped into the three categories previously identified from the literature:

- BIM-technical skills - BIM software, associated standards and project frameworks, processes and technology for managing and exchanging information
- discipline-specific skills - knowledge of relevant physical and technical properties of buildings and construction, regulatory and legal frameworks, project and practice processes, techniques and specialist knowledge within the various design and construction disciplines
- soft skills - personal and interpersonal skills including leadership, communication, social skills, self-awareness, motivation and critical thinking.

Knowledge sharing emerged as an important feature in the development of all of these skills and attributes, so has also been included in this section.

8.2.1 BIM-technical skills

Much of the focus of BIM development has been on refining the software tools and technical structures required to deliver the enhanced outcomes promised by the technology (Miettinen & Paavola 2014). Efforts to develop coherent education programs and BIM curricula have also given prominence to software and technical elements (Sacks & Pikas, 2013). From this emphasis, it might be assumed that BIM-technical skills would be a primary consideration in BIM roles. However, almost all of the interviewees agree that it was the least important skill set, and means very little unless it is supported by appropriate discipline-specific skills and soft skills. The sentiment that a company has "no place for someone who just knows the software" (*Interview 40—The Netherlands, Construction company)*, was widely echoed. Many of the practitioners had stories to tell of organisations or projects that had run into problems because they were focused on employing 'BIM people', without recognising the importance of experience and knowledge in industry practice.

> "It can look fine, but actually, once you start to interrogate the model there'll be all manner of clashes, all manner of issues that are unresolved, that have come from a lack of understanding of building process. And the software doesn't know... things can look quite compelling, but come up really short on delivery. I don't think a BIM process supplements common sense and technical understanding of building code and means and methods of construction. It can hide it a bit, for a while, maybe." *Interview 31—NZ, Project management consultancy*

BIM-technical skills are considered easily teachable to anyone who has the right attitude, and thus are regarded as an overlay to the other skill sets. Practitioners with purely BIM-technical skills are seen as occupying a very a limited position, with little opportunity for development within the industry or for wider project involvement. Companies which are focused on employing staff specifically for their BIM-technical skills are considered to be immature BIM environments. This opinion was commonly expressed by practitioners in companies which had previously adopted this practice, although most had moved on to more integrated BIM training where all staff are expected to work within a BIM environment. An alternative approach was to recognise the limitations of BIM-technical staff and manage them appropriately, to ensure they were not being expected to produce process and strategic outcomes that they were not equipped to deliver.

> "There is a role… as long as you know their strengths and weaknesses you can have them in the group and make sure that we do the process work around them and they can just carry on with what they like."
>
> *Interview 21—Australia, Engineering consultancy*

The focus on BIM-technical skills for their own sake gave rise to concerns about the flexibility of the resulting BIM environment, and staff responsiveness to project challenges. The conflation of BIM-technical skills with BIM expertise was one aspect of this. Companies with insufficient awareness of what is entailed in BIM adoption are employing staff with technical skills for roles that required process and strategic knowledge of BIM.

> "We see technician-level staff who have 4 years' experience of using Revit, and all of a sudden they're Associate in a practice; that's a big leap in management skills that they just haven't got! They don't even have the experience at the bottom—one minute they're churning out door schedules and the next minute they're implementing change strategies in a company. There's got to be an element of failure in that. But there's no telling some people, because the people that have employed them have obviously thought that that's what they want; "Oh, you're using Revit, great, you must be able to do BIM." And you see it all the time. I don't know any other industry where that would have happened."
>
> *Interview 56—UK, Multi-disciplinary consultancy*

Despite this representation of the low relative importance of BIM-technical skills, knowledge of software and related BIM processes is obviously a necessary asset for a BIM practitioner. Over half of interviewees have a training role in their organisation, which means they need a working knowledge of BIM in order to transfer the necessary skills to other staff. Many also have 'hands-on' project responsibilities which requires direct use of BIM-technical skills on a regular basis. Even where this is not the case, knowledge of the software is useful for managing others who had a technical role.

> "The people I work with use mainly Revit or ARCHICAD. It's a bit difficult to tell them what to do to get what I want, so that's a process I am going through, to get the information that is needed to tell people what to do so I get what I want… I am

> educating myself [in the software], just beginning, because I think if I know how it works I can tell participants what to do."
>
> *Interview 41—The Netherlands, Construction company*

BIM-technical skills may be sufficient for operating at an implementation level in a BIM project or within an organisation, but any process or strategic involvement requires a wider understanding of what BIM entails within the industry context. For this reason, most of the BIM practitioners interviewed consider that their role is oriented much more towards skills related to their discipline or to managing the people involved, rather than to the BIM tools and technology.

8.2.2 Discipline-specific skills

BIM adoption affects the ways in which professionals in traditional AEC roles carry out their work, with new elements and approaches introduced into existing role delineations (Uddin & Khanzode, 2014). As established in Chapter 6, they do not necessarily identify themselves as BIM practitioners despite the BIM skills they develop as a result. More commonly, those who claim BIM identity, whether partially or entirely, hold a specialised position that has been created because of the increase in BIM use in their organisation and projects they are involved with. Considerable emphasis is placed on the need for good underlying industry knowledge in such BIM roles. The idea that a person could become a BIM team member without a thorough understanding of construction was rejected by many interviewees. Similar views were expressed by Farnsworth et al. (2015), who argue that practitioners without practical industry knowledge have difficulty applying BIM in project environments. Practitioners agreed that adding BIM-technical skills on top of the other skills was a more robust approach.

> "There's no other way than that these traditional roles make the step to BIM. Because you need their in-depth knowledge, of their part of the construction process. They have to use the BIM technology. And not have a certain person that is very handy with the [BIM] tools and knows how to push the button, doing the work." *Interview 39—The Netherlands, Engineering and management consultancy*

Only one interviewee suggested that they would prefer to take on someone who had BIM skills over another applicant with experience in the discipline, but specified that the new employee would need to be supported into the role in order to develop the necessary practical knowledge and experience.

> "Comparing a graduate with no background in the industry, but they know about tools and standards, against someone who had worked in the industry and had the MEP skills and had tinkered a bit with some of the software, I would go with the graduate, definitely, and give him an opportunity to upskill himself. If they're new to the industry, they will learn a lot quicker the way the business works and the way projects work. Internally that can be supported, so if he's a graduate MEP/ building services manager, with a lot of BIM knowledge, we can support the project knowledge through internal resource, but if we had the senior project guy with just a little bit of BIM knowledge, there's a lack of knowledge within that discipline to support him into BIM." *Interview 46—UK, Multi-disciplinary consultancy*

This opinion also presupposed that the new employee had relevant discipline knowledge, albeit from a theoretical perspective, as well as BIM knowledge. Other practitioners, while stating that they would prioritise industry experience and discipline knowledge above BIM skills, still supported this position to some extent. Most of the practitioners interviewed were heavily involved in training and support roles within their company, in which their main focus was in assisting other employees to expand their discipline-specific skills into a BIM environment. A popular training approach was pairing skill-sets, aligning those with practical experience but no BIM knowledge (typically older employees) with younger, technically aware employees who lacked industry experience. Good practice was seen to be the selection of project teams on the basis of which people contributed the appropriate discipline expertise, and were the right 'fit' for the team, rather than a specific focus on BIM delivery.

A more challenging situation was identified by a few of the strategic-level practitioners in the UK and the Netherlands. They recounted situations where people had qualified in an industry profession, but had been unable to practice due to a lack of opportunities during the global financial crisis (GFC). As the industry returned to normal demand, these people were re-entering the employment market, but lacked both industry experience and BIM awareness. One of the UK-based practitioners further identified that many older employees either retired or were made redundant in the recession, leading to a considerable gap in practical knowledge and experience, and making this skill set even more valuable.

8.2.3 Soft skills

Non-technical capabilities of the people involved in BIM are widely acknowledged to be an important part of the BIM process, and are sought after by employers (Zhao et al., 2015). These capabilities include leadership and interpersonal skills, and other personal traits (Succar et al., 2013). Practitioners agree, and argue that to be successful in a BIM environment, an organisation requires people who are flexible, open to new ideas, willing to discuss problems and negotiate solutions. As such, many of the skills required for successful project teams in a BIM environment are focused around soft skills.

> "My role is about people, process, and technology, all three. If I have to say in which the most of the three, then it's people. After that, it's process; and later, it's technology... The hardest part, and the part with the most energy in it, is people. The biggest problems, also!"
>
> *Interview 59—The Netherlands, Construction company*

The ability to communicate well was foremost in interviewees' descriptions of the characteristics of a good BIM practitioner. Communication, whether through oral, written or visual means is a fundamental skill in any construction project, but BIM projects are seen to have a particular need for skilled communicators. The use of BIM on projects increases transparency in project contributions, making each person involved explicitly responsible, at some level, for the project delivery. This requires team members at all levels to work with other participants in the wider project, to a much greater degree than in non-BIM projects.

Other soft skills identified as valuable attributes of the 'ideal' BIM practitioner include negotiation skills, self-motivation and self-management, and a good attitude. These are also echoed by the literature; Sebastian and van Berlo (2010) detail mentality and culture, including individual and organisational motivation, as an element of BIM maturity assessment, and Succar et al. (2013) lists personal traits and characteristics as factors in measuring competencies.

The collaborative nature of BIM projects gives rise to the potential for conflict over roles and responsibility, particularly at the outset of a project when these are being defined. From the roles descriptions, any of the BIM practitioner roles may be called on to lead the development of BIM project protocols and execution plans, which requires negotiation skills to help the various project contributors to come to an agreement. However, all of the project team members have to work with this throughout the project as responsibilities are revisited and adjusted along the way.

Although attitude cannot strictly be defined as a skill, many interviewees suggested that it was an important aspect of personal interactions, and the right attitude was frequently mentioned alongside communication skills as an essential attribute for members of a BIM project team. When asked to explain what they meant by ‘good attitude’, interviewees shared similar interpretations. An openness to learning and developing new skills was seen as core. Challenging the status quo and looking for improvements on current practice were also linked to this. A related attitude, required particularly in the early stages of BIM adoption in an organisation, is for team members to have a sense of self-confidence and security in their own ability. Several interviewees had stories of staff or co-workers who were apprehensive about their competence or anxious about the level of responsibility they had to assume in a BIM project context, and so were unwilling to take part.

> “It's a lot to ask, you drop them a bit the deep end; it’s what I'm good at doing. To be honest, I wanted to offer the job to another guy, who was relatively new to the industry… and he was too scared to do it. He bottled it. He said, ‘No, I can't do that job you’re offering.’ … I think he could've done it, but obviously, within his head, he couldn't get his head around the opportunity that he'd been given.”
>
> *Interview 46—UK, Multi-disciplinary consultancy*

One school of thought is that soft skills are innate, part of the personality, and so can be developed if a person already possesses them but cannot be instilled if they are not already present. Participants discussed personality traits such as introversion and extroversion in this context. One respondent suggested that a shy or quiet person could be good at the technical side of BIM, but was likely to struggle with much of the management aspect of the role which required projecting an air of authority. Many of the soft skills factors listed by participants as being based on attitude could arguably be considered personality traits rather than skills which are able to be isolated and learned. Characteristics such as willingness to accept change, openness to learning and developing new skills and relationships, self-confidence and a social and sharing outlook are all difficult to evaluate and may be comprehended differently in different contexts. As such, relying on personality assessments in order to develop team members with the desired soft skills is an uncertain approach, though mentioned by interviewees in terms of a person’s ‘fit’ in a team.

> "When I came in and I was this link between [client] and the project, we had a guy seconded from the operational team into our team. He wasn't the right person. He had the right knowledge, but he didn't have the right culture, and there was no changing him." *Interview 49—UK, Client organisation*

A number of participants argued that many of the soft skills identified are the result of sound knowledge of the discipline, and that any BIM manager needs field experience in order to, variously 'speak the language', 'feel the pain' or 'stand toe to toe' with other participants in the design and construction process. To achieve good communication, there needs to be common understanding of construction roles and processes. Authority and leadership will not be granted or respected without a solid grounding in practical knowledge.

> "You get out on site and start arguing with the guys on their playing field, doesn't do any harm, doesn't do anything negative to show them you know what you are talking about, people actually start listening to you for a change."
> *Interview 4—NZ, Architectural practice*

Similarly, experience is essential for project participants to negotiate effectively, as an underlying knowledge is required to ensure that clashes are resolved appropriately and that decisions are made that suit the wider project environment. Although negotiation may be necessary to resolve conflicts, there is no advantage to the project if it results in the wrong decision.

While technical and discipline skills may be transferable across the industry, soft skills are considered to be more individual to each company in terms of its vision of BIM and approach to collaboration. As explained by one BIM practitioner,

> "There's a lot of bigger firms that will go out and purchase people… but I know that they are only going to be good for [BIM-technical skills] and not for the rest of it. So that's where I think that you are better off to develop people yourself than you are to purchase people." *Interview 16—Australia, Multi-disciplinary consultancy*

By bringing in external expertise, a company circumvents the stage of reflecting on their specific needs in the BIM process and what aspects are of most value to them, and thus risks implementing BIM in a way that does not deliver value to them. Developing internal people into the role who bring with them knowledge of the company and how it operates makes the soft skills aspect more prominent, as company expectations and values are carried through the process.

8.2.4 Knowledge sharing

A critical success factor for BIM adoption, identified by Won, Lee, Dossick and Messner (2013), is the willingness to share information among project participants. Thus, it is perhaps unsurprising that BIM practitioners are strong proponents of knowledge sharing, and make use of many channels to do so. Discussion groups and social networks are considered an important source of information around BIM in general, and a way to develop relationships and social skills in an industry environment. The BIM practitioners interviewed are a highly interconnected group; they maintain social as well as professional relationships with their peers, and are very supportive of colleagues who are developing BIM expertise. When describing their role and practice many of the interviewees identified a variety of methods they use to develop and maintain relationships with their peers.

Personal relationships or informal contacts were the most frequently mentioned forms of networking, both within organizations and across discipline and organizational boundaries. Some of these interactions were described as mentor-mentee relationships, although they are often managed at a personal level rather than in a formal arrangement. Although in most cases such relationships are locally-based, some respondents also indicated personal connections across regions or internationally.

> "The most training I have had has come from business mentors. I do it externally, so I've got senior executives that I admire, and I approached them and asked if they would be my mentors, and they accepted. They help me, they have the most pronounced effect on my career that anyone has had. I meet them for an hour or two a month and that has had the most effect on my career, education, outlook, everything. For me, mentorship is key, it's way more important than anything else." *Interview 13—Australia, Architectural practice*

Organization-based networking was common, with formal and informal interest groups meeting to share knowledge and develop relationships. Many of the organizations for which this was described were either multi-disciplinary or had multiple regional offices, so such knowledge sharing served to assist the development of uniform practices across the organization. Organization-based training programs were also included in this category as they were described in several cases as being as much about developing relationships as they were about the technical or process knowledge gained.

Across disciplinary and regional boundaries, Twitter and LinkedIn are used by some to exchange ideas, share experience and ask for help. Conferences were also identified as useful forums for developing wider networks and gaining an appreciation of the wider context of BIM adoption nationally and internationally. More locally, networks are evident in industry-based discussion groups, user groups or more formal workshops. Interviewees consider that all of these approaches to knowledge sharing also help to develop industry relationships, at the same time as exchanging BIM-technical or discipline-specific knowledge.

In some cases, these wider knowledge-sharing relationships introduced an element of tension into the BIM specialist role. Most of the BIM practitioners considered that any advancements in BIM awareness that they could contribute to across the industry would lead to increased opportunities for their own BIM practice, and thus better outcomes for the organization and projects that they were a part of. Several, however, identified that their organization's management considered that there was intellectual property associated with the investment in training and development of BIM processes, and that this needed to be protected. As a result, some interviewees suggested that their involvement in wider networks occurred 'under the radar' and would not necessarily be condoned at an organizational level.

Interactions around these knowledge-sharing practices can be considered 'constellations of practice' (Wenger, 1998) as there are connections formed across a wide range of boundaries of practice and professions. The fragmented nature of the construction industry establishes many of the boundaries that must be navigated. These include boundaries and connections that occur intrafirm, within an individual organization; interfirm, between organizations, in largely project-based interactions; and transfirm, at a wider industry level (Bossink, 2004). Even though there are many levels and boundaries that networks and relationships can potentially span, several practitioners identified that alignment takes place in the thinking of participants. Wenger (1998) notes that alignment can create a sense of community, even across social and physical distances, and this was evident for many of the participants. However, it can also have negative consequences. Alignment may generate dominant views that override other perspectives and exclude alternative ways of addressing challenges that the industry faces. Variously describing such situations as producing 'cliques', 'pockets', 'groupthink', or 'bubbles' within BIM groups, practitioners are aware of the risk of such conformity.

> "I think our community is too cliquey. So, because we all know each other and we've all built this enormous relationship up, because we had to learn ourselves and develop ourselves, I think that's added to the complexity of it further, because everyone is stuck in their own little cliques and not understanding what's beyond what they're doing." *Interview 16—Australia, Multi-disciplinary consultancy*

As a result, knowledge sharing may need to be viewed with an element of caution, to ensure that practitioners remain receptive to new ideas and views, rather than limiting innovation and openness through alignment with their connections.

8.3 BIM adoption and career choice

The current lack of skilled practitioners is often identified as a significant obstacle to greater uptake and better realisation of benefits of BIM (Sun et al., 2017). Given that very little attention has been given to the development of BIM as a professional career path, this is perhaps to be expected. The approach taken by companies or industry sectors to BIM adoption and implementation influences the way that career opportunities or pathways develop within BIM roles. Responses to BIM roles by practitioners themselves and by others within the industry are also influential in shaping the development of professional opportunities in a BIM environment. By connecting the interests, opinions and experience of practitioners, the following discussion seeks to clarify the status of BIM as a career choice for practitioners.

8.3.1 BIM as a new career option

Role development for BIM practitioners often occurs in an incremental fashion. More defined roles tend to emerge as BIM practice becomes embedded in an organisation. At a personal level, practitioners respond differently to the changes in roles that BIM offers. As seen in Chapters 6 and 7, the new roles may be an unwanted but necessary career move for some, while for others they provide an opening to take on a new challenge or learn new skills.

For individuals in this latter group, BIM may offer a vocational choice that they had not previously considered. Similarly, for newcomers to the construction industry, whether school leavers, graduates or more mature workers making a change of career into construction, BIM may open up opportunities for different career paths that were not previously available. This change may also attract new people to work in the industry who would not previously have considered AEC as a potential career. O'Donnell, Karallis and Sandelands (2008, p62) identified that “the engineering and construction industry needs to be ‘cool’” to compete as a career choice, particularly for young people. Views of the construction industry as old-fashioned and physical have made it difficult to attract suitable talent into leadership roles in particular (Ofori, 2008), and have contributed to skills shortages in general. Highlighting the innovation taking place around BIM, and the types of career opportunities that it makes possible, provides an alternative narrative to catch the attention of a wider range of potential future industry participants.

The skill-set that allows a practitioner to operate effectively in a BIM environment in one discipline potentially allows them to transfer into BIM roles in other AEC disciplines. Many of the interviewees had done exactly that, with 12 out of the 73 now working in a different discipline to the one they began their BIM career in. One of the practitioners had translated his technical skills in BIM modelling into a job in the film industry for a time, and others expressed confidence that their skills and experience would translate easily into BIM roles in other disciplines or to jobs outside of AEC.

> “When we've had redundancies, I wasn't particularly worried because I knew I had lots of skills. I know I could literally quit my job tomorrow and I know that I could be employed. Even not in architecture, I've had offers from contractors. But if you look up the skills I've got, like information management and intranets, that could be applied to almost anything.” *Interview 50—UK, Architectural practice*

One practitioner also noted that BIM specialisation offers an opportunity for professionals to differentiate their practice in the employment or promotion market. This allows them to pursue new competencies according to their own interests, but also gives them more value to an employer because of what they can offer beyond the standard industry knowledge.

> “People find their own path. You find what you're interested in. I'm interested in, obviously we've been talking the BIM side, but we have people who have sustainability hats, we have people who've got totally really interested in the design process and obviously put more reviews in that and how we do stuff. We have the guys who are doing the laser cutting, modelling, who are interested in it and want

> to write guidance on how to use it. ... That's kind of how, to me, that's how you get promoted. It's that you have to offer something more than your core."
>
> *Interview 50—UK, Architectural practice*

These perspectives indicate that greater awareness of BIM as a possible career option opens up benefits to organisations and the wider industry, by widening the pool of potential candidates who may be interested in industry careers involving BIM. Because of the demand for BIM skills, and their transferability both within AEC and beyond, practitioners choosing a BIM career also benefit.

8.3.2 Top-down, bottom-up and third-party implementation

The pattern followed by an organisation in BIM adoption and implementation has a potential impact on the nature of the practitioners involved in BIM, and on how BIM practice develops. As previously noted, innovation in BIM implementation within many companies has initially followed a bottom-up approach, often driven by a specific individual with a personal interest in BIM. A common situation is that this person, usually working in a technical role, discovers BIM through a software tool that they can use to improve their own practice, then recognises and champions the advantage of BIM practice to the company as a whole.

> "When I first showed the BIM model to my manager, ooh that used to be in our dreams, because in building services we never imagined fully 3D, that everything could be in 3D!" *Interview 7—NZ, Engineering consultancy*

Because of this requirement for exploring and experimenting in BIM, the role is focused on innovation. The key individual has a significant influence on the context and environment in which BIM skills are disseminated and relationships and information flows develop. This is particularly the case at the earliest stages of the BIM life cycle, because there are few examples or guides to follow. Because the focus of their BIM interest has stemmed from their own role and requirements, the BIM process initiated by these practitioners tends to form within a silo BIM framework. Hartmann et al. (2012) identified the prevalence of bottom-up BIM implementation, and noted that companies which followed this path tended to operate in low collaboration environments.

Although bottom-up implementation can drive innovation throughout a BIM adoption process, it appears more common at earlier stages, and is more likely to have a technological innovation focus (Damanpour & Gopalakrishnan, 1998). As awareness grows and BIM becomes more established, practice tends to move to a top-down implementation, and focus more on innovations around process and administration. This is clearly supported by one interviewee's observation:

> "When we started, it was really bottom-up. I worked at the bottom to get the first projects, of course; you need your first successful projects to convince… And then you need to get an organisational perspective, because that's what they want as well. What is your strategy to implement it company-wide? Then it cannot be just bottom-up, because if it's all bottom-up, then the pre-cast concrete factory, and the contractor, and the engineering company, they cannot do it, they make different steps and cannot be integrated."
>
> *Interview 39—The Netherlands, Engineering and management consultancy*

The difference between top-down and bottom-up innovation in construction, as expressed by Winch (1998, p273), is that "new ideas can either be adopted by firms and implemented on projects, or result from problem-solving on projects and be learned by firms." A top-down approach requires informed leadership to recognise the potential advantages of BIM adoption within current practice, and to provide the resources and support for its implementation into the company.

Practitioners involved in top-down BIM implementation have different characteristics from the technical orientation of bottom-up innovators. Several of the interviewees working at a strategic management level in their organisations were considered BIM specialists or champions by others in the industry, not because of their own ability to implement BIM—which was low to non-existent—but because they had seen the possibilities that BIM offered their practice and had moved as early BIM adopters, despite their own lack of BIM skills. In such cases the practical processes of implementation are managed through the appointment of a champion who is able to integrate a detailed awareness of the company or project needs, with knowledge of BIM processes and technology. Awareness of BIM becomes more widespread as adoption progresses, making the likelihood of top-down implementation greater as organisation and industry leaders see value in BIM and do not rely on technical staff to drive innovation. One practitioner sounded a word of caution regarding the shift to top-down management, however:

> "You can move from a situation where you have got one person running around in an organisation, flying the flag of BIM, to a situation where you have got perhaps a Chief Executive, or a Chief Operational Officer mandating the way you work as

> an organisation. All of a sudden, it moves from one person's passion to the company's property, and I don't know whether it's a good thing or not."
>
> *Interview 58—UK, Cost and planning consultancy*

Others expressed similar concerns, that once ownership of BIM is taken from individual enthusiasts to company level, a more cautious and less open approach to BIM development may result. Companies were considered more likely to focus on maximising their own gain from BIM, rather than supporting the sharing of ideas and processes with project partners and other industry players. Depending on the performance identity of the practitioner, such a move may diminish the attractiveness of the role.

An alternative approach, instead of developing or appointing a champion within the organisation, is to bring in a third-party expert to act as a knowledge broker. The risk with this strategy is that the organisation does not have sufficient understanding of their desired outcomes to provide appropriate direction, and the outsider does not fully understand the context of the specific organisation (Allen, Tushman & Lee, 1979). BIM solutions are not 'one-size-fits-all', but require a specific local implementation. Allen et al. (1979) argue that this is a common issue in situations which involve a transfer of technology, because of differences between organisations' strengths, priorities and expectations. Third-party BIM consultants who were interviewed recognised this weakness, but tended to emphasise the holistic nature of the service they offered, where relationships and processes were important as well as technology.

Use of a third-party as a knowledge broker was described by a number of participants as a negative development for the industry, and they emphasised the need for companies to develop a response that was most appropriate to their own practice.

> "It is a bit of a band-aid solution, I think—you want the key players in the project to be working in that environment. As a pilot exercise, that is fine. But if that is your model going forward, then it is not very sustainable. BIM does not work as an add-on."
>
> *Interview 21—Australia, Engineering consultancy*

Part of the concern around a third-party approach was that many of the BIM consultants involved in selling their skills in this way were not perceived to have the necessary expertise and experience to enable knowledge transfer and substantial change in the company they were working for. The point made by many interviewees was that BIM practitioners should not be considered to have a uniform set of skills, and their particular backgrounds and spheres of activity suit them to different roles and career paths. While many have developed specific skill-sets into much broader application within BIM implementation, others do not necessarily have the same capabilities. Companies need to understand the implications of their stage of BIM implementation and approach to development, and recognise these as key factors in the selection of appropriate practitioners to be involved.

8.3.3 Integrating BIM roles

As BIM practice becomes more widespread, companies and practitioners are moving towards greater emphasis on embedding BIM awareness and skills into discipline-based roles, instead of identifying individuals to take on specific BIM responsibilities. This connects to the argument in the literature that BIM will become business as usual and specific roles will disappear (Akintola et al., 2017).

The idea of making BIM a part of normal industry processes, rather than a separate layer on top of existing practice, was also supported by practitioners. As described in Chapter 6, many of the participants claimed '*not BIM*' or '*BIM, and…*' identities that either prioritised or maintained their discipline-based identity. While the need for individuals with specific BIM skills was seen as necessary in the current environment, there was strong support for BIM to become part of everyone's role.

> "I think they need to have BIM champions, but it sort of defeats the purpose of having a BIM specialist if it's the platform where it's the standard, because by having a specialist you're implying that it's something that's abnormal or something that's out of ordinary. 'Oh, you want to talk about BIM, go and talk to that person over there.'"
>
> *Interview 15—Australia, Property development and management company*

Similar arguments were made regarding environmental sustainability when it first became a significant factor in AEC. Sustainability practice was (and still is) presented as the responsibility of everyone in the supply chain, and requires buy-in from all stakeholders involved (Robichaud & Anantatmula, 2010). However, success in sustainable design and construction still needs specialist roles to manage the process, and provide guidance and oversight. Environmental managers take responsibility for retaining oversight of the longer-term strategies and interests of the organisation and industry needs, as well as managing the more immediate operational issues that have to be dealt with within a project environment (Gluch, 2009). In BIM practice, as in environmental management, these professionals have a specific responsibility to act as gatekeepers to select and filter the knowledge required in a project situation, and support other practitioners to work with that knowledge. As in the sustainability example, this BIM role involves management of other practitioners and integration of a range of skills, and is unlikely to become a purely technical role as posited by Akintola et al. (2017). It is possible however, that it may take on negative controlling and monitoring responsibilities such as those seen in the case of environmental managers (Gluch, 2009).

8.3.4 Precariousness of BIM practice

From the practitioners' perspective, despite the attractions, a BIM career is currently an uncertain prospect. Many of the practitioners expressed apprehension that their career trajectory in their organisation is potentially limited because of the path they have taken. Very few senior management positions exist for those with a technical focus, and strategic BIM roles were considered by many to be short-term position which are necessary during the adoption phase of BIM, but redundant once BIM practice is embedded. As a result, most saw their current career path as a dead end. On the whole, they preferred to stay in BIM practice despite this, and discussed possible options to achieve career advancement. Moving into a specialist BIM consultancy role was suggested by several as a potential future career development. Others saw opportunities in sideways moves, for example from architectural practice to working for a main contractor, or into specialist subcontractors.

This focus on continuing in a BIM role, despite the lack of defined career prospects, contrasts with the widely expressed 'balanced identity' claim described in Chapter 6. Although these practitioners strive to maintain connections to their discipline alongside their BIM identity, their narratives regarding career progression appear to privilege their BIM identity, rather than risk losing the BIM connection. This further implies that their alignment with their organisation is secondary to their career preference of progressing within the BIM field. It also suggests that their contribution to the wider industry, as BIM practitioners, takes precedence over a specific job category or discipline-centred role. Löwstedt and Räisänen (2014) found a similar orientation in a case study of managers within a construction company, and concluded that identity can be connected to change—in that case, serving to obstruct change within the company by aligning managers with their identity of 'construction worker' rather than the needs of the job or the organisation.

In this current study, the identity of BIM practitioners is more aligned with promoting change, and they are prepared to move roles, companies and disciplines in order to achieve the outcomes they think are necessary for the industry. This approach fits the concept of protean careers (Clarke, 2009), where professionals prioritise career opportunities that allow them to build up their skills and knowledge, rather than affiliating themselves with a specific company or even a particular job role. The need for BIM practitioners to self-manage their career development further emphasises their positioning within the protean career model.

This dominance of professional identity over organisational alignment may prove hazardous to the progress of BIM within organisations. In many cases, particularly at early adoption stages, the BIM process of an organisation is heavily reliant on the skills and knowledge of key individuals to enable them to participate in BIM projects and to develop the necessary in-house capabilities.

> "A lot of it is down to individuals rather than companies; in [architectural practice] for example, they've got a guy in there who's really capable, and he'll go that extra yard… So if he left and moved to another practice, working with [architectural practice] could be a real issue." *Interview 21—Australia, Engineering consultancy*

To an organisation new to BIM, investing in a single expert or small team may appear to be the most straightforward approach to BIM adoption. However, with practitioners apparently much more aligned to personal growth and industry benefit, specific organisations face a risk when individuals in significant roles do not find the support or progress within their organisation that they need to support their chosen career path.

8.3.5 The place of professional bodies

Professional bodies did not feature strongly in the interviews, and where they were discussed, practitioners were generally critical of how they had responded to the emergence of BIM practice and its effect on professional roles. Ten of the practitioners interviewed had been or were currently involved in working groups or committees with their relevant professional body, but all expressed frustration at how little progress they made. Part of the issue, according to several of those practitioners as well as others who were not involved with such groups, was that too many of those involved saw BIM as the 'next big thing' and were getting on the bandwagon without having the knowledge or experience that was needed for the institutes to make any real progress. An alternative perspective was that such groups tended to attract people who had a great deal of experience in BIM technology, but little knowledge of the industry practice and application of it.

> "You've got all the geeks that are pushing things like IFC's, so all the buildingSMART guys, it's really hard being in a meeting with them because it's like, 'Jesus Christ, what are they actually talking about…?' I have no idea!"
>
> *Interview 64—UK, Multi-disciplinary consultancy*

The general opinion was that such organisations need to become more dynamic in identifying implications for members, and becoming involved in defining roles, developing training and supporting the requirements of their profession. Currently, most are not believed to be taking a leadership role to support the professions they represent, and in some cases were considered irrelevant as a result.

One professional organisation in Australia was an exception, with several participants in Australia and New Zealand identifying them as a pro-active contributor to BIM professional and technical development in their field. The director of that organisation was named by several industry people as a 'BIM specialist' during the search for interviewees. He saw his BIM involvement as necessary for his profession, but unusual in the industry.

> "What is the role of an association in this space? A lot of people say we shouldn't be, that's not our core business; we should be focusing on policy matters and whatever. In many ways this is a unique thing where we've said, no, actually we've got to be bit more active." *Interview 23—Australia, Professional organisation*

The Royal Institution of Chartered Surveyors (RICS) in the UK and the Associated General Contractors of America (AGC) were two other professional bodies that received favourable mention from some participants. Both of these organisations have launched training and accreditation schemes in BIM, and provide guidance documents and other resources to their membership and the industry as a whole.

The leadership provided by professional bodies is important in defining and legitimizing changes to professional roles (Greenwood, Suddaby & Hinings, 2002). These organisations are also often active in determining the educational priorities for their profession, and in providing continuing professional development (CPD) opportunities for their members (Friedman & Phillips, 2004). As such, the current lack of support for BIM from many professional bodies in AEC is likely to limit the awareness of BIM as a career option, and be an impediment for some people who would otherwise become more active in BIM.

8.3.6 The BIM backlash

One consequence of the recent widespread publicity around BIM adoption is that those later in the adoption curve have become resistant to the idea, and actively avoid engaging with it. Initial BIM use often takes greater resources to achieve appropriate project outcomes than traditional practice, due to initial investment in hardware, software and training, as well as the time required to adapt to a change in process. This is associated with a lack of understanding around what BIM is and what it delivers.

> "Directors in here jump up and down when they hear the word [BIM], saying they're not doing it and they're not touching it, we're not getting paid to do it, it's not happening. Because they're, of course, older school and they just see money and risk associated with it. But if you say we are using a 3D co-ordinated model that's okay, that's all fine, and we can do Revit, okay. But it's that word!"
>
> *Interview 14—Australia, Multi-disciplinary design practice*

Arguments around hype and 'BIMwash', where shortcomings in practice and mismatches between expectation and practical application are exposed, contribute to this (Fox, 2014; Miettinen & Paavola, 2014; Dainty et al., 2017). Industry perceptions that use of BIM is not beneficial to practitioners' job performance and career advancement (Howard, Restrepo & Chang, 2017), or to have negligible impact on project outcomes (Smits et al., 2016) also build up resistance to BIM specifically, even beyond the normal level of resistance to change that might be expected for an innovative and potentially challenging change to practice.

The industry rhetoric presenting BIM as a revolution or paradigm shift, as discussed in Chapter 6, does a further disservice to practitioners who are striving to implement change in their organisations. The transformation that has been widely portrayed as a sudden and complete change in practice is seen in practice to require slow and methodical adjustments and ongoing education. As a result, other professionals affected by their efforts start to view them as nagging or annoying as they try to influence project and organisational processes.

> "I hate to say it, but people are getting sick of hearing about it, you say you're a BIM manager, it's like 'Oh no, here we go. He's going to talk about models again.' It's just the idea of it…" *Interview 68—US, Owner/facilities management*

This can be quite demoralising for the BIM practitioner who is trying to bring about an improvement in industry practices. Even for the most enthusiastic BIM practitioner, such a response serves as a disincentive to pursuing BIM as a career.

8.4 Industry-level influences

The previous sections explored aspects of BIM career options from the perspective of individual and organisational influences. The following discussion looks at the bigger picture of the BIM environment, with consideration of two further issues that represent overarching aspects of BIM adoption. The representation and evaluation of BIM maturity is the first factor addressed, with further concerns expressed about the misleading representation of change in international contexts. Second, a life cycle framework of BIM as a professional life cycle is presented as a way of interpreting the changes and developments taking place in the industry and in the professional roles that provide a BIM service.

8.4.1 Evaluating BIM maturity

BIM practice is not uniform internationally or even nationally, despite ongoing efforts from governments and industry leaders. Change has yet to penetrate lagging industry sectors in the developed BIM environments (Ganah & John, 2014), and many less advanced construction markets still exist, particularly in developing countries (Bui, Merschbrock & Munkvold, 2016). The five countries included in this research were selected because of the different levels of BIM maturity that they are widely perceived to represent. Practitioners from every location compared their own country's practice with other BIM environments, and many were cynical about the progress other countries claimed.

> "In Singapore, our Singapore office has to deliver everything in BIM—but they are at least three years behind us. It's terrible; it's completely uncoordinated but it ticks the boxes. There's a heck of a lot of good people talking about this sort of stuff, but we've done a lot of global tours and we've been surprised by how little - there's pockets of areas where people have done it, but it's more sales pitch than substance." *Interview 37—NZ, Engineering consultancy*

Although there have been many surveys and evaluations published which show the rapid progress of BIM adoption in different international contexts, and within different disciplines and project environment types, practitioners were similarly dubious of how accurately such reports reflect the reality of practice. Practitioners in all countries considered local practice to be much more uneven and poorly developed than the various surveys represent, and as a result they were sceptical about the reported advances in other countries as well.

> "We're designers and architects and engineers and we pitch for a living. You never say, 'Oh, most of our designers are very good ...', 'That wasn't my best work ever...'. I think that's the same level of enthusiasm that's put into [answering BIM surveys]. No one wants to say, 'I'm the BIM manager and I'm shit at it', or, 'What we did was terrible.' So they say, 'Oh, yeah, of course we're doing BIM!'"
>
> *Interview 14—Australia, Multi-disciplinary design practice*

Not all practitioners were negative about the progress made by the industry, but it was widely believed that there is as much disparity in practice within each country as there is between countries, even in the environments that are perceived to be leading the way in BIM adoption internationally.

> "Globally we may be seen as a forefront leader in this, but there's still a lot of people regionally that don't have a lot of experience with it... There's some struggles still even in places where everybody thinks we're leading the curve."
>
> *Interview 67—US, Construction company*

Within each single country and discipline, perceptions of practice varied widely. Practitioners' opinions around BIM adoption and implementation reveal contradictory outlooks. Table 14 presents a selection of optimistic and pessimistic views on a variety of relevant issues. Of course, across all of the participants, opinions include the full spectrum of positions and these quotes have been selected to represent the extremes. Nonetheless, they illustrate the lack of uniformity that is currently evident, within emerging and advanced BIM environments alike.

Part of the challenge in establishing the maturity of BIM is that it has so many different definitions and applications. As illustrated in Chapter 1, each sector of the industry has a slightly different interpretation of what BIM practice entails. As such, it is unsurprising

Table 14 Contradictory views of aspects of BIM practice and progress

Country	Pessimistic	Optimistic
New Zealand	"BIM is one of those odd words that is very easy to use and is bandied around, but I'd safely say in New Zealand that no one does it right now. If they say they do, they're fibbing slightly." *Interview 33—NZ, Architectural practice*	"Our models can be used for everything from a contractor wanting to do simulations in time and cost, to a client who wants to take information to put into a database for asset and facilities management, through to a pretty picture for clients to show the board. Everything that's on that list, we do the whole encompassing thing, in-house." *Interview 30—NZ, Architectural practice*
Australia	"The reality of BIM, it's 1% of our business. I don't know if it is exactly 1%, but it's very, very small… BIM is important, and it's good high-profile stuff, it's good publicity and everything else, but in reality it's a very small proportion of our business right now." *Interview 12—Australia, Architectural practice*	"We're only working on BIM projects, we're entirely within the BIM space, there's enough projects coming through to employ quite a significant number of people." *Interview 21—Australia, Engineering consultancy*
The Netherlands	"It's still a struggle. I'm convinced there is a solid ground, there is potential, but it's not like we're having hundreds of clients at the moment." *Interview 62—The Netherlands, BIM consultancy*	"There's only a problem that's every time I have too much work! It may be 3 times what I can handle, what I get as offers, and also because of the referrals, if you have a client and he is satisfied, another client is contacting me. I can only work 40-50 hours a week!" *Interview 45—The Netherlands, BIM consultancy*
United Kingdom	"At the minute, the full BIM thing isn't really there. We've not had a full BIM project out of this office… we're ramping up. And we've spent a lot of money. I can't say how much but a lot trying to get ready. … I think we're ready, all I need is a proper job. We're itching" *Interview 48—UK, Construction company*	"Contractors are incredibly aware of what's required in BIM. I would argue they're ahead of everyone else…. Certainly, in terms of designing for manufacture and all these kind of subjects, design for manufacture, new surveying techniques, 4D, 5D, they're doing incredible things. They're just not really advertising it." *Interview 64—UK, Multi-disciplinary consultancy*
United States	"It's definitely helpful to know if [graduates] have some knowledge about VDC, and we are asking about that, but in no way it is a factor in hiring at this point. We just cannot expect that people at this point will have that knowledge from school." *Interview 71—US, Construction company*	"Today, most of the people who are coming out of undergraduate and grad school are being taught BIM as part of their curriculum, whether it's architecture, engineering, construction management, civil engineering, they're exposed to the tools. So that's almost an equal playing field there." *Interview 73—US, Multi-disciplinary consultancy*

that there are diverse views among different practitioners, let alone in different disciplines and countries.

> "Remember when BIM first came out, everyone was saying is it modeling or is it management? I think that actually misses the point, because it's all about information, and information is drawn between data. We tend to just say everyone knows it. It's like sustainability when it first came out. There were so many sub-topics but you still tended to just talk about sustainability. I think BIM is the same. Our people interpret BIM in lots of different ways, and that's part of the challenge."
>
> *Interview 64—UK, Multi-disciplinary consultancy*

Balanced and objective representation is necessary to allow practitioners to make an informed choice to move into a BIM career. Again, the risk with the current degree of confusion around BIM practice and progress may act as a disincentive to embracing a BIM professional role. Practitioners who might otherwise be interested in moving into BIM practice may be averse to do so when it is unclear how the industry is responding to BIM. The lack of transparency about the scale of the challenge involved may prove off-putting and is harmful to all involved if decisions are made based on biased or incomplete information. An overly rosy view of BIM is likely to give way to cynicism, when touted changes turn out to be illusory, or disillusionment, when expected transformations do not eventuate. An unduly negative view is likely to deter practitioners from engaging with BIM if progress is not seen to be taking place.

These findings imply that the resources currently spent on benchmarking and surveying activities are producing little benefit, at a professional level at least. Although such information is potentially useful for driving policy or other interventions at an industry level (Kassem & Succar, 2017), it appears to have a predominantly demotivating effect on practitioners. Instead of views of national or international representation of BIM, a greater focus on progress and achievements at a project and company level would better serve practitioners to identify and promote good practice.

8.4.2 The professional life cycle

A life cycle perspective of a professional service was proposed by Lawrence et al. (2016), using the context of LEED consulting roles as an example. A professional life cycle is concerned with the changes and developments in professional roles related to an innovation, that lead to the institution of a new professional service or practice. Professional roles develop in the wider industry context beyond both individual and organisational levels, and must balance the different needs and pressures of other factors such as the requirements of project partners and clients, and competition and relationships with other practitioners. The model has been applied here to BIM development and the changes that are taking place within the professional community as BIM becomes an established part of the industry. A life cycle view of professionalism views BIM maturity from the perspective of the developing professional role of the BIM practitioner. It presents a progression path that is driven by the tension between customisation and standardisation. Lawrence et al. (2016) structure the life cycle into four stages: innovation, validation, diffusion and commodification. Service delivery and expectations move through each stage as practice progresses. Figure 7 illustrates the life cycle model of Lawrence et al. (2016), which has been adapted for application to the BIM professional environment.

At the very beginning of the life cycle, innovation is driven by experimentation and unique solutions, and is dependent on individual creativity; in the BIM environment, this has produced a multiplicity of adoption and implementation approaches as individuals have become enthused about BIM's potential and have introduced it into their company's practices. These individuals have often come from technical backgrounds; consequently,

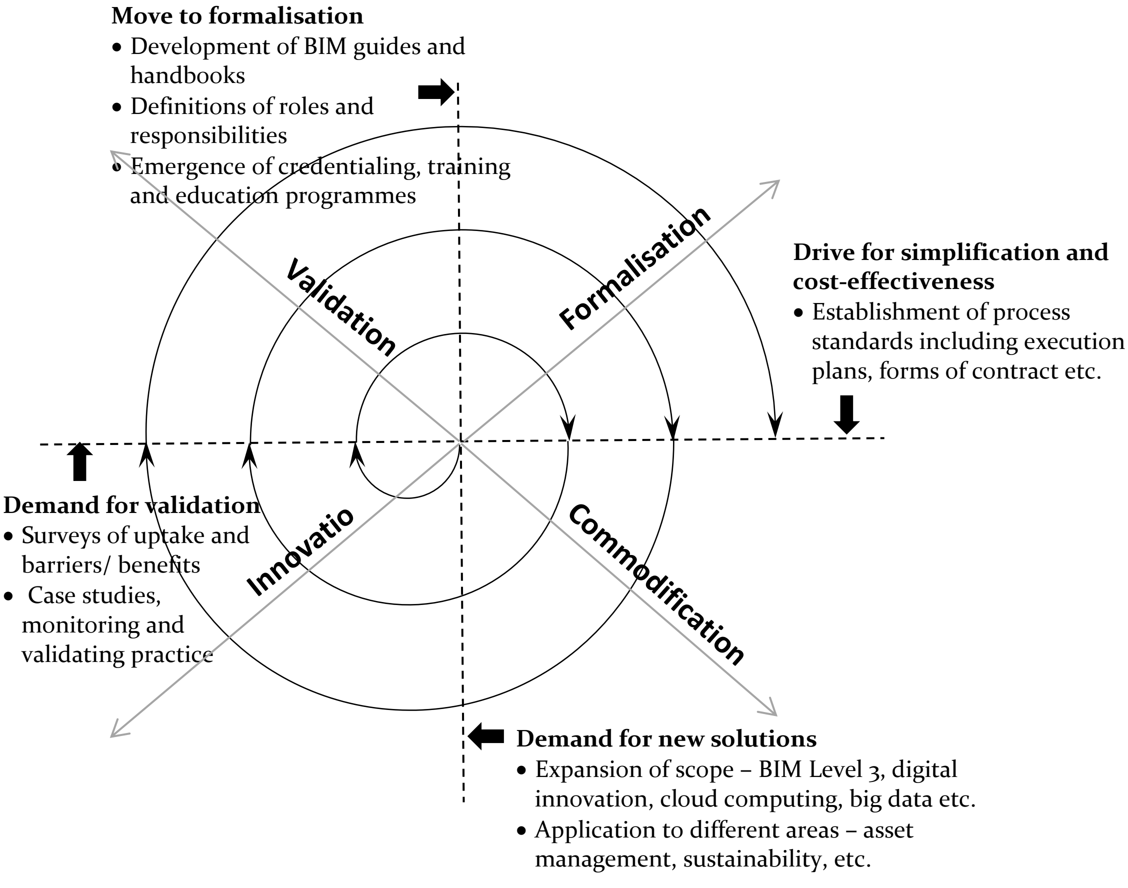

Figure 7 Life cycle model of BIM as a professional service (after Lawrence et al., 2016)

much of early BIM development focused on technical and process implications of BIM (Miettinen & Paavola, 2014). More strategic views of BIM adoption tend to occur at later stages of the professional life cycle, and have broader ramifications for the associated roles and the ways in which practitioners operate in the evolving BIM environment.

As evidenced in many of the interviews, and demonstrated in the descriptions of practice provided in Chapters 4 and 5, 'solo BIM' or hybrid practice can be used to deliver benefits without necessarily involving users in collaborative practice with other project participants. However, much of the advantage that can be derived from BIM adoption lies in the move to more collaborative project environments (Poirier et al., 2016). This requires further innovation by practitioners to promote and manage the change in practice.

According to Lawrence et al. (2016), the second stage of the professional life cycle, validation, occurs when initial innovations draw wider attention, and more emphasis is then given to measuring and documenting outcomes, and to validating practice to ensure skills and knowledge are evaluated and monitored. Reported benefits from the initial innovators in BIM increased demand across the industry, as outcomes reported for early-stage BIM development were generally highly positive (Azhar, 2011). Individual companies sought to customise the successes of others for use in their own circumstances. This led to an increased drive for technical expertise, and high demand for skilled staff.

In their development of the professional life cycle model, Lawrence et al. (2016) focused on LEED and related environmental performance programmes. The associated professional role in that situation has originated from a defined system for evaluating practice, making validation against the system a relatively straightforward process. BIM has had a more informal foundation: instead of developing to meet a given standard, BIM practice emerged following adoption of new technology and evolution of associated processes. As a result, validation of BIM professional roles started from the more fundamental level of establishing the benefits and requirements of BIM practice, hence the plethora of surveys and reviews of BIM uptake and benefits and barriers described in Chapter 1, and debate over the need for, and scope of, the roles required.

In the third stage of the life cycle, formalisation, the industry calls for formalised education and accreditation processes as the innovation takes greater hold and the practice becomes established. Many of the BIM guides and handbooks reviewed in Chapter 3, and other standards and specifications such as the noteworthy BIM publications identified by Kassem et al. (2015), are evidence of the formalisation effort in BIM. Much of this is to do with BIM practice rather than the professional roles involved, but the frameworks and standards also transfer into more defined requirements for skills and tasks of practitioners. Credentials for BIM practitioners have also started to emerge alongside expectations for training and education options. The advantage of this formalisation process is that practitioners have access to a foundation of support material such as case studies and standards to build their practice on. This allows them to establish baseline expectations quickly.

> "We're in a position now where anyone coming in completely new to BIM, as a process, as tools—people, process, technology—can pick up that suite of documents [PAS1192] and go 'right, ok, so that's what it is.' And you can read those within a week and have a good understanding of what BIM is. We've come from a point where, when we started, none of those documents existed, so we've been battling through it and trying to work out what the best things are … now it's a decent suite of documents for people to just pick up and deliver a Level 2 project."
>
> *Interview 56—UK, Multi-disciplinary consultancy*

As availability and use of these documents and the associated professional standards and credentials become more widely adopted, they will in turn feed back into validation processes at another stage of the cycle.

Once formalisation has been addressed, the final stage of the professional life cycle comes into play. Commodification leads to the basic activities involved in the profession becoming standard practice, through which they are simplified and regulated. This means that practitioners can follow practice guidelines and focus on straightforward implementation, rather than having to develop their own approaches. Those with greater knowledge are then freed up to develop innovation, for example expanding the scope of BIM to incorporate other industry innovations or interests, or moving practice into new areas of application, and thus moving the cycle through another iteration.

In this way, the professional life cycle model provides a framework for monitoring and directing progress in the development of BIM as a professional role. These life cycle stages loosely coincide with the preferences for practitioners' identity performance that were identified in Chapter 7. By using the life cycle model as an overview of the professional continuum, the interests and of practitioners can be matched to appropriate roles as the stages progress. When disproportionate emphasis is placed on one stage of the cycle, as currently appears to be the case with innovation, it is difficult for the role to mature. Practitioners whose identity is invested in innovation and inquiry are likely to be less interested in validation and formalisation, whereas interpreters and instructors will be strong in those areas. Those who are more aligned to implementation have an obvious role within the commodification stage.

The diffusion and maturation process for BIM professional roles is clearly still ongoing. The speed at which practice and expectations are evolving means that capabilities of individuals and companies, as well as the industry in general, must be designed and redesigned to remain relevant and effective.

> "There's an interesting quote that I heard a couple of years ago, I heard it at a conference: 'The illiterate of the twenty-first century aren't going to be those who can't read and write. It's going to be those who cannot learn, unlearn, and relearn.' That really stood out to me." *Interview 72—US, Construction company*

That quote, from futurist Alvin Toffler, aligns with the previously mentioned quote attributed to Charles Darwin, "It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is most adaptable to change." Both of these references highlight the view of practitioners that BIM is not the end point of the current drive for industry improvement, and that it is necessary to continue the cycle to develop and establish professional roles, knowledge and skills through and beyond current best practice. By using the life cycle model to provide an overview of the professional continuum, the efforts of practitioners can be fitted to their strengths in the interest of both practitioner and practice.

8.5 Conclusions

Overall, the messages from practice regarding the desirability of a BIM career are mixed. Although there is an established need currently for BIM skills at a variety of levels, the debate about the longevity of BIM specialist roles and the need for integration of BIM skills into the wider industry is ongoing. This can be countered with examples from the sustainability movement in AEC showing an established need for strategic and management roles, a pattern that BIM practice is likely to follow. Individual benefits are reported in employability and career opportunities, which deliver wider advantages to the AEC industry by making it more attractive to a greater variety of potential employees.

The concept of 'you don't know what you don't know' applies to companies that are naïve in their expectations and just want to jump on the BIM bandwagon. Without a framework of their needs and the roles that are necessary to meet them, such companies risk employing people with the wrong skills, or demotivating their BIM practitioners through not resourcing them appropriately or providing the necessary support. The phrase also applies to practitioners, particularly those who equate BIM-technical skills with knowledge and understanding of the BIM process. The current scarcity of BIM practitioners in the market allows insufficiently skilled or aware practitioners to move into BIM roles. They can obtain senior or leadership roles, solely on the basis of youth and BIM skills, both areas that have become mythologised in connection with BIM practice. Lack of awareness of BIM, through management not informing themselves or their companies, leaves organisations open to poor practice from practitioners who may be either unaware of their own weaknesses or taking advantage of a company's ignorance or enthusiasm. Outcomes such as this contribute to a potential backlash against BIM, as practitioners react to poor practice or limited progress in BIM. This applies equally to the wider BIM environment where many surveys and reviews seek to present a positive view of BIM adoption that is regarded with scepticism by practitioners.

Increasing research into company and project performance, rather than the current emphasis on surveys of BIM uptake and performance at a national and international level, would provide more useful information for practitioners. Documentation of both good and bad exemplars would allow practitioners to identify and emulate best practice. Additional effort in connecting this information to the concept of a professional life cycle would also contribute to the development of BIM as a professional role. As a professional service matures, different areas of expertise emerge in innovation, validation, formalisation and commodification. Detailed documentation of company and project activities allows initially innovative practice to move through the life cycle to become standardised, allowing the innovators to continue the cycle and advance the types of professional roles available. By making these stages more explicit, practitioners can relate their interests and strengths to the type of role that best suits them.

9 Approaches and attitudes to BIM certification and credentialing

This chapter is based on the following manuscript:

Davies, K., McMeel, D. & Wilkinson, S. (2017) Approaches and attitudes to BIM certification and credentialing. *Professional Issues in Engineering Education and Practice* (under review)

Chapter summary

Whereas my focus in Chapter 8 was on a practitioner-oriented view of BIM as a vocational choice, in Chapter 9 I look at some of the industry implications that arise from this. In particular, I provide a review of current approaches to what may be variously labelled qualification, certification or credentialing. These include offerings from government or industry organisations, speciality consultants, and commercial training providers. In addition, I draw on selected interviews, to present the views of BIM practitioners on training, education and qualifications that they have encountered.

Training and education providers across the construction industry have had to respond to the changes introduced by the BIM environment. Newcomers to the industry as well as professionals already working in the field require training and upskilling to adapt to national, organisational and project BIM requirements. Many existing educational institutes and industry bodies have diversified the courses they present to include BIM education and training, and a range of new entities have been established for the purpose. A number of these are also offering 'branded' certification to participants. Those interviewed considered it important that education and training opportunities in BIM were widely available, but their views on credentials and certification were often negative. The term 'credentialing' was commonly used in a pejorative sense, with the perception that it is frequently a money-making activity for those issuing the credentials, with little benefit to the practitioners. Possible approaches for more structured and independent skills development and certification are suggested, in order to avoid this negative connotation.

9.1 Introduction

Companies that have made the move to building information modelling, or those currently involved in BIM adoption, often rely heavily on the knowledge and enthusiasm of individual staff members who take on BIM specialist roles. As the field has evolved, these BIM practitioners who have influenced and shaped the application and practice of BIM have been largely self-taught. Consequently, they have taken diverse and uncoordinated approaches to the development of their own skills and knowledge, the skills and knowledge they have passed on to others, and their companies' practices and processes. Miettinen and Paavola (2014) argue that this process of user-led experimentation is essential for organisations to explore the value of BIM for their own operations. As BIM becomes more established, however, this ad-hoc approach becomes impractical and inefficient. Jaradat, Whyte and Luck (2013) identified that not only are specialised skill sets needed for the new professional roles that are emerging with "digital ways of working," they also bring quite different expectations of the process in terms of what are considered to be appropriate methods of working. Given that the adoption of standard processes and methods is one of the underpinning principles of BIM, it is necessary for those who are responsible for its implementation to share a common understanding and approach. This chapter seeks to provide insights into industry moves to define and standardise the skills and roles of BIM practitioners, focusing on the reasons for and approaches to industry-based certification or 'credentialing' in particular.

Companies are understandably hesitant to commit to a change that will have an undetermined impact on their activities. The extent to which they need to change their current practices and processes is often ambiguous, and the staffing, skills and training requirements of BIM can be difficult to identify from current published guidelines and industry documentation. This situation is further complicated by many government entities and other large client organisations mandating BIM use on their projects, requiring organisations and project teams to upskill rapidly to acquire the capabilities this necessitates. The possibility of simply adopting an established industry certification to demonstrate that staff have the requisite competence is thus an attractive option, particularly for managers who may still be trying to get to grips with what BIM means for them personally and their company as a whole.

Credentialing is a term used to cover all forms of third-party recognition of an individual or organisation's ability to meet some predetermined criteria. Different types of credentials include certification, accreditation, occupational registration/licensing, and certificates. Although the importance and value of credentialing varies between different countries and different occupations, generally it is used to establish some degree of control over the scope and quality of specific professional services (Freidson, 1986). Within the current construction industry environment, formal credentials are not required for an individual or company to offer BIM services. No overarching administrative bodies exist to coordinate or establish credentialing approaches. Despite this, numerous certification and certificate options are now offered across the industry. Certificates are commonly associated with education pathways and indicate that an individual has completed a specific course or programme of study, or has been assessed to have a particular level of knowledge. Certification, however, involves an element of skills and knowledge maintenance. Not only do candidates have to demonstrate a certain standard of knowledge, they also need to continue to update their knowledge through professional development, and renew their certification periodically to show they have remained competent in the current context. Although other forms of credentialing are mentioned, the main focus of this discussion is certification.

9.2 BIM as a profession

Since BIM practice first began growing and evolving there have been various arguments around the development of BIM practitioners as a new professional role. A commonly cited barrier to greater use of BIM is the lack of clarity of roles and responsibilities around BIM implementation (Gu & London, 2010). However, there is debate around whether this means the development of BIM skills and capabilities by professionals in traditional industry roles (Akintola et al., 2017), or the institution of a new professional role or roles (Sebastian, 2011). In current industry practice, there are clearly numerous roles that have emerged as a result of the development of BIM; in a review of online job postings, Uhm et al. (2017) identified 35 different BIM-related job titles. Of the job titles listed, some are clearly associated with traditional terms that identify them as professional roles, for example BIM manager, BIM project manager, BIM engineer. Others are less easily defined, such as BIM coordinator and BIM designer, while a third group include terms that would normally exclude them from a professional function, e.g., BIM technician, senior BIM draftsman. Scott (2008) distinguishes between different types of professional authority, with three categories identified, namely creative professionals, carrier professionals, and clinical professionals. Creative professionals generate new frameworks and rules of practice that underpin the work of others in their field. Carrier professionals transmit and interpret the profession's ways of working to others, and "must adapt and translate their messages to fit specific recipients and varying local circumstances" (p228). Clinical professionals make up the largest group, and are involved in actively applying the principles and frameworks of their profession to the problems of their clients or environment. Scott further makes the point that every profession has a set of parallel or subsidiary semi-professional roles that operate under the authority of the core professionals. From this perspective, it appears that the emergent BIM profession therefore follows a similar pattern to other established professional groups. Not all of the BIM roles identified by Uhm et al. (2017) are necessarily held by BIM professionals, but represent a core of BIM professional roles, with individuals acting as creators, carriers or appliers within their domain of specialised expertise and knowledge, supported by technicians or associated roles that enable them to deliver the professional services their clients (whether in-house or external) require. This way of viewing professional roles has similarities with Lawrence et al.'s (2016) concept of the professional life cycle explored in Chapter 8. Different types of role are filled by practitioners with varying interests and levels of expertise, according to the needs of the role.

Writing of the construction management profession, Brown and Phua (2011) observe that "conceptions of professionalism are generally bound up with accepted bodies of knowledge and professional qualifications, which are contested features of CM" (p87). These features are even more contested in the BIM field, where the combination of a rapidly growing technology and a limited number of practitioners has led to an ad hoc development of training and qualifications, and no clearly established body of knowledge. A further level of complexity is identified in Jaradat et al. (2013), with the observation that professional roles within construction project teams are very interdependent, and the boundaries of roles and responsibilities may change from project to project depending on specific social and organisational contexts. Again, a BIM environment is an example of this situation at its most challenging, relying heavily on cross-disciplinary collaboration and sharing of expertise to function effectively. Gustavsson and Gohary (2012) argue that clearly defined roles are in fact counter-productive in collaborative working, and it is more important that roles and responsibilities are flexible and able to change as project needs dictate.

One of the fundamental requirements identified for successful BIM implementation is that it is developed and recognised as a structured career path, together with ongoing training and professional development (Sacks & Pikas, 2013). Although the status of BIM is still unclear in the literature, the emergence of certification and professional qualifications that are specific to BIM practice is one indication that BIM is being viewed by the industry as creating a new professional role.

9.2.1 Professional education and development

BIM competency of an individual is defined by Succar et al. (2013, p178) as "the personal traits, professional knowledge and technical abilities required by an individual to perform a BIM activity or deliver a BIM-related outcome." Competency can be obtained through formal education, vocational or on-the-job training, or professional development. Within a formal education context, BIM is becoming increasingly well-established as part of the curriculum in universities providing degree programs related to the construction industry, whether architecture, engineering, construction management or other related specialisations. In some cases, BIM is incorporated into existing courses, while in others it becomes the focus of a standalone course. Some institutions have developed new programs, often at graduate level, that are largely or completely BIM focused. Many of the BIM courses currently available have a significant focus on technical BIM skills (Abdirad & Dossick, 2016), which tends to be the element of competency that students find easiest to learn, but also most valuable (Sacks & Barak, 2010). More difficult elements such as collaborative working and interpersonal skills are developed by a number of institutions through involving students in multi-disciplinary, cross-institution, and often international collaborative environments (see for example Becerik-Gerber et al., 2012; Solnosky, Parfitt & Holland, 2014). This is increasingly recognised as a valuable approach for preparing students for the complexities of practice. A range of other approaches to developing BIM-competent graduates have been identified (Abdirad & Dossick, 2016) but despite the increasing number of graduates with BIM knowledge this is not sufficient to provide the necessary level of BIM competence across the industry.

Formal academic qualifications are often perceived to fulfil a different function from vocational or professional development, and as a result the education and certification processes for each tend to be managed independently (Bravenboer & Lester, 2016). For construction professionals already within the industry, much of the training and professional development tends to take place informally (Detsimas, Coffey, Sadiqi & Li, 2016). Formal industry training is often focused around compliance issues, particularly to do with workplace health and safety, or internal reporting or documentation requirements. Informal learning is common for the acquisition of new skills, such as BIM, and approaches such as peer-learning, trial-and-error on actual projects, or self-education though technical publications are common in BIM development (Ku & Taiebat, 2011). As a result, such skills are often developed with no formal certification or recognition of the competence of the professional. Lee et al. (2013) found in a survey of companies in the USA that the majority had an in-house BIM training program, often employing their own BIM trainers. However, in most cases this was just-in-time training targeted to specific project needs rather than bigger-picture development of professional roles or awareness.

Many professional organisations require a minimum number of hours of CPD as a condition of membership, and provide a certification programme which documents this. While this may be seen as a good mechanism for certifying professional skills, Friedman and Phillips (2004) identified that the implementation of CPD is frequently inconsistent, irregular and poorly managed. Certification of CPD programmes tends to document attendance, rather than providing an evaluation of any learning that may have taken place. The potential weaknesses of the CPD process is a moot point for BIM practitioners, however, given that BIM is not yet widely recognised as a professional role.

9.2.2 Industry parallels

The evolution of new roles requiring standardisation of skills and processes is not unique to the BIM environment. Within the construction industry, similar paths have been followed in the fields of green building, environmental management and safety management.

In green building, many of the rating systems rate a project more highly if the practitioners working on the project hold related credentials. For example, in the LEED (Leadership in Energy and Environmental Design) rating scheme administered by the US Green Building Council one point is available for having a LEED Accredited Professional (AP) on the project team. While it is not a requirement for team members to possess a LEED credential, this advantage clearly influences the desirability of the credential for practitioners. Similarly, in the UK the BREEAM (Building Research Establishment Environmental Assessment Method) scheme allocates 2 points if a BREEAM AP is engaged on the project. Tucker, Pearce, Bruce, McCoy & Mills (2012) found that the perceived value of green credential systems to practitioners (in terms of factors such as increased knowledge, remuneration and career opportunities) was associated with their affiliation with rating schemes. Credentials that were not directly affiliated with a scheme were considered less valuable. However, Gebken, Bruce & Strong (2010) showed that the value of green credentials depended on professional context, and perceptions of the benefits of professional certification differed for practitioners working in different roles or organisation types.

Environmental managers appear to be positioned similarly to BIM practitioners, in the sense that they are not clearly established as a professional group, with Gluch (2009) identifying that “the qualifications, education, work tasks and organisational position of the role remain ill defined and informal” (p966). However, descriptions of the position of the environmental manager suggest that the BIM specialist role may be less dependent on having these elements of a formally established position. The weakness of the environmental manager role, according to Gluch, is that it has no influence or authority within a project framework. In contrast, the centrality of BIM and thus practitioners with BIM knowledge and expertise within current practice ensure that even without recognised roles or qualifications, there is a clear reliance on those with the necessary skill set.

The safety manager is a role that is not exclusive to construction, but also has a place in many other industries. It is more well-established than the environmental management or sustainability role examples, but is still not clearly defined. The requirements and activities of safety managers are very dependent on the types of organisations they are part of, and their interactions with regulatory, academic, and professional bodies (Provan, Dekker & Rae, 2017). Although there are a multitude of professional certifications for health and safety, there are no established qualifications or certifications for the safety manager role and thus no barriers to unqualified individuals taking on the role. This results in uncertainty as to whether or not it can be considered a profession (Ferguson & Ramsay, 2010). Within the construction sphere specifically, the informal standard for US safety managers is a 30-hour course, which has been identified as a suitable introduction to the role, but insufficient for effective safety management (Hardison, Behm, Hallowell & Fonooni, 2014).

9.2.3 BIM credentials

Currently in the construction industry, BIM credentialing is focused on certification from a variety of third-party providers. Two broad approaches may be used to define industry competency or development frameworks (Lester, 2014). The internal or attributes-based approach is commonly drawn from a review of current practice to determine the skills that competent practitioners demonstrate when carrying out their roles. The abilities, knowledge and personal characteristics identified from the review are then used to form the basis of a role definition. An external or activity-based approach, on the other hand, is focused on the outputs of the role, and defines the tasks or activities that the competent practitioner needs to be able to do, but without specifying how they are to be done. Lester (2014) further notes that models exist which successfully combine aspects of both approaches. All of these different approaches are evident in the range of BIM certification options identified. Many different organisations internationally have identified the need or demand for BIM training and certification, and have moved to provide services at various levels. From these, four types of BIM certification agencies can be identified. A summary of identified certification options is provided in Table 15. A more complete breakdown of the options and the sources of information is provided in Appendix D.

The most common BIM certification providers are established professional bodies that have diversified their scope to include BIM training, which has become a common need as new technology and processes are brought into practice. Much of this is focused on CPD; however, some of these bodies also offer 'branded' certification to participants. Examples of these are the UK-based Royal Institution of Chartered Surveyors (RICS), and the US construction industry association, Associated General Contractors of America (AGC). The RICS offers both a training course (Certificate in Building Information Modelling (BIM): Project Management) and a certification option (RICS-Certified BIM Manager). The AGC combines the two in the AGC Certificate of Management-Building Information Modeling, which requires applicants to complete a set of training modules followed by an examination, in order to become certified. In both cases, the certification is connected to the CPD requirements of the professional body, with certified practitioners required to complete five hours of CPD on BIM-related topics annually, in the case of the RICS certification, and 30 hours of BIM-related continuing education over a 3-year period for the AGC certification. Both schemes require re-certification after 3 years, which is dependent on achieving the CPD requirements. The Building and Construction Authority

(BCA) in Singapore is a government agency rather than a professional body, but has taken a very similar approach, offering 2 and 4-day training courses followed by an examination, with successful candidates then certified in BIM Modelling, BIM Planning or BIM Management, depending on the module completed.

Table 15 Summary of selected BIM certification options

Country	Name	Credential Type	Provider	Uptake as at July 2017 (where available)
UK	BIM Informed Professional	Individual, training and certification	BRE Global	2
UK	BIM Certificated Practitioner (Project Information Manager/ Task Information Manager)	Individual, training and certification	BRE Global	39
UK	BIM Level 2 Business Systems Certification	Company, certification	BRE Global	22 (7 of which have multiple locations certified)
UK	RICS-Certified BIM Manager	Individual, certification	RICS	42
UK	Certificate in Building Information Modelling (BIM): Project Management	Individual, training	RICS	
UK	BIM Level 2 Accreditation	Company, certification	Lloyds Registry	6
UK	Building Information Modelling Certification	Company, certification	Ocean Certification Ltd	No listing of accredited companies; 4 identified on website
UK	BSI Kitemark for Building Information Modelling (BIM)	Company, certification	BSI	
UK	BSI BIM Verification Certification	Company, certification	BSI	
UK	BIM Foundations	Individual, training	Stroma	
UK	BIM (Building Information Modelling) Certification	Company, certification	Stroma	
UK	BIM Staged Certification Scheme	Company, certification	QA International Certification	
Netherlands	BIM Quickscan	Company, benchmarking	TNO	
USA	AGC Certificate of Management-Building Information Modeling (CM-BIM)	Individual, training and certification	Association of General Contractors (AGC)	
Canada	CanBIM Professional Level 1 certification	Individual, training and certification	CanBIM	35
Canada	CanBIM Professional Level 2 certification	Individual, training and/or certification	CanBIM	95
Canada	CanBIM Professional Level 3 certification	Individual, certification	CanBIM	27
Canada	CanBIM Certified Professional	Individual, certification	CanBIM	23
Singapore	Certification course on BIM Planning (Building Developers and Facility Managers)	Individual, training and certification	BCA	
Singapore	Certification course in BIM Modelling (Architecture/ MEP/Structure tracks)	Individual, training and certification	BCA	
Singapore	Certification Course in BIM Management	Individual, training and certification	BCA	
Australia	BIM Excellence Organisational Assessment	Company, benchmarking	Change Agents AEC	
Australia	BIM Excellence Individual Discovery	Individual, benchmarking	Change Agents AEC	
	GRAPHISOFT Certified BIM Manager	Individual, certification	GRAPHISOFT	

BRE is a slightly different case as it is a commercial enterprise, but it is a long-established institution with many construction industry functions in the UK. A suite of BIM training and certification products are some of their more recent offerings. The individual certification is based on completion of Stage 1 and Stage 2 training courses (either face to face or online) and associated assessments, plus submission of documents in which applicants demonstrate that they have the appropriate BIM knowledge, whether developed through training or experience. The application documents are then audited to determine accreditation. Again, the holder of the certification must complete CPD (15 hours per year) and must be re-audited every 3 years. BRE also offer company level accreditation which evaluates company performance and processes for compliance with PAS 1192-2:2013. The company level accreditation is tailored specifically to the individual company and type of operation, and is based on an audit of documents and processes. This is assessed for each location, rather than the organisation as a whole, and must be renewed on an annual basis.

A second category of BIM certification providers are new or peripheral enterprises which have developed as a result of the rapid and widespread expansion of BIM adoption in the construction industry. These commonly seek to establish support structures or systems for the wider BIM context. In many cases these enterprises create a business model based on their support role, and commercialise their activities, with one such activity being the development and delivery of certification to individuals or organisations. An example in this group is TNO in the Netherlands, which developed the Quickscan tool for evaluating and benchmarking companies' BIM performance (Sebastian & van Berlo, 2010). Quickscan is not a formal certification approach but shares some of the same characteristics. Although it offers a free online questionnaire for firms to evaluate their own BIM use, the more substantial purpose of the tool is to allow third-party assessment of a company by certified consultants, that can then determine the suitability of the company for inclusion in BIM projects. A similar approach is the BIM Excellence programme developed in Australia which also uses certified consultants to assess a company's BIM capability, using online evaluation tools along with on-site analysis. BIM Excellence also has options for assessing BIM capability at project, team and individual levels for greater granularity of information. Again, this is currently not a formal certification, but provides a framework for evaluating a company's ability to perform at a required level. In Canada, the CanBIM group is a construction industry organisation that was set up to develop and improve the Canadian industry's capability in BIM. They also offer training and certification for individuals at various levels of BIM expertise. Level 1 certification is based on completing a training course, Level 2 requires training or documented experience, Level 3 includes a recognised degree or diploma and 3-5 years of experience as well as an approved BIM management course and evidence of having completed a project utilizing multi-discipline BIM. The highest level is the CanBIM Certified Professional, for which applicants have to submit evidence of having completed at least 3 projects using integrated, multi-discipline BIM. All require ongoing CPD of between 10-20 hours across 2 years, depending on the level of certification.

A third group offering BIM certification services are organisations which have an established role in accreditation for other standards, which have added BIM standards to their portfolio. These tend to focus at the organisational level, to certify that an organisation is conforming to the requirements of a given standard. Five such services were identified in the UK market, provided by BSI, Lloyd's Register, Ocean Certification Ltd, Stroma Certification, and QA International. All five operate through on-site assessments of a company's operations and management system against the PAS1192 suite of standards, and are reviewed for compliance every 12 months. BSI and Stroma both also offer BIM training courses for individuals. All of these suppliers position themselves as independent certification providers.

Finally, software companies also offer certification options, usually focused primarily on their own software tools, but in some cases explicitly labelled as BIM qualifications. For example, GRAPHISOFT offers certification in ARCHICAD proficiency, but also has a GRAPHISOFT BIM Manager Certification scheme. Candidates must complete a 2-day training course, followed an on-line assessment, and if successful are then entitled to use the title of 'GRAPHISOFT Certified BIM Manager', with renewal every two years.

9.3 Drivers for certification

Although the call for a uniform set of credentials or certification is often heard across the industry, the motivations for a move in this direction are diverse. Perhaps the most straightforward reason offered is that a set of certification options would help define the roles held by BIM practitioners.

> I don't think anyone really grasps the definition [of the BIM Manager role], it's a pretty hard thing, even internally. …We see a lot of people struggling with what it is. *Interview* 8—*NZ, Engineering consultancy*

Because BIM is a relatively new function in a company or project team, the skill-sets and role responsibilities of BIM practitioners are often unclear to other project participants. In some cases, interviewees felt that people who carried out BIM functions were not perceived to be in a 'serious' role but were effectively 'CAD technicians', and that the use of a standard certification for BIM practitioners would improve views of BIM specialist roles from clients, project partners and colleagues. Certification would not necessarily create greater awareness of the activities or requirements that they hold responsibility for, but it would provide a framework for informing the wider industry of what can be expected from BIM practitioners.

A related element of the potential of certification to define roles is as a means to exclude those who claim the same titles as skilled or qualified practitioners, but without the same level of knowledge or skill. Many of the interviewees were critical of other practitioners holding similar positions whom they considered lacked the necessary level of BIM understanding. For them, a certification option would support those who were prepared to take on additional training and certification to establish themselves as BIM practitioners, against those who were treating it as a sideline or temporary step in their career, or were opportunistically moving in to BIM roles without the necessary understanding of the process.

> "I'd challenge anyone who says they're BIM managers, to actually prove that they're BIM managers and not just a software manager. A BIM manager needs to make sure he's not just looking after the software but also getting involved in how the BIM aspect is actually being produced and delivered. I don't know how many of them are doing that." *Interview 6—NZ, Engineering consultancy*

This is related to the desire for professional recognition of BIM specialist roles. Roles such as engineer or architect are widely understood, but the more unusual and less public role of the BIM manager and associated positions do not have the same status. A professional credential would help individuals to establish themselves in a BIM role, and provide a form of validation of their position and expertise.

> “You don't want to call yourself something when you're not... if you move into a title like that, you want something behind you so you actually can back up what you're talking about.”
>
> *Interview 35—NZ, Architectural practice*

From the employers’ perspective, a recognised credential, particularly one that includes some evaluation of experience, would be a valuable addition to their recruitment toolkit. Several interviewees who had been involved in recruiting new BIM staff described developing their own tests or assessment methods to try to capture more than simply technical ability.

External parties are also looking for evidence of a certain standard of knowledge and skill in BIM. Clients seeking to implement BIM are starting to require pre-qualification of individuals and companies for consideration on projects. This is particularly the case in the UK, where the Government mandate for Level 2 BIM use on public sector projects has seen the application of the PAS1192 suite of documents as a standard requirement across both the public and private sectors. Part of this involves ascertaining that project participants have the appropriate skills, experience and systems at both individual and company levels to carry out the work to an appropriate standard. None of the interviewees had experienced that situation at the time (prior to the mandate coming into effect), but were aware that it was coming.

> “Related to training is whether I should go and get certified as well... I'll probably have to do it at some point because I'm almost certain somebody will [ask for it].”
>
> *Interview 50—UK, Architectural practice*

From these perceptions, it appears that there are two key reasons for BIM practitioners, their employers and others they work with within the industry to consider some form of certification to be useful. Professional recognition is the most important reason for practitioners, to help ensure that their roles and areas of influence are clearly expressed in the projects and companies they work within. The call for certification as a quality benchmark is often described as coming from employers and industry clients, but is also heard from practitioners as well, to verify that those in the BIM roles have an established level of experience and skill that qualifies them for their position. Despite these clear arguments in favour of certification, there are some concerns or criticisms about how it is being introduced into the industry.

9.4 Negative views of certification

Certification and 'credentialing' was commonly used in a pejorative sense by participants, with the perception that it was a self-serving exercise for the companies involved in providing it, rather than a service that provided a necessary structure and measure of expertise to the industry. In some cases, the companies offering certification were seen to be trying to raise their profile and demonstrate their relevance to the industry, but more often the perception was simply that BIM courses and qualifications are a money-making activity for those issuing the credentials.

Further to this, many felt that the certification process was simply a tick box exercise on the part of the trainers and examiners, not a measure of competence. Following a very general overview of BIM processes and requirements, a simple examination would label a newcomer with no practical experience as a BIM practitioner.

> "Everyone nowadays is a BIM specialist. Everyone's a BIM expert. I saw somewhere the time it takes to be an expert in your field of something in particular, it's like six years. Or two days if you do the [industry provider] qualification! That's the problem we've got." *Interview 54—UK, BIM consultancy*

Part of this negative attitude stemmed from resentment from some of the early BIM adopters that their expertise and hard-won skills are being commercialised, which is particularly galling to those BIM practitioners who have been very involved in sharing their knowledge and helping others improve their skills, at company or personal expense. Commercial bodies are now seen to be coming in and capturing the knowledge from those who have gone through years of developing and refining the processes and standards. Because in many cases the certification providers have not been immersed in the projects and processes themselves, they do not have the depth of knowledge necessary to either pass on the knowledge, or effectively assess the performance of others.

> "I think we've got some, what I call quite Mickey Mouse, accreditations around at the moment. I was talking to somebody about [certification], it took him two days and cost them almost two grand and really he didn't know any more afterwards than he did at the beginning." *Interview 52—UK, BIM consultancy*

The increasing drive in parts of the industry for clients to require some form of certification to prequalify project participants for involvement in BIM projects was a source of irritation for some interviewees. This was especially the case when those credentials are seen by BIM practitioners as their own expertise repackaged and sold back to them.

> "If you look at my CV, in terms of events I've spoken at—if you looked at that and went 'oh, he doesn't know what he's talking about' I'd be a bit worried. So do I need a piece of paper to do that?" *Interview 50—UK, Architectural practice*

Current developments in certification and associated training schemes are perceived to be imposed on practitioners by outsiders who do not understand the requirements and constraints of their roles. It is unsurprising that for practitioners who have put in a significant amount of effort already to develop the skills and knowledge through their own self-education, networking and building up processes and procedures from nothing, there are negative implications of certification approaches.

9.5 Certification challenges

Depending on the scope of the role, and whether operating at the organisational or project level, BIM practitioners often require a broad scope of knowledge to be able to operate effectively. In general terms, these can be classified into four categories. BIM management skills, domain knowledge, BIM-technical skills and interpersonal/soft skills all contribute to the functions required in a BIM role. Where the certification expected by employers was based on software capability, the training was seen as too limited in scope. Many interviewees expressed the view that BIM software skills were in fact the least important of the range of knowledge needed by effective BIM practitioners, and the easiest to teach. A focus on software can be a trap that limits the necessary transformative approach that BIM adoption requires.

> "There are a lot of companies selling software and they also give courses. They do it quite well, giving as I call it 'klokken cursus' (clock courses)—they know exactly how to deal with a program. A company needs that, let's not forget it, but what I noticed also is that it hangs a lot together with what you want to reach with BIM. You need also somebody with an overall picture. If you send only software vendors to a company ... and give courses about how to use the program, there is a risk that they use the new program but for the old process and for the old approach, et cetera." *Interview 45—The Netherlands, BIM consultancy*

However, although the four categories can be seen to apply to all BIM roles, different domains will have different knowledge sets, and the specific BIM management and technical skills will vary based on the area of influence. As a result, it is difficult to identify universal training and certification requirements, since it is not necessary for everyone to have the same level of knowledge and understanding.

> "For example, for an architect there may be something really specific that they need to know on a particular job, but does everyone need to know it on every job?"
>
> *Interview 73—USA, Multi-disciplinary consultancy*

This variety is not just evident with disciplinary divisions, but applies also to the way in which a company or project has implemented BIM in a particular instance. The diversity of the BIM adoption and implementation process has led to many different interpretations of what roles are required. In the longer term this may well be an unnecessary complication in BIM practice that certification can help to overcome, but at present it means that the certification and training options available do not align with what practitioners are seeking.

> "There's so many different schools of thought. There's so many different approaches. There's so many different environments that BIMs develop in. Everyone's got a different way of doing things."
>
> *Interview 58—UK, Cost and planning consultancy*

Related to this issue of diversity is the fact that BIM approaches and applications are still evolving. At the same time the roles are changing, and the associated titles, terminology and expectations are in a state of flux. This makes it questionable that a particular certification programme will prepare a person for a specific role, without an established role definition.

> "All the names are misleading. Manager is managing people. Some of them don't manage people... BIM coordinator is different on one project than coordinator on another. These titles are meaningless and limiting. People change. Roles change. In BIM, roles change very quickly."
>
> *Interview 19—Australia, BIM consultancy*

Again, the adoption of certification is likely to help develop more unified role definitions, but at the current stage where many of the practitioners are more knowledgeable than those developing and implementing the certifications, there is an information gap that needs to be bridged.

At the organisational level there is similar confusion about which of multiple systems to adopt, in the UK at least, but the logical case for adopting the credential appears clearer. However, the financial implications of certification still make it a difficult decision to make.

> "Every time we do a tender we have to do a huge response, but it will be, 'we're Level two certified. There you go'; that's your tender response. You just have to have a word or two. It's difficult. We could become certified, just by the way our company is set up internally around the processes and protocols, but to pay ten thousand pounds an office, and then pay two thousand pounds a year upkeep, and have it audited every year, that's a huge strain on the business, financially."
>
> *Interview 46—UK, Multi-disciplinary consultancy*

The current rate of change in the BIM environment appears to be a significant challenge for organisations seeking to establish certification schemes. The continuing evolution of roles and practice, and the lack of people with the appropriate skills to develop and administer such programmes, make it difficult to firstly define them in a way that the industry will accept, and then to manage their implementation.

9.6 Discussion

From the review of the currently available certifications, and the findings from the interviews, three aspects of the BIM certification and credentialing situation have been identified that warrant further discussion. First, although both individual and company level certification were discussed by interviewees, the relationship between the two was not considered. Both types of certification are important to the practice of BIM as a profession. Second, the relationship between certification and academic qualifications is a challenging area that requires further consideration. Finally, by contextualising certification as a tool for consistency and standardisation of practice across the industry, recommendations can be developed to guide their development.

9.6.1 Individual vs. company level certification

Despite assertions that "new BIM roles are transitory and only relevant while industry practices and competencies evolve through learning and development" (Akintola et al., 2017), the development of BIM practice is highly dependent on individuals who hold the necessary knowledge and skills to effect the transition from traditional practice. In most situations, these individuals are identified not as traditional practitioners who have developed BIM skills, but as BIM experts who are appointed into specialised BIM roles (Eadie et al., 2015). As such, BIM practice for an organisation can be dependent on a limited number of individuals. BIM certification of these individuals will provide an element of certainty for organisations that the people being employed in key roles for BIM implementation have the requisite capabilities for facilitating the process. However, this also leads to the risk of reliance (and over-reliance) of organisations on an individual as repository of institutional knowledge and capability in BIM.

BIM implementation in a company cannot be achieved through a single role, nor is there a single way of operating in BIM across the design, construction and operation stages of a project. BIM is differentiated across disciplines, and across project types, and across project stages. Different BIM uses are more prominent in different situations and with the involvement of different project partners. As a consequence, common certifications for the individuals involved are unlikely to provide more than a basis for further specialisation. Thus, it is reassuring to see more specialised certification options for different BIM functions, such as those offered by the BCA in Singapore, which distinguish between BIM modelling and management roles, or BRE in the UK that make a distinction between BIM Informed Professionals, for those involved in implementing the BIM process, or BIM Certificated Practitioner, tailored to Project or Task Information Manager roles for project-based construction professionals working within a BIM framework. Other schemes that do not differentiate are likely to become less relevant as the market becomes more aware, as was identified for accreditation in the sustainability field (Bruce, Gebken & Strong, 2010).

Although on one hand BIM requires this level of differentiation for successful practice, it is also necessary for a company to have an over-arching structure of information management processes. It is this process-level evaluation that organisational certifications have been established to address. However, assessment of an organisation's capability is still based on the types of roles they can be expected to fulfil for a client, which can make company-based certification a more challenging process than individual certification. The scope and structure of BIM operations within a company cannot be reduced to the straightforward examination approach which is often used in individual certification. Instead, a more difficult and expensive audit is necessary to evaluate company documentation and practice on a case-by-case basis. This is similar to the quality management standard ISO 9001, and environmental management standard ISO 14001.

Explorations of the impact of those standards and the third-party certification required to institute them suggest that although there is a risk of overly bureaucratic processes with unnecessary levels of checking and documentation, they deliver improved processes and clarity of operations (Chini & Valdez, 2003; Moatazed-Keani & Sechi, 1999). However, one argument is that the establishment of clearly articulated standards and associated compliance procedures is sufficient to deliver the benefits, and certification is not necessary (Christini, Fetsko & Hendrickson, 2004). The benefit of certification is clearer within the UK construction market, where the requirement to demonstrate compliance with PAS 1192 is simplified by having a recognised BIM certification. The adaptation of the UK PAS 1192 suite to the international standard ISO 19650 may be a catalyst for more widespread uptake of certification internationally, but for the quality and environmental management examples, the value of certification is portrayed primarily as a marketing tool, rather than the use of the certification process to achieve improved outcomes.

9.6.2 Relationship to academic qualifications

University programmes are increasingly introducing BIM into existing programmes, as well as establishing new BIM-focused qualifications. As a result, companies are coming to expect a certain level of general BIM awareness and capabilities from graduates (Ahn, Pearce & Kwon, 2012). From the point of view of contractors, four groups of competencies are considered important for construction graduates. Technical competencies, including BIM and other computer skills, rank well below affective competencies (which comprised leadership, collaborative skills and interpersonal skills) and cognitive competency (ethical issues, problem solving skills, adaptability, interdisciplinary application, and safety issues) (Ahn et al., 2012). Software and related technical skills are often the most prominent consideration for BIM practitioners (Becerik-Gerber et al., 2012), and thus feature strongly in the certification processes developed by current BIM practitioners. This suggests that the issues most commonly evaluated by BIM certification are considered to be less significant for formal education programmes. However, Ahn et al. (2012) did not explore whether these skills were considered unimportant within the wider industry, or whether those surveyed expected that technical skills would be developed through practical experience and application. If the latter is the case, a professional certification could be an appropriate place to assess the extent to which practitioners are capable of operating in this environment, but is not a substitute for academic qualifications in BIM.

Options for practitioners to acquire BIM credentials are currently limited to certificates (including in this category the numerous short courses available, as well as diploma, degree and masters programmes developed in recent years) and certification, as previously discussed. Several of the identified certification routes require approved qualifications as a prerequisite to evaluation for the certification, but a further potential route for credentials lies in accreditation of the academic programmes to the requirements of industry bodies. Affiliation between university courses and industry accreditations can lead to improved outcomes for both the university graduates, in terms of job opportunities and professional recognition, and the accreditation body for its perceived relevance and increased membership, as evidenced by the performance of LEED AP (Accredited Professional) programmes in the US (Brown 2009). Furthermore, accreditation of educational programmes against a professional standard leads to improved quality of student outcomes and greater consistency across programmes (Volkwein, Lattuca, Harper & Domingo, 2007). The challenge for the industry bodies is to establish the requirements of accreditation for their profession, and to develop sufficient expertise to administer the accreditation schemes. If BIM roles are to be subsumed into traditional roles, as some assert, this approach would appear to be a logical step to ensure that the members of the associated professional groups hold qualifications appropriate to the use of BIM within their specialisation. From a negative perspective, universities already struggle with a shortage of experts available to teach BIM (Becerik-Gerber et al., 2012), so there is clearly a restricted pool of skilled people with the knowledge required to manage accreditation.

> “We've created our own problem in this regard, we can't get good technical practitioners, they're the people who should be teaching at university as well, but they're too busy in their day-to-day job. So who's going to teach the next generation the skills that they need to get the job and make sure they’re at a level that you want to employ them at?”
>
> *Interview 14—Australia, Multi-disciplinary design practice*

However, BIM is not a separate activity within the construction process, but is embedded in many construction industry functions, and thus included in a wide range of academic qualifications. Consequently, it is difficult to imagine that BIM roles and activities would need to be administered by a new professional body. Some of the existing bodies which might administer accreditation standards of this nature also offer their own certification routes, which may create a conflict of interest, given they already have a revenue stream coming from the certification process. Action on certification and the related definition of roles is connected with issues of identity and demarcation within the professional context (Greenwood et al., 2002) and the many industry bodies which have not yet acted to involve themselves or their members more closely in BIM will have a considerable degree of institutional inertia still to overcome.

9.6.3 Risks of diversity in credentials and certification

Of the 73 BIM professionals interviewed for this project, 22 have changed companies since the interviews were completed, including moving between disciplines and transferring internationally. This indicates a high level of churn in the sector, and is supported by informal data collected for the UK (Rutland, 2016) which suggests that BIM professionals are relatively mobile. Mobility of credentials may therefore become an important issue. Third-party BIM practitioners have already found a niche in the industry, as companies seek to establish BIM but struggle to recruit employees with the necessary skills. In the future, changes across career structures more generally suggest that free-lance BIM practitioners are likely to be more common, with workers less likely to be employees, but instead operating as independent consultants selling their services and talent (BIM 2050 Group, 2014). To ensure credentials are not limited to a specific sector or country, and to improve wider conformity, or at least alignment, local certifications and providers will need to be accredited with relevant national and international standards (Kelly, 2007).

In several cases, multiple BIM credentials are offered within the same environment, for example in the UK with the variety of schemes identified in Table 15. In addition, practitioners may be involved in certification beyond the BIM sphere, in areas such as sustainability, health and safety, or energy management, which have similar credentialing approaches. In a market already crowded with other credentials available to the building practitioner, this may lead to some credentials becoming devalued, and perceived by holders to offer no appreciable benefit to their careers (Bruce et al., 2010).

In the face of a diverse and potentially confusing range of certification or other credentialing options, practitioners may choose not to adopt any of them. Ma, Luong and Zuo (2014) demonstrated that for project managers in Australia, the differences in knowledge and priorities between certified and non-certified professionals were negligible, and there was little demand for credentials from clients or employers. For these practitioners, however, well-established project management bodies of knowledge have been developed by national and international institutions and so accepted practice norms are clearly defined. In the BIM sector currently, there is no agreed body of knowledge (BOK), although recent efforts in various countries have resulted in a number of contributions that have developed in parallel. In the US, the Academic Interoperability Coalition (AiC) has proposed a BIM BOK (Wu, Mayo, Issa, McCuen & Smith, 2017), the Australasian Procurement and Construction Council (APCC) and the Australian Construction Industry Forum (ACIF) have published a BIM Knowledge and Skills Framework (ACIF & APCC, 2017) and the UK BIM Academic Forum (BAF) has established a Learning Outcomes Framework (Underwood & Ayoade, 2015). It is not clear that BIM practice internationally is sufficiently differentiated to require country-specific definitions, and it appears to be another example of the duplication of effort that has characterised development of BIM (Smith, 2014). The resulting uncertainty around what is required for successful BIM practice may paradoxically support the drive for a formalised credential system. Within the development of other professional groups in construction, notably in the LEED and sustainability area, the credentials that were aligned with industry standards or other assessment schemes were most valuable to practitioners. Thus in markets where BIM standards such as PAS 1192 (or ISO 19650) become accepted benchmarks, associated credentialing schemes are likely to see greater uptake.

9.7 Conclusions

The majority of the action in BIM certification is currently taking place in the UK, and arises from the UK Government's BIM mandate. However, certification providers in several other countries also offer similar certification products, and more are likely to be in development. In addition, UK providers are beginning to promote their certification options internationally. As a result, the BIM certification market is rapidly becoming crowded with options, although uptake to date appears slow.

BIM competency assessment and certification can be seen as a possible catalyst to help accelerate the BIM adoption process, by clarifying an established set of requirements and processes that need to be followed in order to attain a particular certification or rating. This process may also facilitate the industry changes of collaboration and integrated practice that have been identified as essential to achieving the full benefits of BIM. This effect has been observed in other standards compliance processes, such as ISO 9001 and ISO 14001, where the increased awareness and familiarity brought about by the standards and the introduction of credentials and accreditation have prompted improvement, but it is not necessarily the credentials themselves that have the greatest impact on practice. In the BIM environment, however, the adoption of mandates or practice standards has been disjointed and inconsistent across different client bodies and regional and national governments. This runs the risk of a similarly disjointed approach to associated credentials.

For credentialing of individual capabilities, alignment of industry-based credentials with structured education is recommended, especially as universities make progress on curriculum development that introduce BIM skills into traditional industry education. Again, models for achieving this sort of integration are available within the industry with the way that professional accreditations have been managed for audit and evaluation of sustainability measures such as LEED or BREEAM. However, the lack of appropriately skilled personnel for development and administration of such schemes remains a significant barrier for training, certification and accreditation.

One of the effects of the increased attention given to regulated training and accreditation programmes is the increased positioning of BIM roles as part of a professional pathway, similar to other professional specialisations within the industry. BIM practitioners and other industry commentators are currently ambivalent about the need for recognition and development of BIM as a professional career path, with many considering that BIM functions will be integrated into other industry roles rather than existing as a standalone profession. Despite this uncertainty, recent progress made by the BIM community to develop a body of knowledge, and the proliferation of BIM qualifications and certification options, indicate that a specific role is emerging.

Part 3

10 Research conclusions

Chapter summary

This thesis has explored the documented understanding of BIM roles as presented in literature (Chapter 2) and in BIM guides and handbooks (Chapter 3). It has investigated BIM practice in the early stages of BIM adoption (Chapter 4), and the pragmatic implementation approach of hybrid BIM (Chapter 5). An identity-oriented view of BIM practitioners (Chapters 6-7) explores BIM roles and relationships from practitioners' own perspectives. Finally, questions of whether BIM practice can be seen as generating a new professional pathway in AEC have then been explored through consideration of aspects of these different views (Chapters 8-9).

In Chapter 10, I draw together the different elements of the discussion in order to return to the original research question and sub-questions. The conclusions provide a view of both the impact of BIM adoption on the development of professional roles, and the influence that BIM practitioners have on BIM adoption and implementation. Suggestions for future research are offered, along with a reflection on the research and analysis process followed in this thesis.

10.1 Research overview

This doctoral thesis started from the premise that BIM practices and practitioners are interlinked, and matters influencing one also act upon the nature and character of the other. However, it was also considered that, despite this interrelatedness, they are commonly treated separately in the wider BIM literature and documentation. Through an examination of BIM practitioners working in disparate roles, companies and countries, a more comprehensive understanding of BIM roles was sought. The aim of this thesis was to use practitioners' experiences and opinions to explore two perspectives of professional development in BIM—the ways that roles have emerged, changed and matured as BIM practice has developed, and also the changes that have occurred in BIM practice because of the influence of practitioners in those roles.

This chapter presents an overall summary of the work that was carried out to achieve this aim, along with the key findings and their implications. Recommendations for practice that arise from the findings are presented. Additionally, the limitations of the research are explored, and future research directions are proposed to overcome the limitations and extend the scope and applications of the findings.

10.1.1 Summary of the research

A review of international literature confirmed the emergence of BIM practitioner roles as one of the core changes to practice required for implementation of BIM in the AEC industry. However, it indicated that the scope of tasks and responsibilities of such roles is poorly defined. A subsequent document analysis was carried out of 36 BIM guidelines, handbooks and other definitive documents that included definitions or descriptions of BIM roles. This analysis further supported the findings of the literature review, that BIM roles have become well-established in the industry, but there is little standardisation in terms of job titles or role definitions. The same sets of roles and responsibility tend to be represented across the range of documents analysed, but the terminology and frames of reference vary, leading to a lack of consistency, and potential confusion in defining roles in project situations.

The core element of this research was a qualitative interview survey across 73 BIM practitioners from five countries, to explore the range of BIM roles evident in practice. Initial interviews took place in New Zealand, and subsequent interview rounds were carried out in countries which are perceived to be at different stages of BIM maturity in advance of New Zealand, namely Australia, the Netherlands, the United Kingdom and the United States. Through loosely-structured narrative interviews, the survey explored the professional context and perceptions of individuals currently involved in a BIM-active role. The underlying premise of the survey was that through examination of the experience, attitudes and opinions of a range of people currently working as BIM practitioners, insight would be gained into the place of BIM as a professional role within AEC, and the career implications of BIM practice for these individuals. This knowledge in turn contributes to a better understanding of how BIM adoption and implementation efforts can be better supported for positive industry outcomes.

This data was supplemented by two New Zealand case studies that explore the roles of a variety of practitioners involved in early BIM practice. The purpose of this part of the research was to look at how BIM implementation affected practitioners without specific BIM roles, who were nevertheless expected to take on responsibility for elements of a BIM process.

10.1.2 Addressing the research questions

The adoption of Building Information Modelling (BIM) in the AEC industry requires the efforts of individuals who are prepared to take responsibility for driving and influencing BIM practice. 'Being' BIM, for these professionals, is about taking on a responsibility and identity that incorporates BIM. This is not merely about adding BIM on top of existing practice, but involves development of a professional awareness as a BIM practitioner, to promote BIM adoption and strive to influence and progress the development of the industry with regard to BIM. A central motivation for almost all practitioners was the desire to improve working practices and products in the AEC industry, and thus make a difference in the industry and the resulting built environment.

The following sections identify the core findings from this research. Although there are many overlapping and interconnected ideas among them, the conclusions have been organised to address the dominant issues arising from the research questions.

- ***Spheres of responsibility of BIM practitioners***

  BIM practitioners take on roles throughout the BIM process, from setting and controlling strategic goals and direction, down to the most straightforward and pragmatic BIM authoring and implementation aspects of BIM. Practitioners at any point on this continuum may be considered 'BIM specialists' by their peers, and play an influential role in how BIM is perceived and accepted by others. New BIM roles have developed in many disciplines to manage and control BIM processes, and have been supported by expansion of traditional roles to include BIM responsibilities.

Those perceived as BIM specialists are not necessarily specialists in the technical or process aspects of BIM. Some are BIM champions in a strategic sense, and provide resources and support to enable others to develop practical skills and knowledge at an organisational and project level. More common, however, is the development of BIM capabilities from a technical background, where the individual practitioner has developed BIM expertise through a hands-on role. This often occurs through their own personal interest and exploration, rather than as a result of company expectations or direction. The knowledge gained through this process is subsequently transferred to others in their organisation and wider network.

- ***Professional identity***

BIM has become part of their professional identity for most of the practitioners interviewed, and they take pride in their BIM skills and derive enjoyment from their involvement in BIM practice. A range of identity performance preferences were identified, comprising implementer, interpreter, instructor, inquirer and innovator identities. This variety indicates the range of interests and abilities expressed by BIM practitioners, and thus the diverse types of roles they are comfortable in engaging with. Practitioners identity preferences are not always well aligned with the organisational and project roles they are expected to fill, making it difficult for practitioners and organisations to achieve their goals. Efforts on the part of individual companies and the industry as a whole are needed to define roles and expectations more clearly. Standardisation of the current plethora of BIM role titles and descriptions would provide practitioners with better guidance to allow them to match their interests and identity preferences to the appropriate role.

Most practitioners are not wholehearted in embracing a BIM identity, but are quick to assert their ongoing involvement with traditional roles and skills. There is an apparent stigma to being perceived as a BIM practitioner that some fear may limit their progression or opportunities in their organisation. The lack of a clear career path for

BIM practitioners is one strong influence in this reluctance to fully accept their BIM role. The range of roles in which practitioners are expected to be actively involved also contributes. Often, they have to balance involvement in strategic, process and technical activities across organisational and project layers of responsibility, leading to conflicting priorities and responsibilities.

- ***Relationship with traditional roles***

In many cases, BIM roles are taken on in parallel with traditional industry roles. A frequent consequence of this pattern is that time and other resources for BIM responsibilities are squeezed out by the overriding dominance of project and discipline expectations. Long-established patterns of working, and traditional industry expectations, tend to overshadow attempts to institute new BIM processes. This is particularly evident when resources are constrained. Such constraints challenge the ability of BIM practitioners to develop their professional identity in a way that embraces the BIM aspects of their role, and so BIM responsibility is not always accepted intentionally or welcomed by those who end up in such roles. Many of the challenges, particularly with early BIM implementation, stem from issues such as communication, early agreement and involvement of parties, exchange of information, and clearly defined project expectations and responsibilities, which are made more obvious in a BIM environment. BIM neither causes nor solves such issues, but can provide a framework for managing them.

- ***Project and organisational implications***

From the presented case studies of early BIM practice, and the exploration of hybrid practice, it is evident that benefits can be gained even from a limited implementation of BIM. These benefits accrue to the project as a whole, but also have an effect on practice at an individual practitioner level. Development can occur in an incremental fashion; at this stage, not all project participants need to be at a particular level before adoption can have a positive impact. Many practitioners can operate with a limited understanding of BIM, as long as they recognise its function within the project context and are prepared to take a collaborative and open approach to sharing information. Progressive and piecemeal BIM adoption does not need to be a negative approach to moving into a BIM implementation. Even for companies where internal BIM adoption was undertaken in a single decisive shift, hybrid BIM implementations at the project level are common. Not all project partners have the capacity or the desire to engage with the BIM process, so achieving a partial use of BIM helps to start them on the path to achieving the benefits. For some companies, hybrid BIM may be sufficient to enable them to realise their project goals without requiring substantial investment or change in staffing or other arrangements. In other cases, it may prove a useful first step in the transition to more integrated BIM practice, to use as a staging point as they begin to engage in new processes and develop their skills and knowledge. At an individual level, hybrid BIM allows a progressive approach to skills development, and an opportunity to test out new ways of working with project information and other project partners.

- ***Challenges to BIM roles and practice***

One challenge to the maturation of BIM practice, and to the acceptance of a BIM role by professionals, is the view that BIM is simply a technological shift. While some benefits can be gained from the technology alone, the more significant improvements come from process changes, in particular around integrated working and collaboration. The lack of skilled practitioners with knowledge and skills in their design or construction discipline as well as technology is hampering development in BIM. On top of these skill sets, the majority of BIM roles also require personal and interpersonal skills to be able to function effectively in collaborative environments. Technology-based roles tend to have less potential for career development and advancement, and so practitioners are making a transition from positions with a technical focus to others with a more strategic component. However, where individuals without the necessary skills are taking on leadership roles, BIM implementation can be limited or poorly framed.

In the drive to increase BIM capability, companies risk focusing only on younger practitioners, losing the potential for the significant contribution that older, more experienced staff have to offer. Further limiting factors for progress in BIM include relying on an individual or small team to provide BIM expertise, rather than embedding it into company practice, thus leaving the organisation at risk of losing its capability if just a few people leave. This is particularly the case where those key individuals are not given the support they need or the opportunities they seek, to fully realise their preferred BIM identity and performance preferences. In such situations practitioners may choose to abandon their BIM identity, and return to previous discipline alignments.

Other industry beliefs and misconceptions also provide further challenges for BIM practitioners. Expectations that BIM will provide a simple solution to long-established problems in the industry such as inefficiency, fragmentation and high costs can result in frustration and disappointment as the expected transformation is less dramatic or significantly slower than anticipated. Similarly, the 'Trojan Horse' idea that BIM practice can be used to progress unrelated industry reforms in areas such as environmental sustainability, improved industry training, and more inclusive hiring practices can overwhelm practitioners with additional responsibilities, or cause disillusionment at what is actually achievable. Such responses can cause a reaction against BIM practice for the BIM practitioners, and increase resistance to BIM adoption in others they have to work with.

- ***Development of BIM careers***

Potential approaches to improve the involvement and influence of BIM practitioners are centred around confirming the role as a professional career. Involvement from professional bodies to define, promote and support BIM practice as it applies to their members would go a long way towards establishing a recognised career path for those interested in BIM. Industry efforts currently in progress such as developing a body of knowledge for BIM practice, and aligning training and education opportunities, also provide a measure of certainty for practitioners. Removing some of the aspects of the BIM environment that serve to demoralise practitioners would also be valuable. These include avoiding 'BIMwash' or hype in the promotion of BIM, and managing training and certification providers to circumvent delivery of low-quality offerings at high prices.

The life cycle model of professional development provides a framework that may prove useful in structuring BIM practice as a professional role. This model provides a representation of the profession that encompasses different levels of professional activity from innovation through validation and formalisation to implementation as standard practice. It allows for definition of a variety of professional roles that each contribute to the overall progression of practice, and incorporates views that allow for the full range of BIM identities and performance preferences expressed by practitioners. Connecting this or a similar framework to the current efforts in curriculum development and certification of BIM professionals would provide a certainty and status for BIM practitioners that is currently lacking.

10.1.3 Recommendations for practice and practitioners

A number of recommendations have been derived from the findings, that apply variously to the BIM practitioners themselves, the companies that employ them, and the industry as a whole.

For BIM practitioners or individuals interested in a BIM career:

1. Develop BIM skills and knowledge alongside discipline-based skills. BIM skills alone have little value, but in connection with specific skills in a design or construction field will offer a wide range of opportunities both within the AEC industry and outside it.
2. Make use of industry networks and connections to advance knowledge of BIM practice. Informal knowledge sharing is a significant resource for developing awareness and skills in BIM and related practice.
3. Align BIM interests and expertise with company and project requirements. BIM practice encompasses a wide range of activities and areas of responsibility, and different people prefer to take different roles or approaches that may not necessarily suit the current needs.

For companies interested in adopting BIM or increasing involvement in BIM projects:

4. Identify and encourage BIM interest in existing staff. Upskilling discipline-based practitioners to be BIM-capable often provides a more sustainable and company-appropriate approach to BIM adoption than bringing in external consultants or hiring new employees specifically for a BIM role.
5. Support practitioners responsible for BIM adoption with sufficient time allocation for establishing appropriate processes and procedures at an organisational level, rather than focusing solely on project-based BIM implementation. This should also include time for carrying out change management activities.

For professional bodies and other industry organisations:

6. Provide a better definition of potential career paths for BIM practitioners, from technical through to strategic roles, and including traditional roles where BIM

skills have been shown to be strong (e.g., design management, project management) as well as new roles such as information manager and BIM coordinator, etc.

7. Manage training and credentialing providers to ensure programmes offered are of acceptable quality.
8. Encourage and support case study and other research at a project and company level, to provide information to aid in the development of validation and formalisation approaches using best practice.
9. Ensure representations of BIM practice and potential benefits through surveys, trade press and industry events are accurate and evidence-based. Hype has a negative effect on current and potential practitioners when they become frustrated by lack of progress or demoralised by organisational or industry barriers.

10.2 Reflections

The scope of the project changed during the course of the research due to the lack of willing case study participants. The interview survey was initially intended to be supplementary to the case studies, to allow findings from the case studies to be checked against the perceptions and experience of a wider range of industry players. Instead the survey became the main source of data for the research, and expanded into additional countries to provide views from environments at different levels of BIM maturity. As a result, while the findings of the study provide insights into BIM practice and professional roles more generally, the intended guidance specific to the New Zealand environment has not been achieved.

These necessary changes to the scope and direction of the research are not considered to be limitations; the project as it eventuated provides a relevant and worthwhile contribution to knowledge of BIM practice and practitioners, albeit with a different focus than originally intended. However, some limitations to the research as conducted are evident, and these have been addressed in the following section. The potential for carrying out the initial research as planned still remains, but this has been taken as read. Instead, a number of other future research directions are described that develop from the findings and the identified limitations.

10.2.1 Limitations

The choices made for this research in terms of the sample selection process and the methods used limit the extent to which the results can be considered generalisable or representative. However, these were deliberate choices which allowed the collection of a rich and diverse set of data, to enable the portrayal of views showing both the diversity currently evident in BIM practice and practitioners, and at the same time the degree of similarity that is apparent. Three areas of limitation are inherent in the design and implementation of this study: the sampling approach and selection of participants; the countries included in the survey; and the speed of change in the BIM environment.

Because their peers considered them to be 'BIM specialists', the practitioners included in this study have been assumed to be influential in the BIM progress of their professional circles. No measure of their influence or involvement was made beyond this assumption. BIM practice is considered solely from the perspective of the interviewees; the perceptions of their colleagues, managers or project partners have not been included beyond their initial involvement in identifying the specialists. The group of participants has been compiled deliberately to contain a wide range of what may be considered BIM expertise, but does not provide an equal representation of the various industry sectors or professionals involved in BIM practice.

This study included participants from a range of countries at different stages of BIM practice to ensure that data was not limited to specific models of industry organisation or governmental influence. For reasons of practicality, language and accessibility, other regions which have been widely identified in the literature as leaders in BIM practice, such as Scandinavia, or rapidly developing BIM environments, such as China, have not been considered. Although the wider literature suggests similar patterns of BIM adoption and development across many different environments, other countries may have different practice trajectories or individual profiles of industry participants that do not reflect the findings of this exploration.

The period over which the data was collected limits these findings to a particular time in BIM development. The UK government's BIM mandate was introduced after data collection was completed, which is likely to have changed the BIM environment in that country, and influenced progress in other countries which look to the UK as a model for development. Even without this significant difference, the rapid pace at which change in

BIM technology and associated practices and processes tends to take place means that not all of the observations and conclusions are necessarily still current. Up-to-date literature has been used as much as possible to counterbalance this effect.

10.2.2 Future research directions

Future research opportunities are proposed to address the identified limitations, and to extend the findings of the study. These are listed below:

1. A longitudinal study to revisit these or similar practitioners would provide an interesting perspective of how the dynamic nature of BIM implementation and development affects professional roles over time. This would help to establish whether BIM professional roles are a transitional requirement during the adoption process, or a permanent addition to the AEC environment.
2. Extending the study to include investigation of how BIM practitioners are perceived by their peers would contribute to understanding of the position of BIM professional roles in the wider industry context. Knowledge of how these roles are seen by others in their project and organisational environments would provide insight into the BIM adoption and implementation process generally, but also into the attractiveness of or impediments to taking on BIM roles. Given that the current shortage of BIM practitioners is considered a barrier to progress in BIM, this could help to identify routes to increasing practitioners' involvement in BIM practice.
3. Discipline-specific investigation of professional roles would provide more targeted information for development of practice within different industry sectors. This would also assist professional bodies to identify the issues that fall within their ambit regarding role definition; training, education and professional development; professional recognition; and credentialing.
4. The professional life cycle model has been identified as a useful construct to focus attention on the continuum of professional roles that exists within BIM practice. A desk-top analysis to apply this model to existing literature and documentation would help to delineate the professional roles that are currently evident, and highlight areas of the life cycle that require further attention or additional data to enable further development of BIM as a profession.

5. The expansion of BIM into markets with quite different AEC industry structures and processes from those included in this study provides the opportunity to explore the extent to which BIM roles are dependent on the wider industry environment. Potentially distinctive markets include Singapore, where a BIM process forms part of the regulatory framework (Kassem et al., 2015); Korea, which has been shown to have a higher reliance on organisational support rather than individual-level drivers (Lee & Yu, 2016); or countries such as Nigeria where BIM implementation is coming from a much lower level of technological readiness (Abubakar, Ibrahim, Kado & Bala, 2014). This investigation could potentially offer insights into alternative approaches to BIM implementation and role development that an examination of more dominant industry structures may not provide.
6. Finally, and less specific to the original research questions, it would be interesting to explore whether the scattered nature of the professional imaginaries that are present within the AEC industry are a source of the lack of coherence and advancement that is currently apparent within BIM professional roles. Other industries such as aerospace, shipbuilding and automotive appear to have been more successful in managing similar changes in technology and processes (Oberoi & Holzer, 2016). A comparison of the types of professional imaginaries evident in different industries would allow evaluation of the impact that these social constructs have on the way practitioners situate themselves and their roles in relation to future directions of their industry.

10.3 Concluding remarks

The contribution of this study to existing knowledge is through its in-depth qualitative exploration of BIM practice from the practitioners' perspective. Such a methodological approach is uncommon in AEC research, but provides a rich and multifaceted view of the complexities of the industry. The format of the interviews was loosely-structured, and the topics covered by different practitioners and the depth to which they discussed them varied widely according to their interests and preoccupations at the time. I have drawn information from a varied and diverse sample that provided data and offered insights across the wide range of aspects that have a bearing on BIM practice and practitioners.

The focus on practitioners' personal and professional characteristics and experiences is also an unusual view of BIM adoption and implementation. As previously noted, most analyses of BIM come from a technology or process perspective, so the approach chosen here provides an alternative view that allows for interpretations and descriptions from the many experts involved. This combination of methodology and focus thus permits a human-centric analysis of an industry that relies on people, but often overlooks their role in favour of organisational and project-centred perspectives.

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Appendices

Appendix A – Ethics documentation

- Ethics approval Ref. 10039
- Amendment to approval (International participants)
- Amendment to approval (Case studies)
- Participant information sheet (BIM specialists)
- Consent form (BIM specialists, organisation)
- Consent form (BIM specialists, individual)
- Participant information sheet (BIM specialists, international)
- Consent form (BIM specialists, international)
- Participant information sheet (Case study)
- Consent form (Case study, interviews)
- Consent form (Case study, organisation)

Office of the Vice-Chancellor
Research Integrity Unit

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UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE

23-Oct-2013

MEMORANDUM TO:

Dr Dermott McMeel Architecture & Planning

Re: Application for Ethics Approval (Our Ref. 10039)

The Committee considered your application for ethics approval for your project entitled The impact of Building Information Modelling (BIM) on professional roles, relationships and skills in the Architecture/ Engineering/ Construction industry.

Ethics approval was given for a period of three years. The expiry date for this approval is 23-Oct-2016.

If the project changes significantly, you are required to submit a new application to UAHPEC for further consideration.

In order that an up-to-date record can be maintained, you are requested to notify UAHPEC once your project is completed.

The Chair and the members of UAHPEC would be happy to discuss general matters relating to ethics approvals if you wish to do so. Contact should be made through the UAHPEC Ethics Administrators at humanethics@auckland.ac.nz in the first instance.

All communication with the UAHPEC regarding this application should include this reference number: **10039.**

(This is a computer generated letter. No signature required.)

UAHPEC Administrators
University of Auckland Human Participants Ethics Committee

Additional information:

1. Do not forget to fill in the 'approval wording' on the Participant Information Sheets and Consent Forms, giving the dates of approval and the reference number, before you send them out to your participants.

2. Should you need to make any changes to the project, write to the UAHPEC Administrators by email (humanethics@auckland.ac.nz) giving full details of the proposed changes including revised documentation.

3. At the end of three years, or if the project is completed before the expiry, please advise UAHPEC of its completion.

4. Should you require an extension, write to UAHPEC by email before the expiry date, giving full details along with revised documentation. An extension can be granted for up to three years, after which a new application must be submitted.

5. If you have obtained funding other than from UniServices, send a copy of this approval letter to the Manager - Funding Processes, UoA Research Office. For UniServices contracts, send a copy of the approval letter to the Contract Manager, UniServices.

6. Please note that UAHPEC may from time to time conduct audits of approved projects to ensure that the research has been carried out according to the approval that was given.

Office of the Vice-Chancellor
Finance, Ethics and Compliance

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UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE (UAHPEC)

27-Mar-2014

MEMORANDUM TO:

Dr Dermott Mc Meel
Architecture & Planning

Re: Request for change of Ethics Approval Ethics Approval (Our Ref. 10039): Amendments Approved

The Committee considered your request for change for your project entitled **The impact of Building Information Modelling (BIM) on professional roles, relationships and skills in the Architecture/Engineering/Construction industry** and approval was granted for the following amendments on 27-Mar-2014.

The Committee approved the following amendments:

1) Extend the study beyond New Zealand, to include participants in Australia, USA and Europe.

2) Use of Skype video calling service (or similar) to conduct interviews.

The expiry date for this approval is 23-Oct-2016.

If the project changes significantly you are required to resubmit a new application to the Committee for further consideration.

In order that an up-to-date record can be maintained, it would be appreciated if you could notify the Committee once your project is completed.

The Chair and the members of the Committee would be happy to discuss general matters relating to ethics approvals. If you wish to do so, please contact the UAHPEC Ethics Administrators at ro- ethics@auckland.ac.nz in the first instance.

Please quote reference number: **10039** on all communication with the UAHPEC regarding this application.

(This is a computer generated letter. No signature required.)
UAHPEC Administrators

University of Auckland Human Participants Ethics Committee

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UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE (UAHPEC)
24-Sep-2014

MEMORANDUM TO:

Dr Dermott Mc Meel,
Architecture & Planning

Re: Request for change of Ethics Approval Ethics Approval (Our Ref. 10039): Amendments Approved

The Committee considered your request for change for your project entitled **The impact of Building Information Modelling (BIM) on professional roles, relationships and skills in the Architecture/Engineering/Construction industry** and approval was granted for the following amendments on 24-Sep-2014.

The Committee approved the following amendments:

1) To collect data based on interviews with project participants and analysis of project documents for Stage 2 of the research study.

2) To use third party for transcription of interview data (with confidentiality agreement).

3) To include participants who are not BIM-specialists for case studies.

4) Participants for case studies may come from New Zealand, Australia, Europe and USA.

The expiry date for this approval is 23-Oct-2016.

If the project changes significantly you are required to resubmit a new application to the Committee for further consideration.

In order that an up-to-date record can be maintained, it would be appreciated if you could notify the Committee once your project is completed.

The Chair and the members of the Committee would be happy to discuss general matters relating to ethics approvals. If you wish to do so, please contact the UAHPEC Ethics Administrators at ro- ethics@auckland.ac.nz in the first instance.

Please quote reference number: **10039** on all communication with the UAHPEC regarding this application.

(This is a computer generated letter. No signature required.)
UAHPEC Administrators
University of Auckland Human Participants Ethics Committee

c.c. Head of Department / School, Architecture & Planning
Dr Marjorie van Roon
Prof Suzanne Wilkinson
Ms Kathryn Davies
Dr Dermott Mc Meel

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PARTICIPANT INFORMATION SHEET (BIM specialists)

Project title: The impact of Building Information Modelling (BIM) on professional roles, relationships and skills in the Architecture/Engineering/Construction (A/E/C) industry: Stage 1 – the BIM specialist.

Name of Researcher: Kathryn Davies

Researcher introduction

My name is Kathryn Davies, I am currently undertaking a PhD in Architecture at the National Institute of Creative Arts and Industry, The University of Auckland, under the supervision of Dr Dermott McMeel (Architecture), and Dr Suzanne Wilkinson (Civil Engineering).

Project description and invitation

The construction industry is experiencing a shift towards the use of Building Information Modelling (BIM) in many aspects of project design and management. The underlying motivation is the improvements in productivity, product quality and sustainability that can be gained through complete prototyping of a building in a simulated system, within a context of tight budgets, demanding time frames and increased competition. These changes and pressures in the industry require adjustments and adaptation in the roles of almost all participants in the A/E/C industry. Skill sets and competences that have developed over many years are now being broken down and reformed as the needs of industry change. One of the most evident changes is the emergence of a BIM specialist role in many companies. Although the need for this role is widely documented, its substance is poorly defined. Stage 1 of this project seeks to define the scope of tasks and responsibilities that the role encompasses within New Zealand companies, and the skills and training required to hold such a position. Future stages will make comparisons with international practice, and examine roles and relationships within case study contexts. The overall goal of the project is to provide guidance for New Zealand companies and project teams establishing their capabilities in BIM and developing BIM-related skills in their staff.

I would like to invite you to participate in this project; your expertise as a BIM specialist and BIM champion in the New Zealand construction industry give you insight into the issues under investigation, and your opinions and experience will be a valuable contribution to knowledge about the role.

Project procedures

Your project involvement will consist of a one-on-one interview which will take approximately 45-60 minutes, at a time and place convenient to you. The interview will be audio recorded and later transcribed, and you will be given a transcript of your interview to review. Participation is voluntary, and you may choose to withdraw any or all of your contributed data up until 2 weeks after you receive a copy of the transcript. Your transcript will be the data on which analysis and publications are based.

Data storage and future use

Your audio recording and raw transcript will be retained electronically until the end of the PhD enrolment (planned for Feb 2016), after which they will be destroyed. The edited version of the transcript (as approved by you) will be retained indefinitely.

The recording and transcript will be accessible by myself and my supervisors only. I will carry out the transcription myself, so there will be no third-party involvement.

If you would like to receive a copy of any publications resulting from this research, you can add your email address to the consent form.

Confidentiality

Your participation will be kept confidential, and your name and that of your company will not be disclosed. In published material your role will be described in terms of your job title and the type of organisation you work for. However, because of the small size of the NZ construction industry and the network of BIM specialists in particular, confidentiality of your identity cannot be completely guaranteed. For this reason you will be given the opportunity to amend the transcript to remove any information that you consider would identify you.

Contact Details

For further information about the project, please contact me, Kathryn Davies, email kdav035@aucklanduni.ac.nz or phone 021 809 312.

You may also contact my supervisors:

Dr Dermott McMeel, email d.mcmeel@auckland.ac.nz, phone 09 373-7599 ext 81926

Dr Suzanne Wilkinson, email s.wilkinson@auckland.ac.nz, phone 09 373-7599 ext 88184

or the Head of School Architecture and Planning: Elizabeth Aitken-Rose, email e.aitken-rose@auckland.ac.nz, phone 09 373 7599 ext 86425

For any queries regarding ethical concerns you may contact the Chair, The University of Auckland Human Participants Ethics Committee, The University of Auckland, Research Office, Private Bag 92019, Auckland 1142. Telephone 09 373 7599 ext 87830/83761. Email: humanethics@auckland.ac.nz.

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE ON 23 OCTOBER 2013 FOR (3) YEARS. REFERENCE NUMBER 10039.

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CONSENT FORM - BIM specialists (organisation)
This form will be held for a period of 6 years

Project title: The impact of Building Information Modelling (BIM) on professional roles, relationships and skills in the Architecture/Engineering/Construction (A/E/C) industry: Stage 1 – the BIM specialist.
Name of Researcher: Kathryn Davies

I have read the Participant Information Sheet, and understand the nature of the research and why I have been selected. I have had the opportunity to ask questions and have them answered to my satisfaction.

- I agree that my employee may take part in this research, and information pertaining to the company may be discussed.
- I give assurance that the decision of staff from my organisation to participate or not to participate will have no effect on their employment status.
- I recognise that I or my employee may withdraw from the study at any time, and my employee may withdraw data up until 2 weeks after receiving a copy of the transcript.
- I understand that data will be kept for 6 years, after which they will be destroyed.

Name ____________________________

Signature ____________________________ Date __________________

☐ I would like to receive a copy of any publications resulting from this research.

Email: ____

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE ON 23 OCTOBER 2013 FOR (3) YEARS. REFERENCE NUMBER 10039.

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CONSENT FORM - BIM specialists
This form will be held for a period of 6 years

Project title: The impact of Building Information Modelling (BIM) on professional roles, relationships and skills in the Architecture/Engineering/Construction (A/E/C) industry: Stage 1 – the BIM specialist.
Name of Researcher: Kathryn Davies

I have read the Participant Information Sheet, and understand the nature of the research and why I have been selected. I have had the opportunity to ask questions and have them answered to my satisfaction.

- I agree to take part in this research.
- I understand that I am free to withdraw participation and/or to withdraw any data traceable to me, at any time up until 2 weeks after I receive the interview transcript.
- I agree to be audio recorded.
- I understand that data will be kept for 6 years, after which they will be destroyed.

Name ____________________________

Signature ____________________________ Date __________________

☐ I would like to receive a copy of any publications resulting from this research.

Email: ____

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PARTICIPANT INFORMATION SHEET (BIM specialist, international)

Project title: The impact of Building Information Modelling (BIM) on professional roles, relationships and skills in the Architecture/Engineering/Construction (A/E/C) industry: Stage 1 – the BIM specialist.

Name of Researcher: Kathryn Davies

Researcher introduction

My name is Kathryn Davies, I am currently undertaking a PhD in Architecture at the National Institute of Creative Arts and Industry, The University of Auckland, New Zealand, under the supervision of Dr Dermott McMeel (Architecture), and Dr Suzanne Wilkinson (Civil Engineering).

Project description and invitation

The construction industry is experiencing a shift towards the use of Building Information Modelling (BIM) in many aspects of project design and management. The underlying motivation is the improvements in productivity, product quality and sustainability that can be gained through complete prototyping of a building in a simulated system, within a context of tight budgets, demanding time frames and increased competition. These changes and pressures in the industry require adjustments and adaptation in the roles of almost all participants in the A/E/C industry. Skill sets and competences that have developed over many years are now being broken down and reformed as the needs of industry change. One of the most evident changes is the emergence of a BIM specialist role in many companies. Although the need for this role is widely documented, its substance is poorly defined. This project seeks to define the scope of tasks and responsibilities that the role encompasses across a range of industry contexts, and the skills and training required to hold such a position. Future stages will examine roles and relationships within case study contexts. The overall goal of the project is to provide guidance for A/E/C companies and project teams establishing their capabilities in BIM and developing BIM-related skills in their staff.

I would like to invite you to participate in this project; your expertise as a BIM specialist and BIM champion in the construction industry give you insight into the issues under investigation, and your opinions and experience will be a valuable contribution to knowledge about the role.

Project procedures

Your project involvement will consist of a one-on-one interview which will take approximately 60 minutes, at a time and place convenient to you. In the event that an in-person interview cannot be arranged, Skype (or a similar system, as agreed with you) will be used. The interview will be audio recorded and later transcribed, and you will be given a transcript of your interview to review. Participation is voluntary, and you may choose to withdraw any or all of your contributed data up until 2 weeks after you receive a copy of the transcript. Your transcript will be the data on which analysis and publications are based.

Data storage and future use

Your audio recording and raw transcript will be retained electronically until the end of the PhD enrolment (planned for Feb 2016), after which they will be destroyed. The edited version of the transcript (as approved by you) will be retained indefinitely.

The recording and transcript will be accessible by myself and my supervisors only. I will carry out the transcription myself, so there will be no third-party involvement.

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Confidentiality

Your participation will be kept confidential, and your name and that of your company will not be disclosed. In published material your role will be described in terms of your job title and the type of organisation you work for. However, because of the interconnected nature of the construction industry and the network of BIM specialists in particular, confidentiality of your identity cannot be completely guaranteed. For this reason you will be given the opportunity to amend the transcript to remove any information that you consider would identify you.

Contact Details

For further information about the project, please contact me, Kathryn Davies, email kdav035@aucklanduni.ac.nz or phone +64 21 809 312.

You may also contact my supervisors:

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CONSENT FORM - BIM specialists (international)
This form will be held for a period of 6 years

Project title: The impact of Building Information Modelling (BIM) on professional roles, relationships and skills in the Architecture/Engineering/Construction (A/E/C) industry: Stage 1 – the BIM specialist.
Name of Researcher: Kathryn Davies

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- I agree to take part in this research.
- I understand that I am free to withdraw participation and/or to withdraw any data traceable to me, at any time up until 2 weeks after I receive the interview transcript.
- I understand that my participation will be kept confidential, and my name will not be disclosed, but I recognise that confidentiality of my identity cannot be completely guaranteed because of the interconnected nature of the construction industry.
- I understand that I will have the opportunity to review the transcript of my interview, and amend it to remove any material that I consider to identify me or that is commercially sensitive.
- In the event that an in-person interview cannot be arranged, I agree that Skype (or a similar system) may be used, and that I will provide the required contact information to allow this.
- I agree to be audio recorded.
- I understand that interview recordings and raw transcripts will be kept until the end of the PhD enrolment (planned for Feb 2016), after which they will be destroyed. Approved transcripts will be kept indefinitely.

Name ______________________________

Signature ______________________________ Date ___________________

☐ I would like to receive a copy of any publications resulting from this research.

Email: ____

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE ON 23 OCTOBER 2013 FOR (3) YEARS. REFERENCE NUMBER 10039.

THE UNIVERSITY OF AUCKLAND
NEW ZEALAND

School of Architecture and Planning
Level 6, 26 Symonds St, Auckland
Ph: 09 373 7599, ext 88134 or 88596

The University of Auckland
Private Bag 92019
Auckland, New Zealand

PARTICIPANT INFORMATION SHEET (Case study participants)

Project title: The impact of Building Information Modelling (BIM) on professional roles, relationships and skills in the Architecture/Engineering/Construction (A/E/C) industry: Stage 2 – Case study of a New Zealand construction project.

Name of Researcher: Kathryn Davies

Researcher introduction

My name is Kathryn Davies, I am currently undertaking a PhD in Architecture at the National Institute of Creative Arts and Industry, The University of Auckland, under the supervision of Dr Dermott McMeel (Architecture), and Dr Suzanne Wilkinson (Civil Engineering).

Project description and invitation

The construction industry is experiencing a shift towards the use of Building Information Modelling (BIM) in many aspects of project design and management. The underlying motivation is the improvements in productivity, product quality and sustainability that can be gained through complete prototyping of a building in a simulated system, within a context of tight budgets, demanding time frames and increased competition. These changes and pressures in the industry require adjustments and adaptation in the roles of almost all participants in the A/E/C industry. Skill sets and competencies that have developed over many years are now being broken down and reformed as the needs of industry change. Stage 1 of this project focuses on the new role of the BIM specialist. Stage 2 however is more interested in how involvement in a BIM-mediated project changes traditional roles and interactions between project team members. Future stages will make comparisons with international practice. The overall goal of the project is to provide guidance for New Zealand companies and project teams establishing their capabilities in BIM and developing BIM-related skills in their staff.

I would like to invite you to participate in this project; you are contributing to the use of BIM in a significant project in the New Zealand construction industry, which will provide insight into the issues under investigation. Your opinions and experience will be a valuable contribution to knowledge about how BIM impacts on project roles and responsibilities.

Project procedures

I have permission from the project client and your organisation to take an observer role in project team meetings. This will not require you to do anything, but you should be aware that notes will be made of the interactions observed at the meeting. In a follow-up to this observation process, your direct project involvement will consist of a one-on-one interview after each project meeting which will take approximately 30 minutes, at a time and place convenient to you. The interview will be audio recorded and later transcribed, and you will be given a transcript of your interview to edit or amend if you wish. Participation is voluntary, and you may choose to withdraw your contributed data until 2 weeks after you have been given each transcript. Your agreed transcript will be the data on which analysis and any publications are based.

Your organisation has given assurances that your choice to participate or not in this research will have no impact on your employment status.

Data storage and future use

The audio recording of your interview will be stored digitally until the interview has been transcribed; at this point the audio recording will be deleted. The recording and transcript will be accessible by me and my supervisors only. I will carry out the transcription myself, so there will be no third-party involvement.

Your consent form and the final version of the transcript, with identifying material removed (as approved by you), will be retained electronically for six years, as required by the University of Auckland ethics policy, after which I will delete the electronic files, and hard copies will be shredded.

Confidentiality

Your participation will be kept confidential, and your name will not be disclosed. In published reports your contribution will be described in terms of your project role.

Because of the small size of the NZ construction industry, confidentiality of your identity cannot be completely guaranteed. For this reason you will be given the option to remove material from the interview transcript that you consider may identify you.

Contact Details

For further information about the project, please contact me, Kathryn Davies, email kdav035@aucklanduni.ac.nz or phone 021 809 312.

You may also contact my supervisors: Dr Dermott McMeel, email d.mcmeel@auckland.ac.nz, telephone 09 373-7599 ext 81926 or Dr Suzanne Wilkinson, email s.wilkinson@auckland.ac.nz, telephone 09 373-7599 ext 88184;

or the Head of School Architecture and Planning: Elizabeth Aitken-Rose, email e.aitken-rose@auckland.ac.nz, telephone 09 373 7599 ext 86425

For any queries regarding ethical concerns you may contact the Chair, The University of Auckland Human Participants Ethics Committee, The University of Auckland, Research Office, Private Bag 92019, Auckland 1142. Telephone 09 373 7599 ext 87830/83761. Email: humanethics@auckland.ac.nz.

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The University of Auckland
Private Bag 92019
Auckland, New Zealand

CONSENT FORM (Case study interviews)
This form will be held for a period of 6 years

Project title: The impact of Building Information Modelling (BIM) on professional roles, relationships and skills in the Architecture/Engineering/Construction (A/E/C) industry: Case study of a construction project.
Name of Researcher: Kathryn Davies

I have read the Participant Information Sheet, and understand the nature of the research and why I have been selected. I have had the opportunity to ask questions and have them answered to my satisfaction.

- I agree to take part in this research. I understand that this participation is entirely voluntary and my employer has given assurances that my choice to participate or not will have no impact on my employment status.
- I understand that I am free to withdraw from the study at any time, or may withdraw data from any interview, up until 2 weeks after I receive the transcript of the interview.
- I agree to be audio recorded.
- I understand that data will be kept for 6 years, after which they will be destroyed.

Name ______________________________

Signature ______________________________ Date ___________________

☐ I would like to receive a copy of any publications resulting from this research.

Email: ____

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The University of Auckland
Private Bag 92019
Auckland, New Zealand

CONSENT FORM (Case study organisation)
This form will be held for a period of 6 years

Project title: The impact of Building Information Modelling (BIM) on professional roles, relationships and skills in the Architecture/Engineering/Construction (A/E/C) industry: Stage 2 – Case study of a New Zealand construction project.
Name of Researcher: Kathryn Davies

I have read the Participant Information Sheet, have understood the nature of the research and why this case study has been selected. I have had the opportunity to ask questions and have them answered to my satisfaction.

- I agree that Kathryn Davies may interview staff members from my organisation who participate in the case study project, with their consent. I give my assurance that the decision of staff to participate or not will not affect their employment status.
- I agree that Kathryn Davies may have access to project documentation related to the BIM implementation. I understand that this documentation will be kept confidential and not used in publications without express permission.
- I understand that the names of individual participants will not be disclosed in any publications resulting from this research.
- I understand that the data and consent forms will be kept for 6 years, after which they will be destroyed.

Name ____________________________ Position ____________________

Signature ____________________________ Date ______________________

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE ON 23 OCTOBER 2013 FOR (3) YEARS. REFERENCE NUMBER 10039.

Appendix B – BIM guides and handbooks

Organisation	Name	Date	Country	Developer type	Notes on document purpose	Notes on roles
ADEB-VBA BIM Work Group (Denis, F.)	Building Information Modelling – Belgian Guide for the Construction Industry	2015	Belgium	Industry collaboration (Industry working group)	"This document and its annexes present a "generic protocol" as well as general rules and fact sheets allowing the stakeholders to define the collaboration rules and thus, optimize the working process." (p7)	Sets out roles and responsibilities for owner's representative (*BIM process manager*) and other stakeholders (*BIM discipline managers*) but defines BIM roles as adjunct to traditional roles.
AEC (UK)	AEC (UK) BIM Technology Protocol - version 2.1.1	2015	United Kingdom	Industry collaboration (Industry working group)	"... builds on the frameworks defined by the UK (and relevant International) protocols, specifications and documents …as well as existing, proven internal company procedures to: provide consistent platform-independent guidance for implementation and use of project BIM technologies." (p6)	Does not provide a fixed title and job description but identifies the tasks to be undertaken under Strategic, Management and Production roles. Lists nominal roles of *BIM Management (Strategic), Coordination (Management)* and *Modeller / Author (Production).*
American Institute of Architects (AIA)	Guide, Instructions and Commentary to the 2013 AIA Digital Practice Documents	2013	USA	Industry body	"The primary purpose of E203–2013 is to initiate, at the outset of a project, a substantive discussion about the extent to which Digital Data and BIM will be utilized, and how Digital Data and models can be used and relied upon. Once a general understanding is reached, the project participants use E203–2013 to document the agreed upon expectations regarding scope and anticipated Authorized Uses of Digital Data and BIM… This guide is intended to provide an in-depth look at this set of Digital Practice documents, and to provide guidance on how the documents are intended to be used" (p2)	Briefly describes roles related to *Digital data management, Model management,* but in general states that roles and responsibilities must be established for each project

Organisation	**Name**	**Date**	**Country**	**Developer type**	**Notes on document purpose**	**Notes on roles**
The American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE)	An Introduction to Building Information Modeling (BIM): A Guide for ASHRAE Members	2009	USA	Industry body	"… identifies the current state-of-the-art of the industry with respect to software applications and related protocols, and provides additional resources and suggested reading material for members planning a transition to BIM." (p3)	Does not specify roles but notes the need for a skills inventory and training provision to ensure all staff have an appropriate level of BIM understanding; suggests *BIM champion* role.
The Associated General Contractors of America (AGC)	The Contractor's Guide to BIM—Edition 2	2010	USA	Industry body	"We hope that this document helps more contractors to understand and participate in the use of these tools and better prepares them for this trend with the promise of revolutionizing our industry" (p. vii)	Roles identified include *Information Manager, Model coordinator, 3D modeling technicians;* detailed list of tasks and activities but they are not allocated to roles.
Building and Construction Authority (BCA)	Singapore BIM Guide Version 2	2012	Singapore	Government agency	"… aims to outline the various possible deliverables, processes and personnel / professionals involved when Building Information Modelling (BIM) is being used in a construction project. Users can use the Guide to clarify the roles and responsibilities of project members when using BIM in a construction project. The roles and responsibilities are then captured in a BIM Execution Plan, to be agreed between the Employer and project members." (p1)	Strongly focused on defining roles and responsibilities throughout a BIM project; identifies core roles of *Project BIM Manager, BIM Coordinator for Consultant, BIM Coordinator for Contractor.*

Organisation	Name	Date	Country	Developer type	Notes on document purpose	Notes on roles
BuildingSMART Finland	Common BIM Requirement 2012, Series 11: Management of a BIM project	2012	Finland	Industry collaboration (Industry body)	"The need for these requirements arises from the rapidly growing use of building information modeling in the construction industry. During all phases of a construction project, the parties to the project have a need to define more precisely than before what is being modeled and how the modeling is done" (Foreword)	Describes in some detail the design team roles of *BIM coordinator* and *Design discipline-based persons in charge*.
Canada BIM Council (CanBIM)	AEC(CAN) BIM Protocol	2014	Canada	Industry collaboration (Industry body)	"This document intends to provide the beginnings of a Canadian based compliant, platform independent protocol for designers BIM authoring tools based on internationally recognized standards and adapted only where required to meet the Canadian AEC industry needs." (p6)	Defines *BIM Manager* as a cross-platform professional responsible for model management, but does not specify the role.
CIC Research Group, Pennsylvania State University (CIC Penn State)	BIM Project Execution Planning Guide and Templates - Version 2.0	2011	USA	Research group (with industry collaboration)	"This Guide provides a structured procedure… for creating and implementing a BIM Project Execution Plan." (p.i)	Does not define roles but provides a structure for doing so within a project. Mentions *BIM Manager* involvement in the process but does not specify the role.
College of the Desert (CoD)	BIM GUIDE Protocols and Project Execution Plan	2011	USA (California)	Client (Educational institute)	"This guide will cover the overall process of developing a BIM project workflow and the basic understanding of College of the Desert's standard." (p4)	Provides outline of responsibilities for each stakeholder, including owner's representative.

Organisation	Name	Date	Country	Developer type	Notes on document purpose	Notes on roles
Construction Industry Council (CIC)	Building Information Model (BIM) Protocol	2013	United Kingdom	Industry collaboration (Industry body)	"The Protocol identifies the Building Information Models that are required to be produced by members of the Project Team and puts into place specific obligations, liabilities and associated limitations on the use of the models." (p.iv)	Specifies role of *Information Manager* (fully documented in a separate publication *Outline Scope of Services for the Role of Information Management*)
The Construction Users Roundtable (CURT)	BIM Implementation: An Owner's Guide to Getting Started	2010	USA	Client (Industry body)	"The booklet is offered as an informational publication only. CURT intends only to synthesize current thought and trends concerning the topic." (pii)	Describes the need for BIM skills and training but does not define specific roles.
CRC Construction Innovation	National Guidelines for Digital Modelling	2009	Australia	Research group	"The purpose of these guidelines is to assist in and promote the adoption of BIM technologies in the Australian building and construction industry, and try to avoid the uncertainty and disparate approaches that created inefficiencies with the implementation of 2D CAD over the past three decades." (p5)	Provides descriptions of skill sets required by *modellers, discipline model managers, project model manager* and *information model manager.*
Department of Defense Military Health System (DoD-MHS)	MHS Facility Life Cycle Management (FLCM) Building Information Modeling (BIM) Minimum Requirements	2014	USA	Client (Government department)	"The primary function of this document is to ensure coordinated BIM standards for the MHS with a FLCM perspective." (p1)	Sets out activities required from *Design and Construction Agents* with regard to BIM, but does not specify particular roles.
Dormitory Authority of the State of New York (DASNY)	Building Information Model (BIM) Standards Manual	2013	USA (New York)	Client (Local body)	"…describes the processes, procedures, and requirements that should be followed for the preparation and submission of BIM on all projects." (p4)	Locates responsibility for BIM with *Design Professionals* but does not define roles in detail

Organisation	Name	Date	Country	Developer type	Notes on document purpose	Notes on roles
Fermi National Accelerator Laboratory - Facilities Engineering Services Section (Fermilab FESS)	Building Information Modeling (BIM) Guide	2015	USA	Client (Research institute)	"...provides a compilation of the FESS/Engineering policies and procedures specific to the utilization of in-house projects and projects developed by outside A/E Consultants. This BIM Guide provides guidance for the A/E Consultant services and is intended as a supplement to the A/E subcontract." (p.ii)	Sets out requirements and responsibilities for *Design Team BIM Manager,* describes activities of the *BIM collaboration team* and notes the need to define responsibilities for a *model manager from each design discipline.*
Georgia Institute of Technology (Georgia Tech)	Georgia Tech BIM Requirements & Guidelines for Architects, Engineers and Contractors	2016	USA (Georgia)	Client (Educational institute)	"The intent of these requirements is to create a prescriptive framework with which Building Information Modeling (BIM) enabled teams will coordinate with Georgia Tech, the Board of Regents, the Georgia State Finance & Investment Commission, and other applicable groups on requirements to being BIM compliant." (p2)	Defines a set of BIM proficiencies, and sets out BIM requirements that the *Design Team* must meet but does not define specific roles; requires roles to be defined in the BIM Execution Plan. BIM Execution Plan template lists responsibilities of the *model manager.*
Georgia State Financing and Investment Commission (GSFIC)	GSFIC BIM Guide	2013	USA (Georgia)	Client (State government)	"… describes the standards that all BIMs for GSFIC construction projects shall abide by." (p4)	Appendix F (BIM Execution Plan) lists responsibilities of the *model manager* from each party in the project.
Hong Kong Housing Authority	Building Information Modelling (BIM) User Guide for Development and Construction Division of Hong Kong Housing Authority	2009	Hong Kong	Client (Government department)	"Standards and guidelines are important for effective model building, electronic file exchange, data and information compatibility, people communication, not only for in-house staff, but also for our consultants and contractors." (p4)	Provides brief outline of responsibility of *project BIM coordinator* and notes other project team members.
Hong Kong Institute of Building Information Modelling (HKIBIM)	BIM Project Specification Rev 3.0	2011	Hong Kong	Industry collaboration (Industry body)	"… establishes a process for adopting BIM on building projects. Clients, project managers, architects, engineers, quantity surveyors, contractors, manufacturers and facility managers can produce a BIM Project Specification with reference to this document." (p3)	Defines roles of *BIM Project Manager* and *BIM modellers*

Organisation	Name	Date	Country	Developer type	Notes on document purpose	Notes on roles
Indiana University	BIM Guidelines & Standards for Architects, Engineers, and Contractors	2015	USA (Indiana)	Client (Educational institute)	"Required on all construction (new and addition/alteration) with total project funding of $5M or greater, required on any project that involves a portion of a facility that has already been delivered with a BIM requirement. Encouraged on all other projects." (p1)	Defines a set of BIM proficiencies, and sets out BIM requirements that the *Design Team* must meet but does not define specific roles; requires roles to be defined in the BIM Execution Plan. BIM Execution Plan template lists responsibilities of the *model manager*.
Los Angeles Community College Districts (LACCD)	LACCD Building Information Modeling Standards Version 4.2 Design-Bid-Build	2016	USA (California)	Client (Educational institute)	"…developed to define a process and establish requirements, procedures and protocol for the utilization of BIM in the various stages of our projects." (p1) Similar but distinct document provided for Design-Build projects.	Defines BIM workflow including roles and collaboration procedures, in particular a *BIM Facilitator* for the design team, *Discipline BIM Lead Modelers* for other participants, and a *VDC manager* for the construction team.
Massachusetts Port Authority (Massport)	BIM Guidelines for Vertical and Horizontal Construction	2015	USA (Massachusetts)	Client (Public authority – transport)	"…for design, construction, civil, and facilities professionals working on all MPA projects. It specifies the guidelines and project model standards to be used within a BIM/Lean collaboration environment. The goal of the guide is to assure consistency in processes and BIM development from MPA's various service providers across multiple types of projects." (p1)	Provides detailed descriptions of key roles including *Prime Design BIM Manager, Construction BIM Manager, BIM Discipline Coordinators* and *Trade BIM Coordinators*. Also details the expected collaboration environment. Specifies client-side roles including the *Design Technologies Integration Group (DTIG) BIM Manager* and the *client's Project Manager*.
NATSPEC	NATSPEC National BIM Guide	2016	Australia	National standard	"…to assist clients, consultants and stakeholders to clarify their BIM requirements in a nationally consistent manner. This will reduce confusion and duplication of effort." (p1)	Gives detailed description of collaboration processes and project roles, including *Design Team BIM Manager, Technical or Trade Lead BIM Coordinators* and *Construction BIM Manager.*

Organisation	Name	Date	Country	Developer type	Notes on document purpose	Notes on roles
New York City Department of Design and Construction (NYC-DDC)	BIM Guidelines	2012	USA (New York)	Client (Local body)	"… provides guidelines for the consistent development and use of BIM across multiple building types and for a wide range of municipal agencies. …The guide is intended to ensure uniformity in the use of BIM for all New York City Public Buildings projects." (p6-7)	Lists minimum responsibilities *for BIM manager* and *Discipline trade coordinator* roles.
New York City School Construction Authority (NYC-SCA)	Building Information Modeling Guidelines and Standards for Architects and Engineers	2014	USA (New York)	Client (Public authority – education)	"…describes the processes, procedures, and requirements that shall be followed for the preparation and submission of BIM Models for SCA Capacity (Line) Projects (new building and additions), as well as to produce, release, and receive data in a consistent format so to maintain an efficient exchange of data between disciplines and the compatibility of each disciplines' Model(s)." (p1)	Defines consultants' BIM roles with a design team *Project Model Manager* and a *Project Model Leader* for each discipline.
New Zealand BIM Acceleration Committee	New Zealand BIM Handbook 2nd Edition	2016	New Zealand	Industry collaboration (Industry body)	"Its primary focus is on the design and construction phases of the building life cycle. To realise the maximum benefits of BIM, the information/data created during the design and construction phases must be fed into facilities and asset management systems and used throughout its life cycle." (p5)	Provides some detail on required tasks and briefly describes roles of *BIM Manager* and *Discipline BIM Coordinators.*
Norwegian Home Builders' Association (BoligBIM)	BIM User Manual Version 2.0.	2012	Norway	Industry body	"The manual delves into the different parts of "working BIM". It seeks to give practical advice associated with the processes, modelling and utilisation of the model itself." (p4)	Provides detailed checklists of tasks and activities based around traditional roles; defines *BIM Co-ordinator* as key BIM role.

Organisation	Name	Date	Country	Developer type	Notes on document purpose	Notes on roles
Ohio State University	Building Information Modeling (BIM) Project Delivery Standards Version 2.0	2017	USA (Ohio)	Client (Educational institute)	"…a reference manual for Design and Construct project team members to understand what relevant 3D geometry and data shall be delivered." (p4)	Provides detailed descriptions of BIM roles and responsibilities, including client roles of *Project Manager* and *Model Manager* as well as *Design and Construct Model Managers,* and *Discipline Model Managers,*
Port Authority of NY & NJ (PANYNJ)	E/A Design Division BIM Standard Manual	2017	USA (New York & New Jersey)	Client (Local authority – transport)	"… describes the processes and procedures required for the preparation and submission of BIM Models for Port Authority of NY & NJ projects." (p1)	Defines various project team roles including *BIM Lead Coordinator, BIM Discipline Coordinators, BIM Users.* It also defines the role and responsibilities of the *CAD\BIM Support Group* on the client/facilities management side.
State of Ohio Department of Administrative Services (Ohio DAS)	State of Ohio Building Information Modeling Protocol	No date	USA (Ohio)	Client (State government)	"…provides general guidance that ensures that building owners know what they should include in their requests for qualifications, agreements, bidding requirements, contracts, and other documents affected by this new medium and process." (p2)	Locates the role of the *model manager* with the architect, unless specifically designated otherwise.
State of Tennessee Office of the State Architect (TN OSA)	Building Information Modeling Standards (BIMs) Version 1.1	2015	USA (Tennessee)	Client (State government)	"…for the consistent development and management of BIM on state building projects" (p1)	Specifies BIM roles for the design team, including *BIM Manager* and *BIM Coordinators.*
University of Southern California (USC)	Building Information Modeling (BIM) Guidelines Version 1.6	2012	USA (California)	Client (Educational institute)	"… defines the Design and Construction scope of work and deliverables for using Building Information Modeling (BIM) on new USC construction projects, major renovations and other projects as required by USC…" (p5)	Defines USC BIM involvement and responsibilities as the owner, as well as the role of the *Design BIM Facilitator/BIM Engineer.*

Organisation	**Name**	**Date**	**Country**	**Developer type**	**Notes on document purpose**	**Notes on roles**
U.S. General Services Administration (GSA)	GSA Building Information Modeling Guide	2007	USA	Client (Government department)	"…an introductory text serving as a foundation and common starting point to support BIM technology in general and individual BIM applications in specific. As an overview, this Series is an over-arching and executive text to be used as a reference guide for GSA members and associates when determining what BIM applications would be appropriate for their specific project, and throughout the adoption and application of the selected technology." (Introduction p.v)	Notes that defining roles and responsibilities of team members is an important requirement in establishing a scope of services for a BIM project, but does not provide any definitions itself.
U.S. Department of Veterans Affairs (VA)	VA BIM Guide v1	2010	USA	Client (Government department)	"…moving both the organisation and its service providers to BIM as effectively and efficiently as possible, and to integrating BIM process requirements and Integrated Project Delivery (IPD) methodologies into its delivery requirements." (p4)	Defines a range of BIM project roles in some detail, including *Design Team Project Manager, Design Team BIM Manager; Technical Discipline Lead BIM Coordinators (Design and Trade), Construction BIM manager*

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Appendix C – Case study interview schedule

Case study involvement in BIM

- Project structure & context:
  - What are the project characteristics? (type, size, value, time frame, participants)
  - What was your role in the project?

- BIM use on the project:
  - Who initiated the use of BIM?
  - At what stage was BIM introduced?
  - What was the scope, extent, uses of BIM on the project?
  - Was it whole building or partial BIM?
  - Were there formal project agreements around BIM? (contracts, execution plans, protocols)
  - Were there BIM deliverables?
  - What was your company's involvement with the model? (modelled in-house, outsourced modelling, models received/exchange from others, models delivered to client)
  - What were your company's documentation and project administration processes?

- Project role:
  - When did you become involved with the project?
  - Have there been changes in your role over the course of the project? (project role, BIM role)
  - Who did you work with most on the project? (internally, cross-party)
  - How does this compare with non-BIM projects?
  - Who do you report to/manage? (BIM, non-BIM projects)

- Training and skills:
  - How do you rate your own BIM expertise?
  - How do you rate the BIM expertise of others in your organisation?
  - How do you rate the BIM expertise of project partners?
  - What was your BIM use/knowledge prior to this project?
  - What formal training have you had in BIM?
  - Is BIM recognised as part of your role/job description/specialisation?
  - Do you need/want to know more?

- Preferences & predictions:
  - Do you think you will be involved in more BIM projects after this one?
  - What type of projects do you think BIM will be used for?
  - Do you think BIM will bring wider industry change? (eg integrated delivery, contracts, working practices)

Appendix D – BIM credentials

Country	Name	Credential type	Provider	Summary of requirements	Cost	Notes
UK	BIM Informed Professional	Individual, training and certification	BRE Global	Applicants must complete the course and exams for BRE Academy BIM Stage 1 [BIM Fundamentals, classroom or BIM Essentials, online] and BRE Academy BIM Stage 2 [Task/Project Information Manager, classroom or BIM: Information management, online]. This is followed by submission of an application with the documents required to provide evidence to demonstrate the required knowledge and understanding. Application documents are audited to determine accreditation.	Stage 1&2 courses £785 each, first year application and membership fee £295, audit fee £200, annual management fee years 2 & 3 £150 per year.	Members are required to undertake a minimum of 15 hours relevant CPD by end of each year of membership. Application is re-audited every 3 years. *This certification is suitable for those wishing to demonstrate their knowledge of the BIM process. Certification audits require demonstration of the detailed knowledge and understanding gained through training and experience on Information Management. This certification is appropriate for policy makers, advisors, educationalists and construction professionals who are implementing the BIM process.* 2 listed as at July 2017

Country	Name	Credential type	Provider	Summary of requirements	Cost	Notes
UK	BIM Certificated Practitioner (Project Information Manager/ Task Information Manager)	Individual, training and certification	BRE Global	Applicants must complete the course and exams for BRE Academy BIM Stage 1 [BIM Fundamentals, classroom or BIM Essentials, online] and BRE Academy BIM Stage 2 [Task/Project Information Manager, classroom or BIM: Information management, online]. This is followed by submission of an application with the documents required to provide evidence of the required knowledge and understanding. Application documents are audited to determine accreditation.	Stage 1&2 courses £785 each, first year application and membership fee £295, audit fee £300, annual management fee years 2 & 3 £150 per year.	Members are required to undertake a minimum of 15 hours relevant CPD by end of each year of membership. Application is re-audited every 3 years. *This certification is suitable for those wishing to demonstrate their application of the BIM process on live projects. Certification audits cover the detailed knowledge and understanding gained through training and experience. Project Information Manager (PIM) and Task Information Manager (TIM) are roles defined within PAS 1192-2:2013. This certification is appropriate for project based construction professionals applying an implemented BIM process.* 39 listed as at July 2017
UK	BIM Level 2 Business Systems Certification	Company, certification	BRE Global	Different documentation required depending on whether applicant company is a Task Team, Lead Supplier or Employer. Assesses the BIM execution plan stage (as defined in PAS 1192:2 2013) including how the business responds to enquiries from customers (EIR) and what the business' software and staff capabilities are	Initial certification £895 application fee, £750 document review fee, additional cost for onsite audit (approx. £2100-£3150 for a small to medium sized company). Annual certification £895 plus an onsite audit fee.	Valid for 3 years *Certification demonstrates that you have met the requirements of PAS 1192-2:2013 and section 4.2 table 8 of the PAS 91:2013 prequalification questionnaire document.* 22 companies listed as at July 2017 (7 of which have multiple locations certified)

Country	Name	Credential type	Provider	Summary of requirements	Cost	Notes
UK	RICS-Certified BIM Manager	Individual, certification	RICS	Applicants must have five years of experience in a relevant sector, such as architecture, engineering or construction; MRICS, AssocRICS, any degree or a recognised professional qualification; 12 months of practical BIM experience either in cost estimating or construction. Applicants must provide: career history; CPD summaries (50 words each); four competency statements (500 words each); a case study (2000 words)	Members assessment fee £200, annual subscription £100; non-members assessment fee £300, annual subscription £175	Requires holders to undertake a minimum of five hours of CPD on BIM-related topics annually. Recertification takes place every three years. *The Building Information Modelling (BIM) Manager Certification recognises individuals who specialise in using the methodology to manage projects. Working to appropriate standards and processes, the certified BIM Manager will offer efficiencies in information handling and exchange in a collaborative,* *compliant manner.* 42 listed as at July 2017
UK	Certificate in Building Information Modelling (BIM): Project Management	Individual, training	RICS	6-month online course, with an online examination at completion.	£895.00 for RICS members; £995.00 for non-members	The course will "cover the entire BIM project lifecycle and provide you with detailed knowledge and the skills required in order to manage each step of the project."
UK	BIM Level 2 Accreditation	Company, certification	Lloyds Registry	Assessors conduct a gap analysis of the company to identify areas requiring attention, and develops an implementation plan. Once completed, an implementation assessment is performed against a live BIM Project to determine if the company's system fully conforms to requirements.	Established on a company by company basis	*The accreditation is valid for three years, during which time the BIM provider is under a surveillance program. Failure to demonstrate ongoing commitment to BIM and/or lack of maintenance of standards, competencies and processes can result in accreditation suspension or withdrawal.* 6 listed at July 2017

Country	Name	Credential type	Provider	Summary of requirements	Cost	Notes
UK	Building Information Modelling Certification	Company, certification	Ocean Certification Ltd	Audit of company tailored to individual companies with capability assessed as defined within the standards PAS1192-2:2013 and PAS 91:2013 section 4.2.	Estimated at £5,000 over three years (Ravenscroft, 2015)	*Ocean Certification is a UKAS accredited certification body and has developed considerable experience over a number of years in certifying management systems within* UK *architecture, design engineering and construction. We have now developed certification to BIM Level 2 so that companies can demonstrate capability defined within the standards PAS1192-2:2013 and PAS 91:2013 section 4.2.* No listing of Ocean accredited companies, but 4 have been identified on their website
UK	BSI Kitemark for Building Information Modelling (BIM)	Company, certification	BSI			*Developed for Tier 1 Main Contractors (Contractors with a direct commercial relationship with the client). To achieve the BSI Kitemark evidence is required of the main contractor's capability to deliver projects in compliance with PAS 1192-2, incorporating BS 11000 Collaborative Business Relationships or ISO 9001 Quality Management systems and assessment of completed projects*
UK	BSI BIM Verification Certification	Company, certification	BSI	Tier 1 Main Contractor, Tier 2 Sub-contractors and suppliers, Tier 3 or 4 Sub-contractors and suppliers		*Developed for any contractor involved in using BIM to deliver new buildings or infrastructure projects.*

Country	Name	Credential type	Provider	Summary of requirements	Cost	Notes
UK	BIM Foundations	Individual, training	Stroma	1-day training course		*Stroma Certification offers a BIM Certification scheme for companies in line with PAS 1192-2:2013 (Capital Delivery Phase of Construction) and PAS 1192-3:2013 (Operational Phase of Construction Projects). Stroma Certification certifies design and construction disciplines against the current Government BIM requirement. Our BIM Certification scheme is available to businesses of any size, with BIM Professional expertise to assess you throughout the certification process to help you achieve BIM Certification against Level 2.*
UK	BIM (Building Information Modelling) Certification	Company, certification	Stroma	Desktop & on-site assessment	Application fee £495; Desktop assessment £995/day; Onsite assessment £1995/day	Reviewed every year for compliance, re-certified every 3 years. *Achieving BIM Certification demonstrates that you are able to operate to the Government's BIM Level 2 requirements with respect to BIM Execution Planning and Asset Management.*
UK	BIM Staged Certification Scheme	Company, certification	QA International Certification	Certification provided through on-site assessment in 4 separate stages: Stage 1 – Management Manual, Capability Assessment & Training Plans Stage 2 – Operating Procedures & Operational Records Stage 3 – Project Application & Project Evidence Stage 4 – Final Assessment, Procedures / Activities & Certification		

Country	Name	Credential type	Provider	Summary of requirements	Cost	Notes
Netherlands	BIM Quickscan	Company, benchmarking	TNO	Companies can perform an online selfscan questionnaire, or engage a certified expert to help with interpreting the results and create an action plan for follow up improvements.		*This quick scan will give you an insight into the level of BIM in your company. The objective of the Quick Scan is to give you an insight into BIM, your own level of BIM and possible improvements.*
USA/ International	Autodesk Certified Professional	Individual, training and certification	Autodesk	Requires applicants to demonstrate mastery of Autodesk software, e.g., Revit Architecture		
USA	AGC Certificate of Management-Building Information Modeling (CM-BIM)	Individual, training and certification	Association of General Contractors (AGC)	4 training courses, delivered by approved instructors over 32 hours, supported by a participant's manual for each unit. 1: Introduction to BIM 2: BIM Technology 3: BIM Project execution planning 4: BIM adoption, implementation and ROI Followed by an online exam conducted at a licensed test centre. A passing score of 91/125 is required.	Course fees per course $300-375 for members; $450-475 for nonmembers Exam fee US$575 (July 2017); re-examination additional $100.	Valid for 3 years, requires 30 hours of BIM-related continuing education over each 3-year period for renewal. https://www.agc.org/learn/education-training/building-information-modeling/cm-bim https://www.agc.org/learn/education-training/building-information-modeling-education-program
Canada	CanBIM Professional Level 1 certification	Individual, training and certification	CanBIM	Completed a CanBIM-approved introductory level course in Building Information Modeling.	Members CAN$60 application fee plus CAN$100 certification fee; non-members CAN$75 application fee plus CAN$125 certification fee	CPD requirement of 10 hours of learning over 2 years 35 listed at July 2017

Country	Name	Credential type	Provider	Summary of requirements	Cost	Notes
Canada	CanBIM Professional Level 2 certification	Individual, training and/or certification	CanBIM	Completed a CanBIM-approved introductory level BIM-related software course or courses through academic training or a minimum of 2,000 documented hours of relevant experience utilizing BIM-related software and its application.	Members CAN$60 application fee plus CAN$200 certification fee; non-members CAN$75 application fee plus CAN$225 certification fee	CPD requirement of 15 hours of learning over 2 years 95 listed at July 2017
Canada	CanBIM Professional Level 3 certification	Individual, certification	CanBIM	Have a recognized degree in a building-related and/or infrastructure-related discipline plus three years (6,000 hours) of relevant experience or a recognized diploma in a building-related and/or infrastructure-related discipline plus five years (10,000 hours) of relevant experience. Submit evidence of having successfully completed a CanBIM-approved, BIM management course and of having completed 1 building and/or infrastructure project utilizing multi-discipline BIM.	Members CAN$60 application fee plus CAN$300 certification fee; non-members CAN$75 application fee plus CAN$325 certification fee	CPD requirement of 15 hours of learning over 2 years 27 listed at July 2017
Canada	CanBIM Certified Professional	Individual, certification	CanBIM	Submit evidence of having completed 3 building and/or infrastructure projects utilizing integrated, multi-discipline BIM.	Members CAN$60 application fee plus CAN$400 certification fee; non-members CAN$75 application fee plus CAN$425 certification fee	CPD requirement of 20 hours of learning over 2 years 23 listed at July 2017

Country	Name	Credential type	Provider	Summary of requirements	Cost	Notes
Singapore	Certification course on BIM Planning (Building Developers and Facility Managers)	Individual, training and certification	BCA	2-day training course with assessment on completion.	S$700.00 (subsidies available)	*Designed for Building Developers and Facility Managers to enhance their knowledge for effective BIM project planning during the early phases of their projects. The objectives of this course are to enhance the knowledge of participants into BIM process, the planning of BIM project, BIM standards and guidelines, and the assessment of a BIM project execution plan.*
Singapore	Certification course in BIM Modelling (Architecture/ MEP/Structure tracks)	Individual, training and certification	BCA	4-day training course with assessment on completion.	S$1,790.00(subsidies available)	*The objectives of this course are:* *• To provide an understanding of BIM processes and benefits* *• To equip participants the practical 3D BIM [track specific] modelling skills and technical knowledge to start and support a project using BIM.* *• To enable participants to be familiar with the e–submission template guideline*
Singapore	Certification Course on BIM Management	Individual, training and certification	BCA	4-day training course with assessment on completion	S$1,240.00(subsidies available)	*Designed to provide industry professionals with the knowledge to implement and execute a BIM project.*
Australia	BIM Excellence Organisational Assessment	Company, benchmarking	Change Agents AEC	Online assessment tool plus onsite validation		
Australia	BIM Excellence Individual Discovery	Individual, benchmarking	Change Agents AEC	Online assessment tool	Free	