A FRAMEWORK FOR MANAGING BIM-ENABLED CONSTRUCTION ORGANISATIONS THROUGH INNOVATIVE BIM CULTURE

by

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To my parents and husband

whose boundless love and unwavering support made this journey possible and

for everyone who have waited patiently for this to be finished

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List of Abbreviations

BIM	-	Building Information Modelling
BDS	-	Building Description Systems
BPM	-	Building Product Model
CAD	-	Computer-Aided Design
CDE	-	Common Data Environment
CVF	-	Competing Values Framework
DE	-	Digital Engineering
DEEP	-	Digital Engineering Execution Plan
DEMP	-	Digital Engineering Management Plan
DfMA	-	Design For Manufacture and Assembly
ECS	-	Exemplar Case Study
EOI	-	Employer Information Requirements
FM	-	Facility Manager
GBM	-	Generic Building Model
GDP	-	Gross Domestic Product
GLIDE	-	Graphical Language for Interactive Design
ICT	-	Information And Communication Technology
IT	-	Information Technology
ITP	-	Inspection And Test Plans
KPI	-	Key Performance Indicator
LOD	-	Level Of Details
LOI	-	Level Of Information
MEP	-	Mechanical, Electrical and Plumbing
NAWIC	-	National Association of Women In Construction
NBS	-	National Building Specification
QA	-	Quality Assurance
QS	-	Quantity Surveyor
RFI	-	Request For Information
SA	-	South Australia
UK	-	United Kingdom
VOT	-	Value Orientation Theory

Abstract

Building Information Modelling (BIM) represents a significant shift in the construction industry, introducing a new way of managing and collaborating on construction projects. The integration of BIM into a construction business requires a cultural change and a shift in mindset. To fully leverage BIM benefits, it is imperative for organisations to establish an environment that fosters a culture of innovation, capable of seamlessly integrating and embedding BIM to the organisational strategy and practices. Yet curiously, research to promote strong innovative BIM culture are scant due to the phenomenon's inherent complexity and subjective nature. Hence, this study aims to develop a framework for managing BIM-enabled construction organisations towards a strong innovative BIM culture through investigating and analysing the cultural manifestations. The synthesis of literature that combines the concepts of 'BIM', 'organisational culture', and 'innovation culture' led to define organisational innovative BIM culture and develop a conceptual framework to manage innovative BIM culture based on cultural manifestations by leveraging the Schein's organisational culture theory and innovation culture theory. This study is situated within the interpretive research paradigm and employs case study as its research strategy. Four large-sized BIM-enabled construction organisations were selected as the cases, and the organisational BIM culture was considered as the unit of analysis. Six in-depth semi-structured interviews involving respondents from both managerial level and operational level was used as the primary data collection technique. Additionally, direct observations and documentation were employed as secondary data collection techniques to provide a comprehensive understanding of the organisational BIM culture within each case. The cultural manifestations of BIM culture of all four cases in terms of 'behaviours' and 'patterns of underlying beliefs' were identified and later analysed them to derive 'underlying beliefs. The underlying beliefs were analysed against the cultural dimensions viz. human relationships; organisation's interaction with the environment; the nature of reality, time; the nature of human activity; and the nature of human nature based on the Value orientation Theory (VOT).

The emergent findings revealed that a strong innovative BIM culture consists of underlying beliefs of participative authority system as best authority system, groupism as the best way to organise, cooperation as the best way to relate to each other, and inherent goodness of human nature. Further, a construction organisation with a strong innovative BIM culture believes in being proactive with a 'doing' orientation as the best way to behave, pragmatism as the best way to find the truth, dominating the environment as the best way to relate to its environment and being future orientated. Corresponding to these cultural dimensions most prominent strategies to promote a strong BIM culture included empowering the BIM team with the authority and influence needed to drive meaningful change; cultivate an environment where employees feel comfortable and empowered to raise their concerns and ideas; implement a structured feedback loop where employees can share their experiences, challenges, and suggestions for improvement; promote verbal appreciations reinforce positive behaviour and contributions, boosting morale and motivation; eliminate the practice of maintaining existing skills by investing in regular upskilling programs to enhance employee capabilities; conduct case studies and gather feedback from various stakeholders to refine BIM approaches based on real-world experiences; leverage BIM as a tool to demonstrate the technological prowess to clients, giving a competitive edge in winning projects and actively develop comprehensive guidelines, plans, and protocols for digital engineering and BIM implementation.

Based on the findings, this study provides a diagnostic tool and a framework to be used as tools to manage BIM culture in construction organisations. Firstly, a tool was developed to present underlying beliefs in a spectrum of weak to strong innovative BIM cultures that can

be used to diagnose different existing BIM cultures of organisations based on their cultural manifestations. Secondly, a framework to manage construction organisations towards a strong innovative BIM culture was developed considering strategies to strengthen strong BIM culture. The study conceptually contributes to the expanding literature on BIM and organisational culture by not only formulating a definition of organisational BIM culture and but also refining and extending it to define an innovative BIM culture. Further, the study contributed theoretically by both the theory building and theory testing. Accordingly, the study developed a conceptual framework to manage organisations towards innovative BIM culture, and based it to find underlying beliefs, patterns of underlying beliefs and behaviours to uncover innovative BIM cultures of construction organisations. This study made methodological contributions to the knowledge by developing a methodology to uncover cultural manifestations in cultural setting using a systematically developed case study strategy. Emergent findings also had practical implications for BIM managers, upper management, and change agents within construction organisations, empowering them to understand and manage their organisation's BIM culture effectively by identifying areas of improvement, and implementing strategies tailored to their unique cultural context. The study focused on large sized BIM-enabled construction organisations in Australia and given that cultural studies are context specific, future studies could utilise the insights from the present study in diverse geographical settings, considering the variations in national cultures in different countries.

Keywords: Building Information Modelling, case study, innovative BIM culture organisational culture, underlying beliefs, strong culture, strategies

Declaration

This thesis presents work carried out by myself and does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university; to the best of my knowledge it does not contain any materials previously published or written by another person except where due reference is made in the text; and all substantive contributions by others to the work presented, including jointly authored publications, are clearly acknowledged.



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2. Samaraweera, A., Jayasanka, T A D K., Vidanagamage S, Rameezdeen, R.. and **Alankarage, S.** Conceptual Framework for Suicide Prevention Process in Construction In: Perera, S and Hardie M, (Eds) Proceedings of The 45th Australasian Universities Building Education Association Conference, 23rd -25th November 2022, Western Sydney University, Australia

3. **Alankarage, S.,** Samaraweera, A., Royle, J., Macolino, Adrian., Robertson, S., & Palihakkara, A.D. (2022). Cultural basic assumptions of consultants and contractors during negotiations: The case of South Australian construction industry. In proceedings of *10th World Construction Symposium.* Colombo: Ceylon Institute of Builders (CIOB), 24th - 26th June 2022, Colombo, Sri Lanka.

4. Rajenthiran, N., **Madhuwanthi H.A.S.**, Samarweera,A., Dissanayake D.M. P.P. & Sirimewan D.C (2020). Cross-cultural Dimensions in Construction Projects: Case Study of Sri Lanka . In proceedings of *9th International Conference on Management and Economics (ICME) 2020* on 'The Role of Business Intelligence in Shaping Organizations in emerging Economies'.

CHAPTER 01: INTRODUCTION

The purpose of the introduction chapter is threefold. First, to outline the research question, aim and objectives, and provide a succinct overview of the methodologies employed to achieve the study's stated objectives. Second, to convey its significance and the motivating factors that led to this study's execution and delineate the study's scope and limitations. Finally, to illustrate the thesis contents and structure. The selection of contents and headings in this chapter has been deliberate and purposeful because they align with the guidelines for introductory chapters of dissertations and projects in the built environment field, as specified by Farrell, Sherratt and Richardson (2017).

1.1 Background

As a major component in the global economy, the construction industry contributes around 6% of the world's GDP through engineering and construction activities, translating to approximately $10 trillion in annual revenue (Stojanovska-Georgievska et al. 2022). The industry is expected to experience significant growth, with an estimated 85% increase by 2030 and a 4% annual growth rate between 2018 and 2023 (Klein et al. 2022). However, the fragmented nature of the construction industry remains a challenge, as does the lack of collaborative project delivery systems, the sparse adoption of interoperability standards, and the scarcity of project process automation (Knobel et al. 2021). The industry is increasingly complex, with highly dispersed and data-intensive project-based organisations managed by a diverse knowledge workforce with growing information sharing requirements (Siebelink et al. 2021). Therefore, it is crucial that the industry adapts to the digital age and leverages digital solutions to address the challenges confronting it. An example of such innovation is Building Information Modelling (BIM), which has been introduced as a digital advancement in the construction industry (Sackey, Tuuli & Dainty 2015; Sompolgrunk, Banihashemi & Mohandes 2023).

BIM encompasses a set of IT tools that enable the creation, management and collaborative sharing of building information among various participants in a construction project and offers a range of digital functionalities beyond three-dimensional (3D) modelling (Papadonikolaki 2018). BIM is well known for the benefits of lower failure costs, increased productivity, and effective communication (Siebelink, Voordijk & Adriaanse 2018). By 2025, the global market is anticipated to realise that BIM usage will result in estimated savings of 13-21% in the initial design and building stage and 10-17% in the operations and maintenance stage (Stojanovska-Georgievska et al. 2022). BIM has also emerged as a crucial

necessity for gaining a commercial edge and ensuring survival in the highly competitive and dynamic industry (Siebelink, et al., 2021). Given its potential to revolutionise the construction industry and address persistent challenges, the adoption and integration of BIM in construction organisations is imperative for the industry's future success and growth.

However, the NBS (2019) survey conducted in Australia revealed that there were reservations about its benefits even among the organisations that had adopted BIM. For instance, 56% of those who are using BIM do not believe that it has increased company or project profitability and 40% do not believe that adopting BIM has increased project delivery. As Davies, McMeel and Wilkinson (2017) observed, these individuals who doubt the potential benefits of BIM tend to continue working in traditional ways, hindering the full integration of BIM within organisations that have already embraced it. This scepticism within companies either prevents the adoption of BIM altogether or limits the extent to which BIM can be implemented. Thus, despite the evident advantages that BIM offers to construction organisations, not all these organisations can fully capitalise on these benefits. Attaining the full potential of the BIM will only be possible if the people using BIM adapt and adopt the required practices (Bryde, Broquetas & Volm 2013). When the employees of an organisation utilise a limited scope of features of the technology and hardly pledge any extensions associated with the technology, there is an underutilization of that technology in the organisation (Jasperson, Carter & Zmud 2005). This inadequate use of the implemented technology by the employees contributes to a reduced return on investment (Li, Hsieh & Rai 2013). This is largely because only a minority of individuals within these organisations genuinely embrace and make effective use of BIM.

The organisational culture plays a crucial role in determining how individuals within the organisation perceive and integrate BIM into their workflows (Siebelink, et al., 2021). BIM is built on a culture of collaboration that extends beyond the design phase to encompass the entire project development process. If the organisational culture does not align with the collaborative ethos of BIM and instead treats it as a temporary trend, it becomes challenging to fully integrate BIM into the organization's practices (Knobel *et al.,* 2021). Such a permanent culture should bring efficiency and depth to the cycle of change and innovation management in an organisation (Zakariyyah, John & Ijaola 2021).

While external factors such as regulatory environment, client demands, supply chain collaboration, technology, market conditions, and industry trends certainly influence the broader context of BIM adoption, the internal dynamics shaped by organisational culture play a foundational role (Xu, J. et al. 2018). A positive and forward-thinking organisational

culture creates an environment where employees are more receptive to change, innovation, and collaboration, ultimately determining the success or challenges in the implementation of BIM at the organisational level (Wang et al. 2020). Therefore, to promote effective BIM use, it is crucial to establish a cultural setting where individuals are willing to engage in transformative learning, even if they find it demanding and intimidating.

1.2 Research gaps and problem justification

Despite BIM's widely recognised advantages, the pace and degree of its usage varies among construction organisations and the realisation of the benefits in practice often falls short (Alankarage et al. 2022; Kudirat Olabisi & Adamu 2018). This can be attributed to the disruptions brought by BIM as an innovation that challenges traditional bricks and mortar practices (Sackey, Tuuli & Dainty 2015). BIM represents a significant departure from construction practices that rely heavily on physical drawings, manual processes, and established workflows (Adam et al. 2022). Implementing BIM often requires employees to acquire new skills and knowledge in using digital modelling software and collaborative platforms and necessitates a significant investment of both time and resources in terms of software, hardware, and training (Siebelink et al. 2021). BIM use even has the potential to eliminate certain roles within organisations and affect people's way of thinking and behaviours (Zakariyyah, John & Ijaola 2021). These new workflows, processes, behaviours and mindset associated with BIM fundamentally transform the intra-organisational environment, ultimately giving rise to a distinct organisational culture centred around BIM (Knobel *et al.*, 2021)- this is referred to as organisational BIM culture (Alankarage et al. 2023). According to Siebelink, Voordijk and Adriaanse (2018) this organisational BIM culture guides the actions and decisions made in the BIM environment and encompasses a collection of fundamental assumptions and established practices deeply rooted within an organisation. Culture is often passed on to new employees as part of their orientation and integration into the organisation (*ibid*). Therefore, understanding organisational BIM culture is necessary to explain why things work or fail when an organisation implements BIM (Zakariyyah, John & Ijaola 2021).

The emergence of an organisational BIM culture, which occurs due to the disruptions to established workflows and behaviours, also undermines a sense of identity and creates employee anxiety about losing their group membership (Knobel *et al.*, 2021). This prompts individuals with a vested interest in the current *status quo* to exhibit a range of responses from ambivalence to outright resistance for BIM (Klein et al. 2022). Resistance to BIM use stems from employees' need to adapt to a new delivery process that can take them out of

their comfort zones (Jaaron, Hijazi & Musleh 2022). Pertaining to these circumstances, if only a few individuals within the organisation embrace and effectively use BIM, its potential advantages may remain underutilised despite the technical completion of BIM projects (Wang et al. 2020). Thus, a supportive environment is required to encourage everyone to willingly accept and foster BIM, while taking risks and embracing transformational learning even if it seems (at face value) difficult and intimidating (Sompolgrunk, Banihashemi & Mohandes 2023). Establishing such an environment, as highlighted by Burdon and Dovey (2015), necessitates a thorough examination of the suitability of the existing organisational form and the cultural beliefs it has given rise to. Therefore, unless appropriate cultural manifestations reinforce BIM efforts, they will likely encounter effective resistance that impedes the desired transformation (Alankarage et al. 2023). According to Schein (1994), this can be achieved by creating an innovative culture that adapts to turbulent environments by developing new missions, goals, products, services, methods, values and underlying beliefs. Given that BIM is a disruptive innovation, when a construction organisation adapts and embeds BIM through altering its interests and behaviours, its success rests upon an innovative culture which supports the BIM implementation (Alankarage et al. 2023; Knobel et al. 2021; Zakariyyah, John & Ijaola 2021).

Many studies argue that for a successful BIM implementation, a supportive organisational culture is necessary (Zakariyyah, John & Ijaola 2021). Further, the UK BIM Alliance's 2021 survey underscores that when it comes to BIM implementation changing the prevailing organisational culture is a formidable challenge. This is not surprising, as organisational culture is often seen as the elusive ‘black box’ responsible for many persistent issues in the construction industry (Ankrah & Proverbs 2004). The concept of organisational culture in a BIM context is a relatively new and less established field, warranting further exploration and clarification (Knobel et al. 2021; Xu, J. et al. 2018). A systematic review conducted by Alankarage et al. (2023), which focused on the role within the BIM setting, revealed that existing BIM related literature has made references to organisational culture have perceived organisational culture as both a driver and a barrier to the use of BIM within organisations (Ahuja, Sawhney & Arif 2018). For instance, Ogwueleka (2015) conducted a study on BIM implementation and suggested organisational culture as a significant factor to consider when introducing BIM. Enshassi et al. (2019) identifies organisational culture as an obstruction to BIM implementation. Similarly, Ibrahim et al. (2019) conducted a study on BIM implementation barriers that depicts organisational culture as a factor inhibiting BIM

implementation. Despite these references limited attention is given to in depth analysis of organisational culture in BIM setting (Xu, J. et al. 2018).

A few papers have referred to organisational BIM culture, explaining it as a facet of organisational culture (Alankarage et al. 2023). However, it should be noted that these studies have mainly explained BIM culture based on the visible artifacts of culture within a BIM-enabled organisation. For instance, Ahuja et al. (2018) state that the organisational BIM culture consists of teams who accept BIM and turn their skill and capabilities into the desired outcomes. Che et al. (2019) proffer that in a BIM environment, organisational culture emphasises the collective involvement and contribution of the organisational employees. However, even in these cases, the relationship between organisational BIM culture and BIM technology, processes and people remain at the level of artifact-level cultural manifestations. Xu et al. (2018) propose a different perspective on BIM culture by considering it as a reflection of BIM climate. They draw upon existing literature on safety climate and safety culture to conceptualise BIM climate and BIM culture. BIM climate (according to their definition (*ibid*)) refers to individual perceptions and attitudes regarding the benefits, challenges, risks and influencing factors associated with BIM use. However, it is important to note that the authors did not empirically investigate the organisational BIM culture and depict that *"there is no well-established BIM-related knowledge in terms of organisational culture (p.6)."* Thus, efforts to define and explore BIM culture beyond superficial artifacts have been limited.

Even the existing studies that have attempted to examine BIM culture beyond superficial levels have been primarily concentrated on investigating it within construction projects, rather than exploring culture within organisations. For instance, Brewer and Gajendran (2012) compare the beliefs of construction project participants with the espoused values of the construction industry to identify the issues that lead to sub-optimal levels of BIM use. Similarly, Hossain et al. (2013) use the Competing Values Framework (CVF) to study the culture of construction projects to reveal the basic assumptions on which project functions and the values in the BIM environment. These studies have emphasised cognitive levels of an organisational culture are essential in explaining BIM culture as they represent the core cultural manifestations. Consequently, there exists a research gap in comprehensively defining and investigating organisational BIM culture, considering the diverse manifestations of culture within the BIM context.

To understand BIM through an organisational cultural lens, it is essential to consider all the cultural manifestations including unconscious beliefs that may not be readily apparent due

to their taken-for-granted nature (Schein, 2010). This can be achieved by bringing organisational culture knowledge to BIM context (Alankarage et al. 2023; Knobel et al. 2021). However, organisational culture research is complex and sophisticated in nature and cultural research within the context of the construction industry is not an exempt from this challenge. In fact, the complexity of organisational culture is further exacerbated due to its unique features, including temporary project organisations, involvement of multiple stakeholders and a fragmented supply chain (Gajendran et al., 2012). Therefore, studying BIM culture in construction organisations needs a different and well-thought approach. The preferred research methods adopted in organisational culture research are debatable but are polarised between the qualitative-quantitative dichotomy. However, the abundance of quantitative culture studies in practice suggests that this paradigm is favoured in organisational culture research (Schein, 2010). Most culture questionnaires in quantitative studies are thought to have only assessed organisational climate rather than actual organisational culture (Hofstede et al., 2010). Thus, despite their widespread use, many critics argue that quantitative approaches merely study the superficial level of the cultural aspect, providing insufficient depth to understand the cognitive levels that define organisational culture (Schein, 2010). Hence, it would be worthwhile to initiate research that concentrates on creating effective qualitative methodologies for comprehending the organisational BIM culture.

Therefore, the research question is:

how to manage organisational BIM culture in BIM-enabled construction organisations towards a strong innovative BIM culture by uncovering its cultural manifestations?

1.3 Research Aim and objectives

The study aims to develop a framework for managing BIM-enabled construction organisations towards a strong innovative BIM culture through investigating and analysing the cultural manifestations.

1. review the concepts of ‘BIM’, ‘organisational culture’ and ‘innovative culture’ to define the concept of ‘organisational innovative BIM culture’ and premised upon the aforementioned to develop a conceptual framework to manage innovative BIM culture;
2. develop a methodology to derive cultural manifestations encompassing behaviours and patterns of underlying beliefs in BIM-enabled construction organisations;

3. analyse cultural manifestations encompassing behaviours and patterns of underlying beliefs to derive underlying beliefs of BIM-enabled construction organisations and develop a tool to diagnose an innovative BIM culture;
4. derive strategies to promote underlying beliefs of a strong innovative BIM culture in BIM-enabled construction organisations; and
5. develop and empirically validate a framework to manage construction organisations towards a strong innovative BIM culture.

1.4 Research methods summary

A case study was selected as the research strategy for the current study. Four large-sized contractor construction organisations in Australia were selected as cases focusing on investigating the concept of 'organisational BIM culture' as the unit of analysis. Semi-structured interviews, direct observations, and documentation were employed as data collection techniques to facilitate data triangulation. A pilot case study was conducted to pre-test and refine the semi-structured interview guideline and verify the ability to collect and analyse data to derive cultural manifestations. Within each case, the interviews were conducted with six key participants. Herein three personnel were selected from the managerial level and three from the operational level, each with a minimum of five years of industry experience and one year of experience with BIM. The semi-structured interview process utilised an indirect questioning method aimed at uncovering underlying beliefs concerning the organisational BIM culture. As secondary data collection techniques, this study followed direct observation and documentation. The observations were carried out in the interviewees' offices while documentation was carried out referring to meeting minutes, written protocols, BIM implementation/execution plans, the home page for the company website, electronic media produced by the company and organisational structure. Data analysis encompassed both within-case and cross-case analysis, utilising code-based content analysis techniques supported by NVivo20. Based on the cross-case analysis the framework to manage construction organisations towards a strong innovative BIM culture was developed and later validated for its practicality (logic, fit, depth and applicability) to the industry by conducting interviews with four BIM experts.

1.5 Scope and limitations

This study focused only on organisational BIM culture in contractor organisations. Furthermore, the study was limited to Australian context; thus, case studies were conducted with large-sized construction organisations with past and current BIM experience. This study

relied solely on interviews with key personnel, artifact observation and documentation. The interviewees were selected from senior management level and operational level.

1.6 Research significance

This study makes a substantial contribution for both researchers and practitioners. Specifically, the study identified and addressed the often-overlooked synergy between BIM and organisational culture in the construction industry. This recognised that BIM's implementation is deeply intertwined with an organisation's cultural fabric and aimed to shed light on this critical but neglected aspect. The current study combined Schein's organisational culture theory and innovative culture theory to develop a conceptual framework for understanding organisational BIM culture and innovative BIM culture. This synthesis bridged the gap between discussions of BIM and organisational culture, contributing to the literature in this area. Instead of relying on quantitative research methods commonly used in previous studies, this research employed a qualitative approach, focusing on uncovering underlying beliefs hidden within organisational BIM culture. The study used a case study strategy and multiple sources of evidence, offering a method to extract and analyse these beliefs. The study provided a detailed methodology for uncovering underlying beliefs, patterns of these beliefs, and corresponding behaviours within an organisational BIM culture. This methodology involves a three-level coding system and the use of NVivo software, which can be applied effectively in similar cultural settings.

The study introduced a framework for managing construction organisations towards a strong innovative BIM culture. It also presented a diagnostic tool for analysing the existing BIM culture, helping construction organisations assess their position on the spectrum from weak to strong innovative BIM culture. This research also offered practical strategies for nurturing a strong innovative BIM culture within construction organisations. These strategies encompass participative decision-making, collaboration and teamwork, a cooperative work environment, and fostering a proactive and forward-thinking atmosphere. Emergent findings had practical implications for BIM managers, upper management, and change agents within construction organisations. It empowers them to understand and manage their organisation's BIM culture effectively, identify areas of improvement, and implement strategies tailored to their unique cultural context.

The current study has published five research papers across four journals and one conference. The comprehensive bibliographic information for these papers can be found on page xviii.

1.7 Summary of key findings

The study defined organisational BIM culture as patterns of underlying beliefs guided by behaviours and artifacts that emerge as a response to external adaptation and internal integration problems posed by BIM implementation. These patterns were influenced by the cultural dimensions of human relationships, human nature, human activity, reality and truth, relationship to the environment, and time. The study also extended this definition to innovative BIM culture, which prioritised underlying beliefs corresponding to these dimensions such as groupism, participative authority, goodness in human and mutability, pro-activity, pragmatism in decision making, organisational dominance, and near-future orientation. To understand organisational BIM culture, a qualitative methodology was adopted, involving case studies supported with semi-structured interviews, direct observations, and documentation analysis. The interview questions focused on challenges related to external adaptation and internal integration in a BIM environment. The methodology aimed to reveal underlying beliefs and patterns of underlying beliefs, using a three-level coding system for data analysis. The study included within-case analyses to identify patterns of underlying beliefs and behaviours of four large-sized construction organisations (Cases A, B, C, and D). These patterns were then analysed in relation to the six cultural dimensions. The results revealed similarities and differences in underlying beliefs among the cases, highlighting variations in cultural dimensions in a spectrum of weak to strong. It was found that a strong innovative BIM culture is characterised by several key underlying beliefs such as participative authority system, preference for groupism, cooperation and mutual interdependence, belief in human goodness, focus on quality and efficiency, proactive orientation, pragmatic truth-seeking, disposition to dominate the environment and future-oriented mindset. Based on the behaviours observed in the cross-case analysis, strategies were formulated to promote a strong innovative BIM culture. These strategies were categorised according to each cultural dimension. A framework for managing construction organisations toward a strong innovative BIM culture was developed. This framework consists of four primary components: identifying the existing organisational BIM culture, utilising an innovative BIM culture diagnostic tool, implementing strategies to nurture a strong innovative BIM culture, and achieving a strong innovative BIM culture.

1.8 Outline of the thesis

This thesis is composed of twelve chapters, Figure 1.1 provides a visual representation that illustrates the relationship between these chapters and the research objectives.

Chapter 01- Introduction - In this chapter, the background of the research, the research problem, the overall aim and objectives, the chosen research methodology, the scope and limitations of the study, as well as the breakdown of chapters are comprehensively detailed.

Chapter 02- Literature review- This chapter provides an overview of BIM and organisational culture, setting the context for the study. It begins by discussing the importance of BIM in the construction industry, tracing its evolution, defining BIM, outlining its benefits and applications, and exploring its impact on construction organisations. The chapter then shifts its focus to organisational culture, examining its core elements, different levels of cultural manifestations and methods to uncover culture, with a particular emphasis on Schein's organisational culture theory as a framework.

Chapter 03- Research framework- The chapter offers a comprehensive explanation of the research framework designed to comprehend organisational BIM culture, with an extension to innovative BIM culture. This framework serves as the cornerstone for exploring and grasping the cultural dimensions linked to the integration of BIM within construction organisations.

Chapter 04- Research methodology- This chapter outlines the research methodology employed to fulfil the study's objectives along with the rationale behind the chosen methods. This chapter focuses on the formulation of a research methodology aimed at uncovering the underlying beliefs of a BIM-enabled construction organisation. The chosen research strategy is a case study. A detailed explanation of how various data collection techniques are integrated to ensure effective data triangulation for this cultural study is also provided.

Chapter 05- Pilot case study- In this chapter, the outcomes of the pilot case study are presented which sought to: explore the viability of the interview questions and guide; rehearse in-direct questions; and verify the analysis approach to be used in deriving cultural manifestations in terms of underlying beliefs, patterns of underlying beliefs and behaviours in organisational BIM culture from the collected data.

Chapter 06- Within-case analysis of organisation A- In this chapter, the analysis of empirical data from organisation A was carried out through constant comparison, coding, and theme building methods. This chapter presents the discovered patterns of underlying beliefs and the underlying beliefs that drive organisation A.

Chapter 07- Within-case analysis of organisation B- In this chapter, the analysis of empirical data from organisation B was carried out through constant comparison, coding,

and theme building methods. This chapter presents the discovered patterns of underlying beliefs and the underlying beliefs that drive organisation B.

Chapter 08- Within-case analysis of organisation C- In this chapter, the analysis of empirical data from organisation C was carried out through constant comparison, coding, and theme building methods. This chapter presents the discovered patterns of underlying beliefs and the underlying beliefs that drive organisation C.

Chapter 09- Within-case analysis of organisation D- In this chapter, the analysis of empirical data from organisation D was carried out through constant comparison, coding, and theme building methods. This chapter presents the discovered patterns of underlying beliefs and the underlying beliefs that drive organisation D.

Chapter 10- Cross-case analysis- This chapter analyses the underlying beliefs, patterns of these beliefs and corresponding behavioural patterns across all cases. Emergent findings also identify the conditions that lead to the development of weak, moderate and strong innovative BIM cultures. A diagnostic tool is introduced and is designed based on the underlying beliefs and patterns of these beliefs identified in the research. Next, strategies are deduced for cultivating a strong innovative BIM culture by considering the behavioural patterns pinpointed through the cross-case analysis.

Chapter 11: Framework validation and discussion- In this chapter, the framework developed in Chapter 10 is validated using qualitative interviews with four BIM experts. Further, the chapter discusses the findings from cross case analysis by comparing them with existing literature.

Chapter 12- Conclusion- In this chapter, the research's conclusions are discussed, with a focus on their contributions to knowledge and practical implications. Furthermore, the chapter explores the limitations of the study and propose potential areas for future research.

1.9 Summary

In this chapter, the background of the research is outlined. It offers a rationale for the thesis and presents the research's aim to investigate and analyse the BIM cultural manifestations in BIM-enabled construction organisations to manage such organisations towards ensuring a strong innovative BIM culture. Five objectives were established to achieve the research aim. Furthermore, the study’s research method was briefly introduced within this chapter. The chapter also presented the study’s scope, limitations and research significance. To conclude, the chapter provided an overview of the thesis's structure.

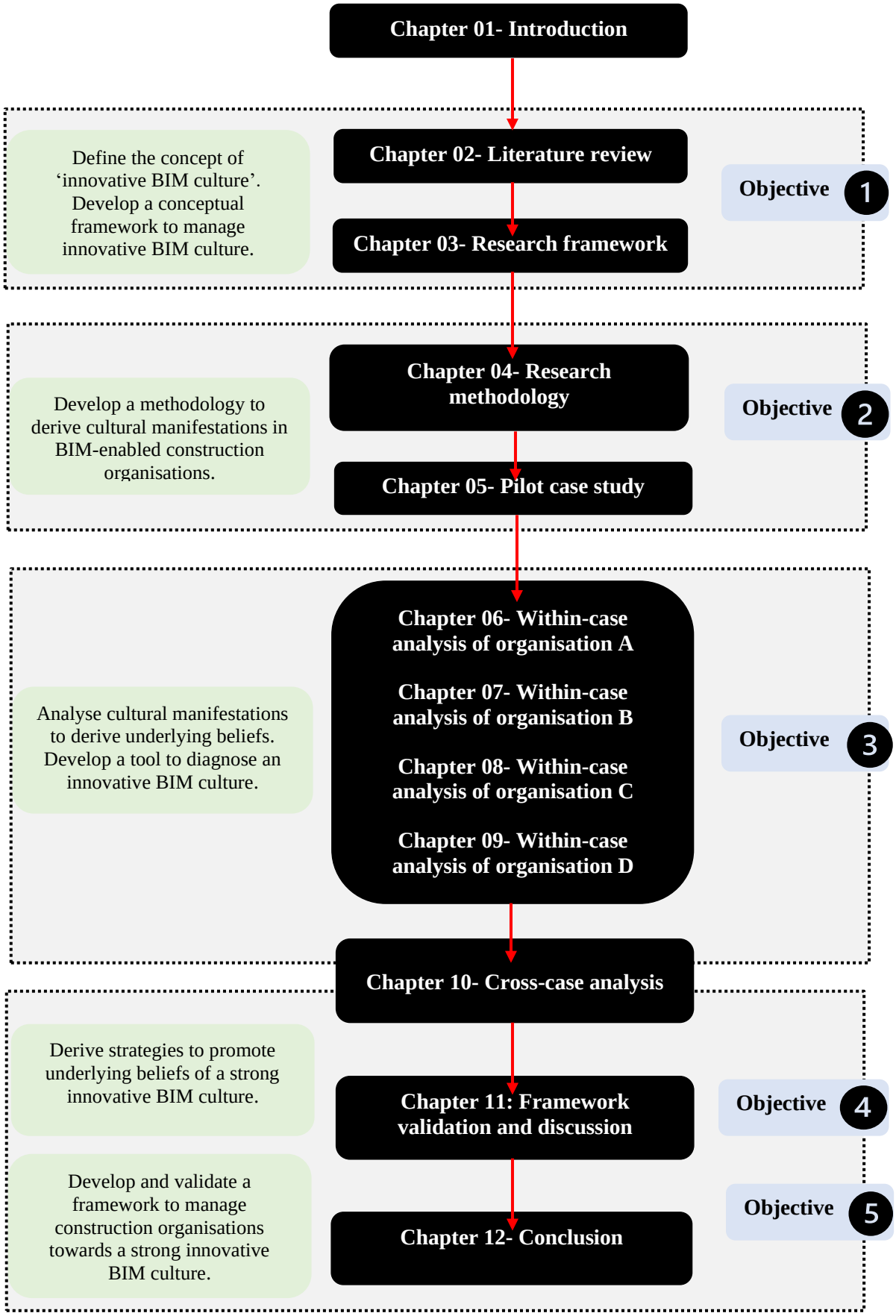

Figure 1.1. Outline of the thesis

CHAPTER 02- LITERATURE REVIEW

2.1 Introduction

The Chapter 01 introduced the study. This chapter examines current literature on the concepts of BIM and organisational culture to establish the study's context. Initial sections discuss the need to use BIM in the construction industry, evolution of BIM, definition of BIM, the benefits, and applications of BIM and how BIM impact construction organisations. Later sections focus on discussing the concept of organisational culture, delving into its core elements, the various levels cultural manifestations, and how to uncover the culture by realising cultural manifestations. This part of the review specifically focuses on Schein's organisational culture theory as the framework for understanding organisational culture. The literature findings on BIM and organisational culture presented in this chapter will guide the foundation and background to develop the research framework for organisational BIM culture in Chapter 03.

2.2 Building Information Modelling

2.2.1 Current status of construction industry: need for BIM

The construction industry is a crucial part of the world economy that generates a significant portion of the global GDP, accounting for around 6% and bringing in approximately $10 trillion in revenue annually through engineering and construction activities (Stojanovska-Georgievska et al. 2022). Predictions indicate that the industry will experience substantial growth, with an estimated 85% increase by 2030, reflecting an average annual growth rate of 4% between 2018 and 2023 (Klein et al. 2022). However, the construction industry, like many other sectors, is facing challenges as it adapts to an increasingly digitalised environment (Jaaron, Hijazi & Musleh 2022). The sector has long been plagued with challenges such as inefficiencies, cost overruns, time delays, lack of collaboration and as a consequence, poor building quality (Shojaei, Oti-Sarpong & Burgess 2022). A significant issue is the lack of accurate and timely project information, which stems from outdated project management systems, inadequate data sharing and poor communication among project stakeholders (Xu, Jinying, Lu & Papadonikolaki 2022). This challenge has resulted in cost overruns, delays and even project failure and organisation liquidation (Ullah, Lill & Witt 2019). The industry is known for its complex project structures, which require several parties with conflicting interests to work together to achieve project goals (Ahn, Kwak & Suk 2016). This has resulted in a lack of collaboration among parties, often leading to more delays, errors and communication breakdowns. Ensuring that construction projects meet quality standards has also become a major concern as quality control is often overlooked in

the sector due to various reasons such as inadequate supervision, use of substandard materials and poor workmanship (Xu, Jinying, Lu & Papadonikolaki 2022). These issues further exacerbate issues such as poor building quality, which can result in safety hazards, increased maintenance costs and damage to the construction industry's reputation (Shojaei, Oti-Sarpong & Burgess 2022) and have impeded the industry's growth and omnipresent poor productivity levels (Abioye et al. 2021). The sector's decline in performance and productivity has been a persistent challenge for more than five decades (Ahn et al., 2016). This issue has grown to become a significant concern that demands effective solutions and requires the identification of underlying causes.

Inadequate digital skills and technology implementation within the sector have been associated with cost inefficiencies, subpar quality performance, ill-informed decision-making, project delays and underperformance in productivity, health, and safety (Bello et al. 2021). Recently, it has become increasingly evident that the sector must adopt digitisation and enhance its technological capabilities expediently, particularly given existing labour shortages, the impact of the COVID-19 pandemic and the need to establish sustainable infrastructures (Gbadamosi et al. 2019). To move the sector away from its conventional and fragmented organisational methods, BIM has made noteworthy contributions towards enhancing business operations, optimising service processes and increasing industry productivity (Jaaron, Hijazi & Musleh 2022; Murguia et al. 2023). Therefore, it is imperative to gain a thorough understanding of the introduction and evolution of BIM within the sector, as well as the benefits it offers to all stakeholders (e.g., clients, contractors and designers). As a digital technology, BIM has revolutionised how construction projects are designed, constructed and managed and has its roots in the 1970s (Latiffi, Aryani Ahmad, Brahim & Fathi 2014). However, it was not until the 1990s that it began to gain sector momentum and adoption - since then, it has undergone significant evolution, with its adoption becoming increasingly widespread.

2.2.2 Evolution of BIM: from drawing to modelling

BIM has undergone several evolutionary stages (refer to Figure 2.1) since the introduction of its precursor, Building Description Systems (BDS) in 1975 (Eastman, Charles M 1999). Early applications were constrained by the fact that they ran on costly mainframe computer systems, making them accessible only to large engineering companies with the financial means to afford such systems (Latiffi, Aryani Ahmad, Brahim & Fathi 2014). To address these limitations, the Graphical Language for Interactive Design (GLIDE) was introduced in 1977 as an enhanced form of BDS (Eastman, C & Henrion 1977). Even though they were

not commercially available, these systems ushered in more sophisticated solid modelling geometry for building design and integrated database techniques to support more complex models, thereby extending the link between geometric representations (Sinoh et al. 2020). These systems were built on the idea of utilising computers to prototype building elements rather than simply creating 2D design drawings (Latiffi, Aryani Ahmad, Brahim & Fathi 2014). Despite the progress made by these two systems, their applications were limited to the design stage, highlighting the need for more sophisticated programs that could foster collaboration among the various parties involved during the project's construction phase.

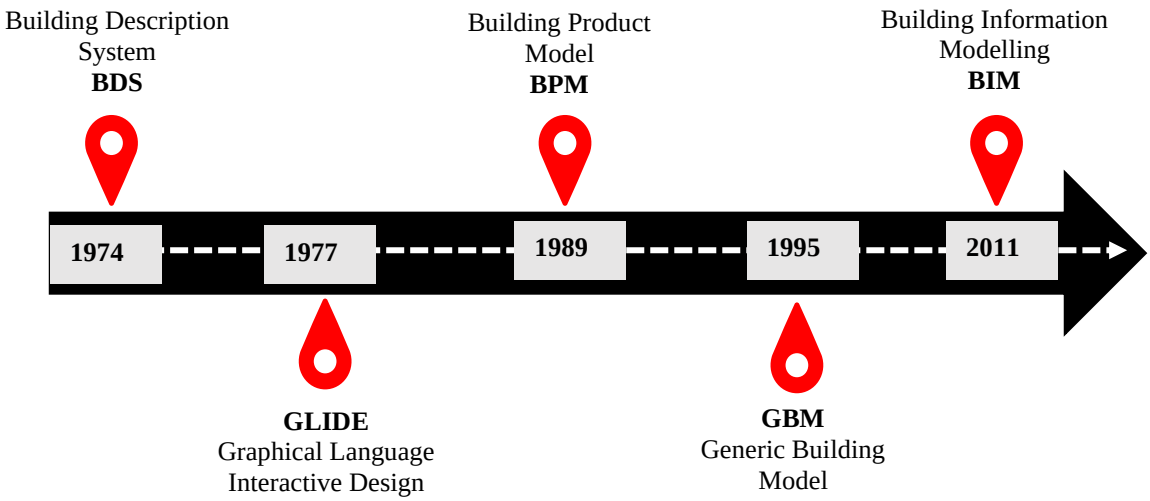

Figure 2.1. Evolution of BIM

To address these shortcomings, the Building Product Model (BPM) was developed in 1989, which encompassed design application, construction process and the participation of construction stakeholders. Unlike earlier systems, BPM functioned as a database, storing project information throughout the project's entire lifecycle, resulting in improved communication that could be easily interpreted by Computer-Aided Design (CAD) during construction (Sinoh et al. 2020). Nevertheless, BPM was limited in scope, focusing solely on product information, which spurred the need for additional advancements in the sector. Consequently, the Generic Building Model (GBM) was introduced in 1995 to address the wider requirements of the construction sector (Eastman, Charles M & Siabiris 1995). GBM had the capability to manage information related to projects incorporating construction activities.

Akin to other technology developments, BIM has been evolved to address the sector's needs overtime - therefore BIM is not a completely novel concept but rather an enhanced and more sophisticated iteration of previous technologies. As BIM's capabilities continue to advance, it introduces various dimension levels resulting in multidimensional BIM. Multidimensional

BIM, also known as nD BIM, expands on the traditional three-dimensional model by incorporating additional dimensions as required by a specific project (Xu, Jinying, Lu & Papadonikolaki 2022).

Figure 2.2 illustrates that these dimensions offer a comprehensive understanding of a construction project, encompassing aspects such as its physical representation (3D) (Koutamanis 2020), scheduling and sequencing (4D) (Wildenauer 2020), cost estimation (5D) (Charef et al., 2018), sustainability analysis (6D) (Megahed 2015), and facility management (7D) (Panteli, Kylili & Fokaides 2020). 3D BIM refers to the use of three-dimensional modelling software to create digital representations of buildings and their components. 3D model contains data about the building's geometry, spatial relationships, materials and other attributes in addition to a visual representation of the building (Koutamanis 2020). The 4D BIM dimension incorporates time, allowing for the scheduling and sequencing of construction activities, enhancing project planning and coordination, and identifying potential conflicts or delays (Wildenauer 2020). The 5D BIM dimension adds cost, enabling the tracking and management of project costs, improving budgeting and financial control, and identifying potential cost overruns or savings opportunities (Charef et al., 2018). The 6D BIM dimension adds sustainability, facilitating analysis and optimisation of the building's environmental performance, improving energy efficiency, reducing carbon footprint, and enhancing overall sustainability (Megahed 2015). Lastly, the 7D BIM dimension includes asset management, allowing for the tracking and maintenance of building assets throughout their entire lifecycle (Koutamanis 2020). This improves the efficiency of building operations and maintenance and enables identification of asset replacement or renewal needs.

While dimensions up to 7D have been present for some time, the most recent addition is the 8D dimension, which focuses on maintaining health and safety by identifying risks and preventing critical hazardous events during construction (Panteli, Kylili & Fokaides 2020). It is anticipated that in the future, new dimensions will continue to emerge under the concept of the Nth generic dimension.

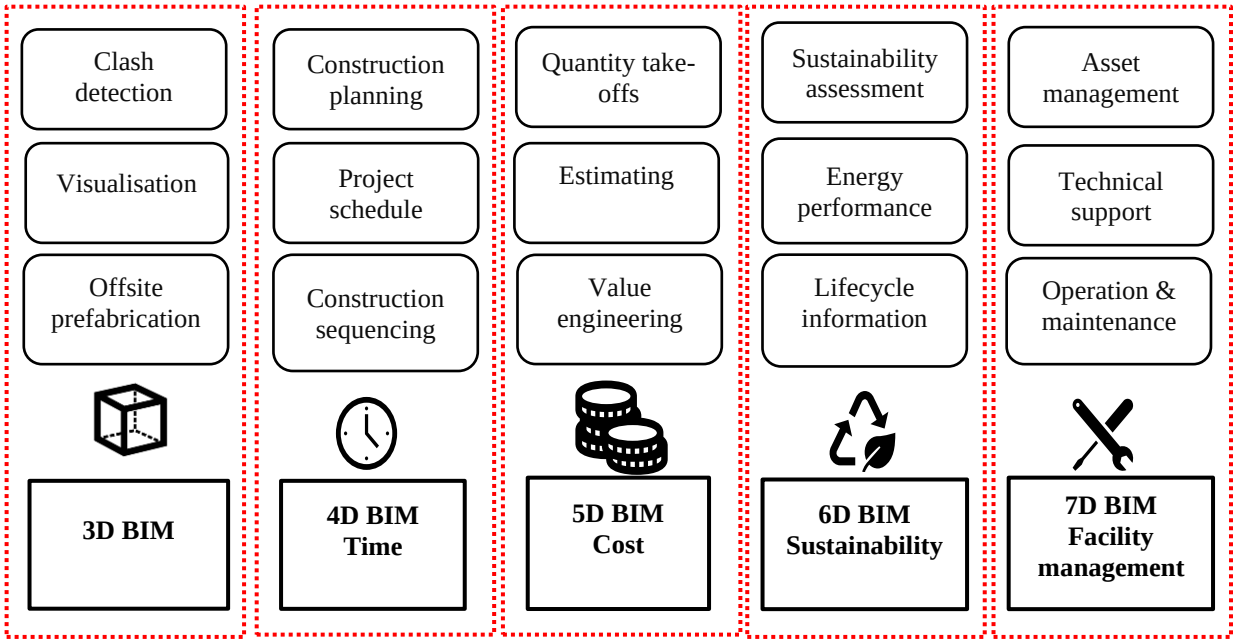

Figure 2.2. BIM dimensions

Adapted from Charef, Alaka and Emmitt (2018); Koutamanis (2020); Megahed (2015); Wildenauer (2020)

2.2.3 BIM in construction organisations: benefits and applications

BIM has proven to be highly advantageous for construction organisations, bringing a wide range of benefits; for example, improvements in quality, defect reduction, streamlined documentation processes, enhanced decision-making, reduced claims and litigation, improved communication and collaboration and ultimately leading to increased productivity and efficiency (Hong et al. 2020; Lee, S., Yu & Jeong 2015). Further, Ahn et al. (2016) have outlined various areas where BIM can be applied, including site analysis, building permit processes, communication, energy simulation, design optimisation analysis, constructability studies, scheduling, resource analysis, materials procurement, prefabrication, asset management and facilities management. By understanding and identifying the various application areas of BIM, construction organisations can effectively implement BIM and leverage its maximum benefits at each stage of the project. Ghaffarianhoseini et al. (2017) highlight the importance of aligning BIM usage with specific project stages to optimise its benefits. Table 2.1 provides an illustration of the alignment between BIM application areas and the corresponding benefits across the various stages of a construction project's life cycle. The pre-construction stage involves planning and design, while the post-construction stage encompasses activities related to operation and demolition.

Table 2.1. BIM application areas and the corresponding benefits across the various stages of a construction project's life cycle

Stages of Project lifecycle		BIM application areas	Benefits of BIM	Author(s), year
Pre-construction stage	Planning	Visualisation, Site analysis, cost estimating, phase planning (scheduling) and existing condition modelling	Improves concept and feasibility, effective site analysis for understanding environmental and resource issues, improves the efficiency and accuracy with which existing conditions are documented, and better stakeholder communication	(Lee, S., Yu & Jeong 2015; Megahed 2015; Murguia et al. 2023; Stojanovska-Georgievska et al. 2022; Ullah, Lill & Witt 2019)
	Design	Visualisation, site analysis, cost estimating, phase planning (scheduling), design review, energy simulation, marketing, constructability study and communication	Effective design reviews that lead to sustainable design, improves energy efficiency, early resolution of design clashes by model visualising, allows for quicker and more accurate cost estimation	(Ahn, Kwak & Suk 2016; Megahed 2015; Stojanovska-Georgievska et al. 2022; Ullah, Lill & Witt 2019)
Construction stage	Construction	Visualisation, site analysis, cost estimating, Phase planning (scheduling), site logistics, spatial coordination, resource analysis, materials procurement, prefabrication, communication, building permit process, quality control and safety planning	Evaluates the construction of complex building systems to improve resource planning and sequencing alternatives, effective project resource storage and procurement management, offsite fabrication of various building components using a design model as the foundation, improve health and safety and reduces site congestion	(Ahn, Kwak & Suk 2016; Megahed 2015; Murguia et al. 2023; Sompolgrunk, Banihashemi & Mohandes 2023; Stojanovska-Georgievska et al. 2022; Ullah, Lill & Witt 2019)
Post-construction stage	Operation and Demolition	Maintenance scheduling, asset management, facility management, space management, building system analysis, recycling, demolition planning and scheduling and demolition waste management	Aids in decision-making regarding a facility's operations, repair, maintenance and replacement, makes asset management more efficient, accurate and information rich, reduced lifecycle costs, improved operational efficiency, assists in scheduling maintenance and offers simple information access during maintenance	(Megahed 2015; Stojanovska-Georgievska et al. 2022; Ullah, Lill & Witt 2019)

2.2.4 Building Information Modelling (BIM): the definition debate and dilemma

BIM may appear to require no introduction yet; it currently remains an ambiguous term. BIM's almost continual evolution has led to the development of numerous definitions, which has contributed to ambiguity and confusion regarding its precise value and implications. Aranda-Mena et al. (2009) highlight this ambiguity in their research, suggesting that BIM is subject to various interpretations by different professionals. This ambiguity has resulted in misunderstanding and perplexity within the industry (Siebelink, Voordijk & Adriaanse 2018). It can make it challenging for professionals to align their understanding and expectations of BIM, leading to potential discrepancies in its implementation and utilisation. To address this issue Table 2.2 summarises several definitions of BIM given in pertinent literature.

Table 2.2. BIM definitions by product vendors, professional institutes, and academia (2008-2021)

	Definition	Authors, year
Professional institutes	A systematic application of **information controls, standards, processes, and systems** from asset inception to project design and construction, commissioning and ongoing use using a virtual asset (3D).	(NBS 2019)
	Building Information Modelling (BIM) is a **digital representation** of physical and functional characteristics of a facility. As such it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its lifecycle from inception onward.	(NIBS, 2012)
BIM software product vendors	**A holistic process** to create and manage information for a built asset integrating structured, multi-disciplinary data to build a digital representation of an asset across its lifecycle, from planning and design to construction and operations, using an intelligent model and a cloud platform.	(Autodesk 2022)
BIM academics	Building Information Modelling (BIM) is **a collection of interconnected policies, processes, and technologies** that produce a methodology for managing critical building project and design data in digital format throughout the building's life cycle.	(Succar 2009)
	Building Information Modelling (BIM) is a modelling **technology and set of processes** for creating, communicating and analysing building models.	(Eastman, C. M. et al. 2011)
	Building Information Modelling (BIM) represents the **process** of development and use of a computer-generated model to simulate the planning, design, construction and operation of a facility.	(Azhar, Hein & Sketo 2008)
	Building Information Modelling (BIM) is **an IT-enabled approach** in the form of a data repository that entails creating and maintaining an integrated digital representation of all building information for various phases within the life cycle of a project.	(Gu & London 2010)
	Building Information Modelling (BIM) is **an object-based and multidisciplinary approach** aimed to facilitate	(Siebelink, Voordijk &

	Definition	Authors, year
	collaboration between parties and the integration of object-related information across the life cycle.	Adriaanse 2018)
	Building Information Modelling (BIM) is **an intelligent 3D virtual building model** that can be built digitally and contains all relevant building information.	(Woo, Wilsmann & Kang 2010)

According to Miettinen and Paavola (2014), because there is no single satisfactory definition, BIM must be viewed as a multidimensional, historically evolving and complex phenomenon. Every emerging definition of BIM reflects its transformative potential and effects on the construction sector (Kassem et al. 2014). These BIM definitions have evolved based on whether BIM is viewed as a tool, a process or both as demonstrated in Figure 2.3.

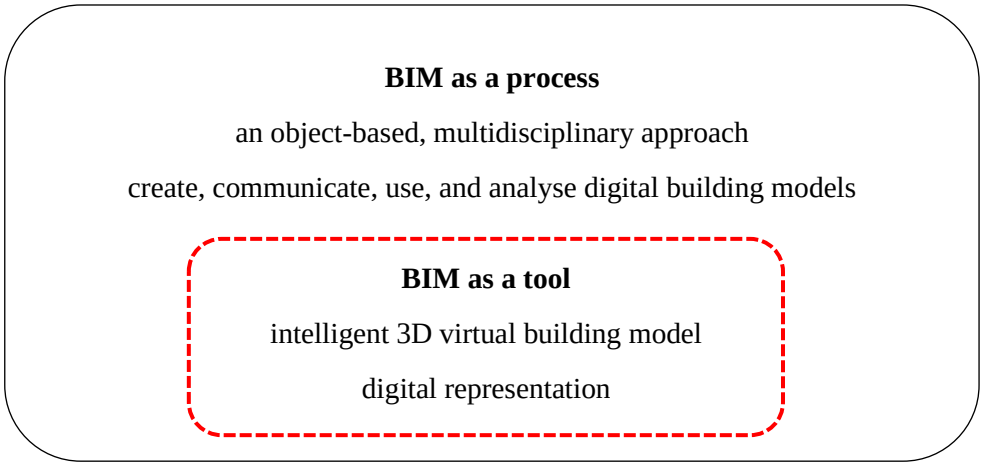

Figure 2.3. BIM as a tool and a process

For example, Woo, Wilsmann and Kang (2010) define BIM as an intelligent 3D virtual building model that can be built digitally and contains all relevant building information. Alternatively, Azhar, Hein and Sketo (2008) explain BIM as a process of development and use of a computer-generated model to simulate the planning, design, construction and operation of a facility. Eastman, C. M. et al. (2011) describe BIM as a modelling technology and set of processes for creating, communicating and analysing building models. Alternatively, Hardin and McCool (2015) explain BIM using the analogy of a three-legged stool, where tools, processes and behaviours represent the three legs. The pragmatic definition of by Succar (2009) which describes BIM as: *"a set of technologies, processes, and policies enabling multiple stakeholders to collaboratively design, construct, and operate a facility in virtual space,"* acknowledges the growing connotation of BIM. This definition goes beyond others giving a comprehensive description of BIM, considering it as a whole organisational transformation.

These technological and process-oriented dimensions of BIM have resulted in characterising it as an innovation (Brewer & Gajendran 2012; Hosseini et al. 2016; Kassem et al. 2014; Klein et al. 2022). Even more, BIM is recognised as a disruptive innovation defined by Loosemore (2014) as an innovation that departs significantly from industry norms, rendering existing business models obsolete, transforming the basis of competition in the industry, and generating sustainable competitive advantages by reshaping the entire industry. This sentiment is echoed by Gledson (2016), who identifies BIM as the most prominent radical, transformative and disruptive innovation to have impacted the construction industry. Poirier, Staub-French and Forgues (2015) also endorse the idea that BIM represents a disruptive innovation, contributing to the reconfiguration of practices within the sector. Accordingly, this research adopts the perspective of defining BIM as an innovation that encompasses both tool and processes. This aligns with the idea that BIM is not merely a singular tool or a set of processes but a combination of both, emphasising the interconnected nature of technologies and methodologies involved in BIM. Further, adding from Succar's (2009) definition, this study acknowledges that BIM has various dimensions, evolves over time, and is a complex entity shaped by technological advancements and changing industry needs. Therefore, in the context of this present research, the definition of BIM was interpreted as an innovation that leverages existing technological tools and processes to generate and manage design and project information; where such subsequently enables multiple stakeholders to collaboratively engage in the design, construction and operation of a facility.

2.2.5 BIM impacts: emergence of a new culture

The use of BIM is expected to address traditional and frequent issues in the construction industry such as delays, reworks, system coordination, rising costs and wastage, which are important concerns for stakeholders (Afifuddin Husairi, Muhammad Najib & Sabariah 2018). However, to unleash BIM’s benefits, organisations must be willing to embrace the transformational changes that BIM entails across many aspects. Reluctance or resistance towards BIM arises due to the need for employees to adapt to a new delivery process that takes them out of their comfort zones (Jaaron, Hijazi & Musleh 2022). Embracing BIM requires individuals to learn new software tools and develop proficiency in working with 3D models and data. The National BIM Report (2020) conducted a survey to investigate perceptions of people on their use of BIM and revealed that 90% of BIM users agree that BIM implementation necessitates substantial changes to their current industry practices. This means that BIM's transformative power extends beyond individual skill sets; it also affects the organisation's processes and workflows (Alankarage et al. 2023). As BIM becomes the

foundation of project delivery, a culture of innovation and adaptability emerges, emphasising continuous learning and the pursuit of excellence (Jaaron, Hijazi & Musleh 2022).

2.2.5.1 Changes in technology and process

In the context of implementing BIM, it is common to observe technological changes involving the integration and replacement of software and hardware systems (Khosrowshahi and Arayici, 2012). A variety of software programs are available for creating BIM models, catering to different domains such as architectural, structural, construction, and mechanical, electrical and plumbing (MEP) design. Leading industry vendors, including Autodesk (Revit Architecture, Revit MEP, Revit Structure), Bentley Systems (Bentley RAM, STAAD.Pro), ArchiCAD, Vectorworks and Tekla Structures, offer a range of BIM-related technologies. These vendors have developed numerous BIM solutions that address various industry requirements, including design, clash detection, engineering, planning and scheduling, cost estimation and energy analysis. Table 2.3 displays the prominent software used in architecture, structure, construction and MEP design within the industry.

Table 2.3. BIM software tools
(Adapted from (Enegbuma et al. 2014; Kalfa 2018)

	Software	
Architecture	• ArchiCAD • Revit Architecture • Bentley Architecture • Allplan Architecture • Vectorworks Architect	• Digital Project Designer • IDEA Architectural Design (IntelliCAD) • CADSoft Envisioneer • RhinoBIM (BETA)
Structure	• Revit Structure • Bentley RAM, STAAD, and ProSteel • Graytec Advance Design • Tekla Structures • Strad and Steel	• Bentley Structural Modeler • CypeCAD • Scia • Structure Soft Metal Wood Framer • Robot Structural Analysis
Construction	• Bentley ConstructSim • Navisworks • Vico Office Suite • Innovaya	• Solibri Model Checker • Vela Field BIM • Tekla BIMSight • Synchro Professional
MEP	• Bentley Hevacomp Mechanical Designer • AutoSprink • CADMEP (CADduct / CADmech)	• Revit MEP • PipeDesigner 3D • Digital Project MEP Systems Routing

2.2.5.2 Changes in skills and competencies

The implementation of BIM brings about significant changes that extend beyond the technological aspects, leading to disruptions at the intra-organisational level (Ahmed & Kassem 2018). As a disruptive innovation, BIM requires people-related changes within

organisations. At the employee level, the use of BIM can challenge deeply ingrained behaviours and workflows, potentially causing dysfunction and anxiety among individuals who feel their place within the group is threatened (Knobel et al. 2021). Isomorphic pressures including government mandates, and the need to maintain the legitimacy in the industry have forced organisations to use BIM merely based on social cues without having a proper knowledge of BIM and its impacts. Dissemination of BIM (over existing traditional practices) has stimulated the need for ample changes in skills and capabilities expected from employees (Voordijk & Sloot 2019). A mismatch between available and required skills and competencies affects the changes in the composition of the employees (Olatunji 2011). The absence of the complementary change in the skills of BIM users reverts old methods due to the lack of ways to convince them that BIM is advantageous to professionalise and speed up their actions (Rogers *et al*., 2015).

2.2.5.3 Changes in roles and responsibilities

BIM use in construction organisations has engendered immediate changes in the roles and responsibilities of all personnel involved in the BIM implementation process - adding a burden to their already complex roles and responsibilities (Shurooq & Saad 2020). Further, individuals need to learn new software to re-invent the workflow, change and assign responsibilities (Arayici *et al*., 2011). As BIM takes traditional approaches to construction works and places them in a computerised atmosphere, it changes the roles and the responsibilities of the project participants (Voordijk and Sloot, 2019). For instance, based on BIM, Quantity Surveyors (QS) could use BIM models to extract quantities and develop cost estimates. However, to gain the opportunity of automated quantification, the QS's role needs to adapt with sophisticated services associated with the 4D time and 5D cost modelling (Addy *et al*., 2018). Table 2.4 summarises new responsibilities that emerge alongside the use of BIM.

Table 2.4. New responsibilities assigned to different stakeholders
Adopted from Latiffi, Ahmad Aryani, Brahim and Fathi (2015)

Role	Responsibilities
Client	Defines the appropriate method to use BIM.
Contractor	Prepare schedules and plans ahead using 4D models, executes constructability analysis.
Architect	Develops construction level information and documents, develops conceptual and detail design and analysis.
MEP Engineer	Develops shop drawings.
Quantity Surveyor (QS)	Uses 3D model to extract quantities and to produce cost estimates.
Facility Manager (FM)	Input necessary information to the BIM model to assist in FM.

In addition to expanding the responsibilities of existing roles, the adoption of BIM has indeed created new job roles in the form of BIM experts. These professionals possess specialised knowledge and skills in BIM technology and processes, and they play a crucial role in driving the successful implementation of BIM within construction projects (Samuelson and Björk, 2013). BIM experts are typically highly trained and experienced individuals who have a deep understanding of BIM methodologies, software applications and best practices. They are responsible for overseeing and managing the BIM implementation process, working closely with project teams to ensure that BIM models are effectively utilised throughout the project lifecycle (Davies, Wilkinson & McMeel 2017). Key new roles that emerge include BIM manager, BIM coordinator and these roles are responsible for overseeing the implementation of BIM processes and workflows within the organisation. They ensure that the BIM models are properly developed, maintained and shared among project stakeholders (Kassem, Abd Raoff & Ouahrani 2018). Another emerging role is that of the BIM Modeler or BIM Technician. This person is responsible for creating and updating the BIM models, which involve translating design and construction information into a digital format. They work closely with architects, engineers and other project team members to ensure accurate and coordinated BIM models (Barison & Santos 2010). Table 2.5 presents new emergent BIM related job roles and their job description.

Table 2.5. New emergent BIM related job roles

Role	Job description	Authors, year
BIM manager	Managing people in BIM implementation and maintaining the BIM process.	(Barison & Santos 2010)
	Coordinating BIM training, assisting in hardware and software related issues, creating organisational level BIM processes, protocols and standards.	(Davies, Wilkinson & McMeel 2017)
	Understanding BIM related legal implications.	(Kassem, Abd Raoff & Ouahrani 2018)
BIM coordinator	Specifying the BIM objectives, developing and maintaining BIM protocols and procedures, developing proposal for adjustments in BIM model and discussing with the project team, performing quality control of the model and drawings.	(Kassem, Abd Raoff & Ouahrani 2018)
Information manager	Checking, integrating and coordinating the information, making decisions to accept or reject exchange of data in common data environment (CDE).	(Kassem, Abd Raoff & Ouahrani 2018)
BIM Facilitator	Aiding other professionals who are not yet proficient in using BIM software.	(Barison & Santos 2010)
BIM modeller/BIM Operator/ Model author	Creating, developing, and extracting 2D documentation from BIM models.	(Barison & Santos 2010)
	Taking responsibility for model information quality and delivery.	(Davies, Wilkinson & McMeel 2017)

Role	Job description	Authors, year
BIM technician	Coordinating and preparing the production of technical drawings and 3D models. Conducting clash detection and recording data.	(Kassem, Abd Raoff & Ouahrani 2018)
BIM analyst	Carrying out simulations and analysis based on the BIM model.	(Barison & Santos 2010)
BIM researcher	Coordinating, organising, and developing BIM research.	(Barison & Santos 2010)

2.2.5.4 Changes in training and learning

Acquiring continuous training and learning new software and practices have become the new norm to sustain in the organisation (Alankarage et al. 2023). Adequate training of individuals is crucial when implementing BIM to ensure their ability to actively participate in the evolving work environment brought about by this new technology (Gu & London 2010). The realisation of the benefits of adopting BIM is thought to be closely tied to effective training in BIM technology. When properly trained personnel perceive BIM as user-friendly, they are more likely to exhibit a greater willingness to embrace BIM implementation compared to untrained staff (Xu, J. et al. 2018). Effective training programs that are well-designed and comprehensive play a crucial role in enhancing the skills of employees and expanding their understanding of BIM concepts and tools (Ahn, Kwak & Suk 2016). It is important to provide initial formal training, which can be conducted either internally within the organisation or through external sources such as consultants and vendors (Eadie et al. 2014). However, this initial training should be followed by continuous training and on-the-job support facilitated by colleagues and supervisors. Such ongoing training and support are crucial for meeting the evolving needs of users even after the initial implementation phase (Ahankoob, Manley & Abbasnejad 2019). This ensures that users' needs are met effectively and enables them to leverage the full potential of BIM throughout its implementation and beyond. The learning and unlearning could cause BIM wash due to the resistance to change resulting in fragmentation and inertia, lack of buy-in from employees and misperceptions on BIM (Knobel et al. 2021). Thus, a comprehensive training and learning program are necessary for organisations to upskill their staff, expand their knowledge of BIM and create a workforce that can maximise the benefits of BIM in their projects.

In summary, all these changes and modifications to BIM processes, technologies, roles, skills and structures result in changes to behaviours and way of thinking of the employees in BIM-enabled construction organisations (Merschbrock et al. 2018). This ultimately contribute to a cultural shift in the organisations, resulting to create an organisational BIM culture (Alankarage et al. 2023; Alankarage et al. 2022). Understanding this organisational

BIM culture could help to solve problems for the organisation and would improve BIM usage and ease the adoption (Knobel et al. 2021). Organisational BIM culture also explains why things work or fail when an organisation implements BIM (Zakariyyah, John & Ijaola 2021). Moreover, when the organisational BIM culture is uncovered it is possible to discover the true beliefs of employees, which guide their concomitant decisions and actions (de Almeida & de Brito 2017). Thus, cultural perspective provides the ability to delve deeper into employee behaviours to uncover the rationale behind their adverse behaviours, promoting well-adaptation to changes. Given that the BIM culture is a facet of the organisational culture, the organisational BIM culture can be understood through the concept of organisational culture (Alankarage et al. 2023).

2.3 Organisational culture

2.3.1 Organisational culture: the definition dilemma

The concept of culture has sparked vigorous academic debate and led to the development of numerous approaches to defining and studying organisational culture. As presented by (Hofstede 1984), organisational culture is a collective programming of the mind which distinguishes members of one organisation from another. It consists of values and behaviours that set one group or category of people apart from another. This definition is built on the function that the organisational culture conveys a feeling of identity for an organisation's employees by providing unwritten and frequently unspoken guidelines and norms. The notion *"the way we do things around here"* is the simplest way used in the literature to explain the organisational culture (Deal 1985). This summarises the normative nature of organisational culture in shaping problem-solving behaviour and shaping people's thinking and interpretations of reality (p. 605). O'Reilly, Chatman and Caldwell (1991) define organisational culture as visible patterns of norms and values that define an organisation. It significantly impacts the organisation's operations and its members that become prominent, as well as how members perceive and engage with each other, approach decision-making and address problems. Similarly, Deshpandé, Farley and Webster Jr (1993) consider organisational culture as shared values, which create a consistent framework that enables individuals to comprehend and navigate the functioning of an organisation.

Schein (2010) argues that these definitions fall short of revealing the essence of culture. Schein (*ibid*) contends that the term organisational culture refers to a deeper level of fundamental assumptions and beliefs held and shared by individuals within an organisation and exceeds behaviours, values and norms. More specifically, organisational culture emphasises problem-solving functions stating culture as: *"the patterns of basic assumptions*

which a given group has invented, discovered, or developed in learning to cope with its problems of external adaptation and internal integration, which have worked well enough to be considered valid, and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems" (p. 17) (*ibid*). With this definition, 'organisational culture' is emphasised as being reserved to patterns of invisible and deeper fundamental beliefs that all members of the organisation share and operate subconsciously to define fundamental behaviour of the members.

Many recent researchers have found importance in Schein's organisational culture definition and its concepts, which include artifacts, espoused values, and fundamental assumptions, as a starting point for understanding and studying culture within organisations. Giorgi, Lockwood and Glynn (2015) conducted a study, which drew upon three decades of research on organisational culture. They (*ibid*) identified artifacts (stories, frames and toolkits), values and perceptions as central in defining organisational culture. Serpa (2016) describes organisational culture as a collective way of being, thinking and acting that is shared among people within an organisation. It involves a mutual understanding and reciprocal expectations among individuals, shaping their behaviours and interactions within the organisational context. Thokozani (2017) expressed organisational culture as the written and verbal rules that are circulated within the organisation and serve as guides for employees' behaviour. These rules encompass the aspect of stable beliefs, values and principles that are developed and shared within the organisation. It is evident that in discussions and definitions of organisational culture, there is a noticeable repetition of concepts such as beliefs, values and behaviours, which were originally introduced by Schein (2010). Hence, for this study Schein's (2010) definition of organisational culture was used as a stipulative definition to consistently carry the specified meaning of the term throughout the study.

2.3.2 Elements of organisational culture: visible to invisible

Before attempting to determine how culture is created, evolves and changes, it is necessary to first understand the elements of culture. As expounded by Schein (1983), culture exists in a conceptual hierarchy with three major levels as artifacts, values and assumptions, where the phenomena at each level influence and are influenced by one another as demonstrated in Figure 2.4. Schein's three-layered organisational culture model (*ibid*) has significant impacted upon the field of organisational culture, influencing an entire generation of researchers (Mikušová, Klabusayová & Meier 2023).

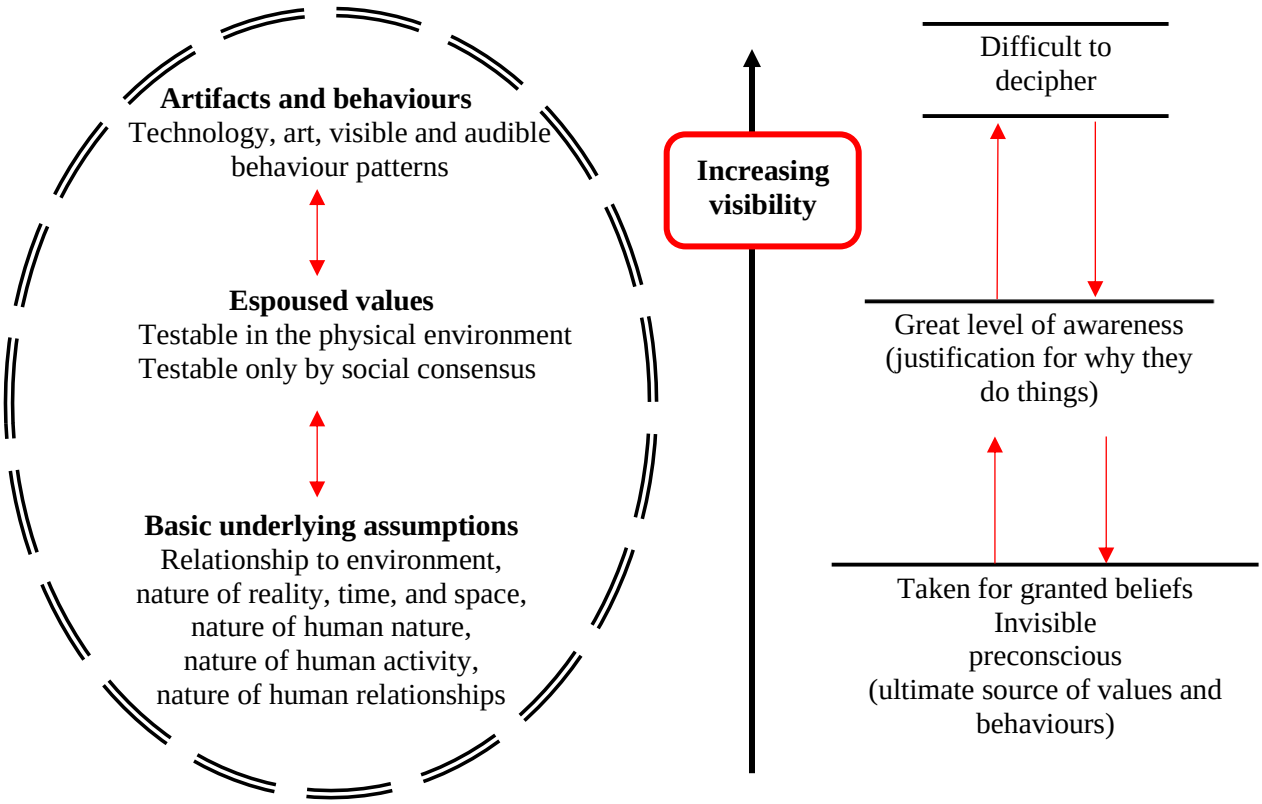

Figure 2.4. Elements of organisational culture

Fig. 2.4 illustrates that organisational culture is composed of multiple layers, with some being more visible than others. The dashed circle encompassing the multiple layers represents the boundary of the organisational culture. At the most superficial first level, artifacts include the organisation's built environment, including visible or audible behaviours, technology, architecture, dress code, office layout myths and stories about the organisation (Schein 2004). Artifacts and behaviours are observable and most visible but difficult to decipher. This level of culture explains 'how' a group builds its environment and answers the question 'what' behaviour patterns are apparent among the employees (Schein 1984). However, to understand the logic behind employee behaviour, espoused values that govern behaviour must be examined (Schein 1984). The second level is composed of the values or beliefs that are publicly expressed by individuals within the organisation. These values provide guidance for behaviour and are often used to justify actions taken by members of the organisation (Schein 1984). So, values have greater credibility in providing rationale for behaviours and governing those behaviours. Even though values assist in understanding the rationale for behaviour, they do not delineate the culture essence or driving forces behind it. As individuals act on these espoused beliefs (which lead to the behaviour and successfully solve problems), these values become entrenched as underlying assumptions in the third

level. These assumptions are unconscious beliefs of a group that explain why members perceive and think in certain ways (Schein 2010).

Martin (2002) emphasises that interpreting culture solely based on the visible elements such as artifacts and behaviour patterns, can be misleading. While these elements provide some insights into the culture of a group, it is the inner layers that truly help in understanding the essence of organisational culture (Cameron & Quinn 2006; Schein 2010). By exploring and analysing these underlying layers, a deeper understanding of the culture can be gained - moving beyond the surface-level manifestations. The inner levels of organisational culture encompass values and underlying basic assumptions. While values and basic assumptions are often portrayed as two separate levels, Schein (2010) emphasises that it is the values held by individuals or groups that ultimately drive their behaviour. When individuals or groups exhibit behaviour to solve a problem, the underlying value that initially motivated that behaviour becomes deeply ingrained as a basic assumption within the organisational culture. Hofstede et al. (1990), further support the concept of underlying basic assumptions by referring to them as: *"taken for granted values."* This term implies that these assumptions are deeply ingrained and often go unquestioned within a culture. Schein (1984) also emphasises that these underlying basic assumptions, or taken for granted values, are considered the core or essence of the culture; this is because they form the foundational beliefs and principles that shape the behaviour and thinking of individuals within the culture. This simplification condenses the levels of organisational culture into two dimensions: the superficial level (encompassing observable behaviours), and the core level (comprising the underlying beliefs). This reductionist approach provides a more streamlined understanding of organisational culture, delineating between surface-level manifestations and the fundamental beliefs that drive them – refer to Figure 2.5.

In a similar view to Schein (2010), (Deal 1985) asserts that the culture consists of patterns of behaviours and patterns of thoughts. These interpretations of cultural elements place focus on the visible behaviours and the invisible source of behaviours, i.e., beliefs. Thus, the levels of culture can be seen by a casual observer on the surface, and in a deeper level more difficult to ascertain (Wilson 2001). Furthermore, Kilmann, Saxton and Serpa (1986) support this claiming that the culture manifests itself through cognitive components of behavioural norms, hidden assumptions and human nature, all of which occur at a distinct level of depth. Duarte and Tennant (1999) use the metaphor of an iceberg to illustrate the visible and invisible elements of organisational culture. For an iceberg, a portion of it is visible above the water level, and the rest remains submerged by the tides. The tip of the iceberg is easily

discoverable and constitutes a composition of artifacts and behaviours. This is the same as in first level of the Schein's cultural manifestations "artifacts and behaviours." For the gigantic part of culture viz. the cognitive component: values and underlying assumptions are hidden under the water, and therefore invisible. The level 2 and 3 have been included as the basic and tacit beliefs held by people beneath the water level (Duarte & Tennant 1999). These are the hidden deeply held underlying beliefs of organisational members as the essence of organisational culture.

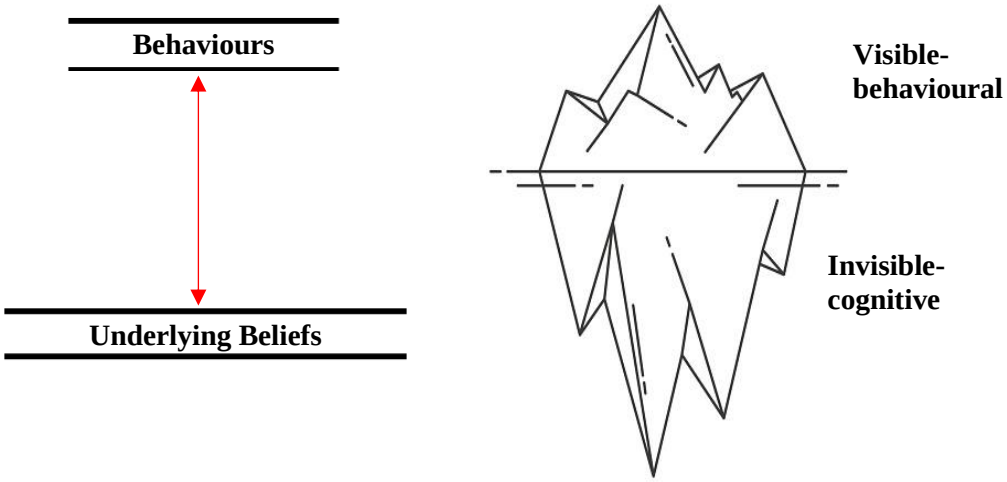

Figure 2.5. Organisational culture iceberg

According to Schein (1985), the challenge in understanding organisational culture lies not in simply observing behaviours at the surface level but in deciphering the meaning behind artifacts and their interrelationships. It is crucial to uncover the deeper patterns and underlying beliefs that these artifacts represent (Samaraweera, Senaratne & Sandanayake 2018). By delving into the underlying beliefs, one can uncover the implicit rules, expectations and shared meanings that influence the organisation's functioning (Knobel et al. 2021). This deeper level of analysis enables a richer understanding of the culture, its dynamics and the factors that shape it. Thus, it is essential to understand what constitutes as underlying beliefs.

2.3.3 Underlying beliefs: formation of patterns of underlying beliefs

The underlying beliefs are the 'essence' of culture, which are embedded in the organisational members, therefore operate unconsciously. Schein (1984) offers six cultural dimensions, inspired by the Value orientation Theory (VOT) of Kluckhohn and Strodtbeck (1961). The culture dimensions include beliefs that govern the organisation's interaction with the environment, the nature of reality, the nature of human activity, the nature of human nature,

human relationships and nature of time. These underlying beliefs can be discerned through various orientations, and their interpretations are elucidated as discussed by (Hills 2002; Kluckhohn & Strodtbeck 1961; Schein 2010).

The relationship of a group to its environment

A group's perception of its total environment shapes the organisation's primary mission. This is understood in terms of (for example) whether humans must live in harmony with nature, whether nature can be controlled, or whether people must submit to nature. These core beliefs portray how the organisational members view its relationship to the environment within which it operates. So, primary questions to uncover these core beliefs related to environment include: is the organisation dominating and changing its surroundings? will the organisation try to harmonise with the environment by carving out its own niche?; or is it under the impression that it must submit to the environment and accept whatever niche is available?

The nature of reality and truth

These beliefs focus on what is true, how the group discovers or determines what is true, and on what basis it acts. The emphasis here is on: how members of a group act; how they determine what information is relevant; and when they have adequate information to decide whether to act or what to do. The organisations use different criteria to determine truth such as pragmatic test, social consensus or reliance on wisdom. Thus, when making decisions some organisations take a more rational approach, conducting research and gathering quantifiable data. Others strongly believe in the power of observation and rely on the experience of their own or others or think that discussion and debate are the best ways to find the truth.

The nature of human nature

The beliefs explain the view an organisation has of its members. They are centred on what it means to be 'human,' and what kinds of behaviours are considered 'inhuman'. Thus, they explain the human characteristics such as good and evil, individual self-determination and the ability to change. These beliefs provide the grounds for inclusion and exclusion of members from the group. In an organisation, this refers to the fundamental beliefs about how employees and managers are perceived. These beliefs on human nature underpin incentive and control systems of organisations.

The nature of human activity

These beliefs answer the question - what is the correct way to behave? Core beliefs are oriented in three forms as: "doing," "being" and "being-in-becoming." The doing orientation correlates closely with the belief that nature can be controlled and manipulated, nature of reality is pragmatic and human nature is perfectible. The being orientation holds that nature is supreme and that humanity is submissive to it. Being-in-becoming emphasises self-actualisation, self-development and reaching one's full potential.

The nature of human relationships

Beliefs concerned with how individual members should interact with one another to preserve group safety and comfort are considered in this category. Problems in the internal environment relate to power, hierarchy and influence within the group and concerns on love, intimacy and peer relationships are solved based on these beliefs. These beliefs answer questions such as: what is the "correct" way for people to interact with one another, to share power and affection? What is the best way to organise? What is the best authority system?

The nature of time

Beliefs are based on how the time is viewed in the group. These beliefs explain the organisation’s basic orientation toward past, present and future. They provide insight into how the group perceives and values time as a concept. They influence the organisation's perspective on historical events, present actions and future goals. The beliefs regarding time form a significant aspect of the organisation's overall culture and contribute to its temporal orientation.

Schein (2010) and Hills (2002) present basic questions that must be addressed in order to determine the underlying beliefs within an organisation. They subsequently provided a detailed explanation for each of the questions, proposing potential answers and asserting that the preferred response within a given society reflects the society's fundamental beliefs towards that particular aspect of its environment. The underlying beliefs for each question are presented in Table 2.6.

Table 2.6. Underlying beliefs of organisational culture

(Adapted from (Hills 2002; Kluckhohn & Strodtbeck 1961; Schein 2010))

Organisational culture dimension	**Questions need to be answered**	**Underlying beliefs (cultural orientations)**
The relationship of a group to its environment - *relating to the world outside.*	**Main questions** How do the organisation and its members interact with the outside world, particularly the external market of the organisation's services? Is it a domination, submission, harmony? **Sub questions** Is the group's primary goal to influence the external environment or to react to it?	Domination Submission Harmony
The nature of reality and truth - *relating to the search for truth and purpose.*	**Main questions** How is truth determined? What is the source of truth, and how does it come to light? By tradition, wisdom, conflict and debate, pragmatic criteria, scientific method or social consensus? **Sub questions** How is the organisation's mission determined? How does the group learn about its continual effort to improve its purpose, and ultimate goals?	Tradition Wisdom Conflict and debate Pragmatic criteria Scientific method Social consensus
The nature of human nature - *relating to human nature.*	**Main questions** In this organisation, how is human nature viewed; perfectible, immutable, good, neutral, or evil? **Sub questions** Is everyone equal, or are some more equal than others? Where do the best organisational ideas come from? Is it necessary to dominate and control individuals, or may they be given the freedom to excel?	Perfectible Immutable Good Neutral Evil
The nature of human activity - *relating to human activity.*	**Main questions** Is the group focused on doing, being, or becoming?	Doing Being Becoming
The nature of human relationships - *relating to human relationships.*	**Main questions** Would it be more effective to structure society based on individualism or groupism? **Sub questions** In the organisation, how are connections viewed? Are they crucial in networking, or do people operate alone behind closed doors?	Individualism Groupism
	Main questions Would an autocratic or participatory authority system be more effective? **Sub questions** Is communication free and open within the organisation, or are relationships rigorously controlled?	Autocratic Participatory

Organisational culture dimension	**Questions need to be answered**	**Underlying beliefs (cultural orientations)**
	Main questions What is the ideal way for individuals to interact with one another? Is life characterised by competition or cooperation? **Sub questions** How would you describe the informal social atmosphere? Is there love, intimacy, or peer relationships?	Competition Cooperation
The nature of time - *relating to time.*	**Main questions** Is the organisation's basic orientation toward past, present and future? What does time mean to this organisation?	Past Present Future

Identifying and understanding these underlying beliefs requires careful exploration and analysis, as they operate at a subconscious level as abstract beliefs collectively within the group. Underlying beliefs are abstract and may not be immediately visible but significantly influence the way members interact and make decisions within the organisation (Hills, 2002). The underlying beliefs, when combined and repeated across the organisation, form patterns. These are known as the 'patterns of underlying beliefs' (Schein 2010). These patterns represent the prevalent ways of thinking and behaving within the group, and collectively they constitute the organisational culture. The patterns of underlying beliefs are manifested through observable behaviours and artifacts such as routines, rituals, symbols, language and other tangible and intangible elements that reflect the organisation's culture (Samaraweera, Senaratne & Sandanayake 2018) – refer to Figure 2.6. As the patterns of underlying beliefs become established and perpetuated, they served to reinforce and uphold the abstract underlying beliefs.

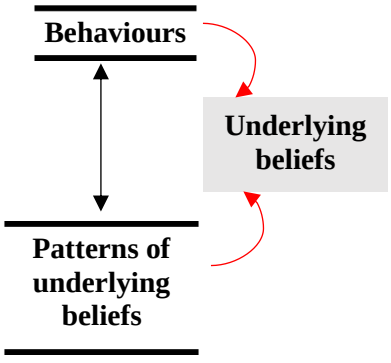

Figure 2.6. Relationship between behaviours, patterns of underlying beliefs and underlying beliefs

Therefore, to dig deeper into the organisational culture core to find underlying beliefs, first it is necessary identify the patterns of underlying beliefs. Schein (2010) proposes a method to surface the patterns of underlying beliefs through understanding organisation's external

and internal problems. By studying how the organisation addresses problems, copes with difficulties and makes decisions, one can gain a deeper understanding of its underlying beliefs and consequently, its culture.

2.3.4 Cultural manifestations: means of realising patterns of underlying beliefs

When understanding the organisational culture, surfacing the invisible underlying beliefs can be difficult. Schein (2010) organisational culture definition emphasises that to realise the deeply held beliefs of organisational culture, it is necessary to understand external adaptation and internal integration problems faced by an organisation and how they answer each problem as a group. The responses to these 'external adaptation' and 'internal integration problems' reveal the underlying beliefs governing the behaviours, ultimately create the organisational culture. Thus, to identify the elements of organisational culture, it is essential to go down the external adaptation and internal integration problems and question how the group answers each problem. These problems include what appears to be its core mission, goals, means of accomplishing goals, available measurement systems, its remedial actions, its terminology system, the authority, peer and rewards systems and ideology. Once this is completed, it will be clear that there is a deeper level of assumptions, beliefs that connects the many 'responses' to these problems (*ibid*). These are the essence of culture or hidden scripts which were referred in Section 3.2. Consequently, the culture definition by Schein (2010) serves as a solid foundation to explore organisational culture.

The problems of external adaptation and internal integration

External adaptation refers the processes that keep a group together. External adaptation and survival problems deal with the organisation's definition of the outside environment and mechanisms adopted by the leadership and the members to survive in the external environment (Schein 2010). These include the problems related to mission and strategy, goals, means measurement and correction.

- Mission and strategy - developing a shared understanding on the primary task, core mission or manifest and latent functions. This is the reason for the existence of the organisation.
- Goals - developing consensus on the concrete goals, reflected from the core mission.
- Means - developing consensus on the means to attain the established goals. This considers the organisational structures, division of labour and processes of decision making.

- Measurement - developing consensus on the measuring criteria of how well the group perform against the goals. This deals with the means to monitor the progress such as information and control systems.
- Correction actions - developing consensus on the appropriate repair or remedial strategies to be used if the goals are not being accomplished.

Internal integration is the method by which an organisation builds and maintains itself. Internal integration problems that any group must address for it to function as a social system are associated with common language and conceptual categories, group boundaries and criteria for inclusion and exclusion, power and status, intimacy, friendship, and love, rewards and punishments and ideology (Schein 2010). These issues relate to how the organisation interacts internally, while fostering the sense of unity required for the group to accomplish its external mission.

- Common language and conceptual categories - this considers the words/language and concepts that members of the group use to communicate with one another. A group is impossible to form if its members cannot communicate and comprehend one another.
- Group boundaries and criteria for inclusion and exclusion - who joins the group (who is in), how they join, and why some people are excluded from the organisation (who is out) and criteria used to establish membership are considered.
- Power and status - an organisation should work out how group members gain, lose and maintain power and status and what is the way to allocate authority and resources.
- Intimacy, friendship and love - an organisation should workout regarding how to handle and form rules for peer relationships.
- Rewards and punishments - consensus on criteria for allocation of rewards and punishments in the organisation should be developed. Members must understand heroic and sinful behaviours within the group; what actions get rewarded in terms of status, property and power and what actions get punished by withdrawing rewards.
- Ideology - giving meaning to unexplainable and inexplicable issues and problems are considered. Organisations encounter mysterious and incomprehensible events that need to be explained for its members to react to those events and reduce anxiety associated with dealing with them.

This Figure 2.7 depicts the how external adaptation and internal integration problems and responses to them relate to behaviours, patterns of underlying beliefs and underlying beliefs.

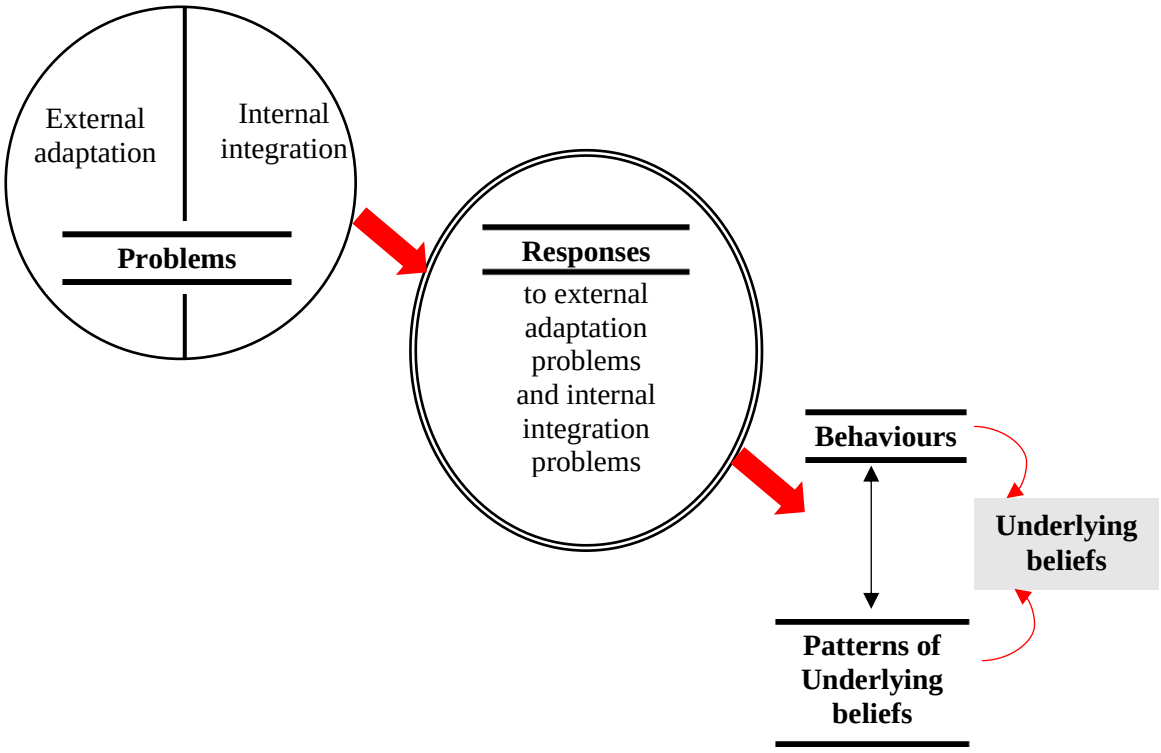

Figure 2.7. The relationship between external adaptation and internal integration problems, their responses, behaviours and patterns of underlying beliefs and underlying beliefs

2.4 Summary

This chapter presented literature on BIM and organisational culture to provide context and background information. This chapter laid the foundation to devise a method to derive cultural manifestations of an organisational culture, with the potential for future refinement in the BIM context. The chapter also identified research and methodological issues in comprehending organisational BIM culture and underscored the need for managing organisational BIM cultures towards strong innovative BIM cultures. The next chapter aims to develop a conceptual framework to diagnose organisational BIM culture in construction organisations and further extend it to build a conceptual framework to manage construction organisations towards a strong innovative BIM culture.

CHAPTER 03- RESEARCH FRAMEWORK

3.1 Introduction

The Chapter 02 provided the extant literature on BIM and organisational culture to provide context and background information to the study. This chapter aims to provide a detailed explanation of the research framework that has been developed for understanding organisational BIM culture. This framework is further extended to understand innovative BIM culture. The focus is on outlining the structure and components of the framework, which serves as a foundation for investigating and understanding the cultural aspects related to the implementation and adoption of BIM within construction organisations. Therefore, this chapter draws upon the BIM literature and culture theory discussed in chapter 02. Accordingly, the works of different scholars were used in developing the conceptual framework as summarised in Table 3.1.

Table 3.1. Summary of the concepts and research works used in developing the conceptual framework and the working definition for organisational BIM culture

Concepts	Authors, year
Definition of BIM.	(Siebelink, Voordijk & Adriaanse 2018; Succar 2009)
Behaviours and underlying beliefs as cultural manifestations.	(Cameron & Quinn 2006; Hofstede 1998; Schein 1983, 1984, 2010)
Underlying beliefs– Value Orientation Theory.	(Hills 2002; Kluckhohn & Strodtbeck 1961)
Underlying beliefs – Innovative culture.	(Kaarst-Brown 2008; Schein 1994)
External adaptation and survival problems.	(Knobel et al. 2021; Schein 2010)
Internal integration problems.	(Knobel et al. 2021; Schein 2010)

3.2 Conceptualising organisational BIM culture

This present study adopts the approach outlined by Jabareen (2009), which involves five distinct phases to develop the conceptual framework for understanding organisational BIM culture *viz.*: 1) mapping the selected data sources (refer to Table 3.1); 2) identifying and naming concepts (refer to Table 3.1); 3) deconstructing and categorising the concepts (refer to Sub section 3.2.1); 4) integrating concepts (refer to Sub section 3.2.1); and 5) synthesis, re-synthesis (refer to Sub section 3.2.2). The study intends to discover behaviours and underlying beliefs as cultural manifestations drawing from the Value Orientation Theory (VOT) and Schein's culture theory, due to the inspiration from their comprehensive, exclusive dimensions, simplicity and potential applicability at both individual and aggregate levels (Hartl & Hess 2017; Knobel et al. 2021; Maznevski et al. 2002; Samaraweera, Senaratne & Sandanayake 2018). This means that the concepts discussed in section 3.3,

which include external survival problems, internal integration problems, behaviours and underlying beliefs are combined synergistically to understand the concept of organisational BIM culture. In Section 2.3 in Chapter 02 arguments are made explaining that if someone is to discover the organisational culture, they should extract the underlying beliefs by questioning the problems faced by the employees in the organisational context. Similarly, given that the organisational BIM culture is a facet of organisational culture it is comparative to derive its underlying beliefs. This can be achieved by identifying the external adaptation and internal integration problems faced by a BIM-enabled construction organisation and question how it solve each problem. Schein (1984), proffers that these problems are associated with an organisation's core mission, goals, means of achieving objectives, available performance measurement systems, corrective actions taken, language, the authority, rewards systems and ideology.

3.2.1 The problems of external adaptation and internal integration in a BIM-enabled construction organisation

External adaptation problems refer to the challenges an organisation faces with the introduction of BIM while adjusting to changes in its operating environment for survival. Thus, to survive in the commercial environment, BIM-enabled organisations should develop census on its BIM mission, strategy, goals, means for achieving those goals, metrics and protocols for BIM evaluation, as well as corrective measures. This requires the organisation to invest in the latest BIM technology, stay updated with the latest industry trends and maintain relationships with BIM experts aligning the use of BIM with strategic objectives is crucial for success (Goedknegt, 2015). Table 3.2 presents a potential list of problems of external adaptation and survival in a BIM-enabled-construction organisation as adapted from Knobel et al. (2021) and Schein (2010).

Table 3.2. The problems of external adaptation and survival in a BIM-enabled-construction organisation
(Adapted by Knobel et al., 2021; Schein, 2010)

The problems of external adaptation and survival in a BIM-enabled construction organisation	
Mission and Strategy	Developing a consensus on organisational BIM mission and strategy.
Goals	Developing consensus on BIM goals and objectives.
Means	Developing consensus on means to be used in achieving BIM strategy.
Measurement	Developing consensus on the criteria to be used in BIM performance evaluation.
Correction actions	Developing consensus on remedial actions to ensure that members meet the BIM mission and strategy.

BIM as a technological change has a profound effect on people's cultural beliefs and values, which in turn, affect an organisation's ability to survive in a competitive market (Siebelink et al., 2018). According to Knobel et al. (2021), organisational BIM culture formed through founder's beliefs and values on how things should be done in a BIM setting. The founder's determine ultimate survival problem and define the group's core mission and primary purpose. When an organisation adopts BIM, it begins to modify the original learned beliefs and values proven to be effective in traditional setting (Zakariyyah, John & Ijaola 2021). If the primary purpose of using BIM does not align with the strategic objectives of the organisation, then BIM usage may not be successful (Siebelink et al., 2018). In a BIM-enabled organisation, the primary purpose of using BIM revolves around different problems: gaining a competitive advantage, fulfilling client's demand, enhancing collaborative relationship and improve efficiency (Abdul Ghafar & Ibrahim 2018; Goedknegt 2015). While performing these manifest functions, members in the company develop a consensus on its BIM mission, strategy and goals to achieve the mission. This process involves making decisions about the products and services offered and reflects the organisation's identity. Overtime and when the founders and employees share these beliefs, they become taken for granted creating a vital part of BIM culture (Knobel et al., 2021).

The way an organisation chooses to execute its strategy and objectives is the subsequent aspect of its cultural makeup. This is also true for how a BIM-enabled construction organisation implements BIM strategy and objectives (Alankarage et al. 2023). For instance, when BIM is introduced to a company, their organisational structure has to be modified to incorporate a new BIM department (Siebelink et al. 2021). The company's BIM department has the responsibility to educate and train employees and subcontractors while conducting research on how to best utilise BIM to maximise its benefits (Ahn, Kwak & Suk 2016). When these modified organisational structures succeed in BIM diffusion, the group become convinced that their way of organising is correct. The level to which the organisational structure aligns with the BIM use and the environment in which the organisation operates to develop a census on the means to be used in achieving BIM strategy. How a BIM-enabled construction organisation measures its BIM performance, detect errors and take remedial actions to ensure that they meet the BIM mission and strategy, develops shared beliefs within the group (Knobel et al., 2021). BIM performance of the organisations are measured by establishing metrics and key performance indicators (KPIs) that align with their BIM mission and strategy (Badrinath & Hsieh 2019). Additionally, BIM maturity scores for each BIM project could provide an idea on BIM performance of the company (Siebelink et al.

2021). To detect errors, the organisations implement quality control processes such as regular BIM model reviews, clash detection and BIM data validation (Ahn et al., 2016). The correction actions to address them involve correcting the model data, communicating the issue to relevant party and providing continuous training (Liao & Teo 2018). Cultural norms develop overtime around these areas. Thus, consensus on the criteria to be used in BIM performance evaluation and correction actions become essential elements of organisational BIM culture. To identify the cultural elements of a particular group, one can employ an approach that involves examining the group's perspective on each of these issues *viz.*: central BIM mission, strategy, goals, means for achieving those goals, metrics and protocols for BIM evaluation, as well as corrective measures.

For a group to be able to adjust to changes in its external surroundings, it needs to establish and sustain internal relationships and connections between its members. Internal integration problems, on the other hand, relate to the challenges an organisation faces while integrating new processes, structures and practices to support BIM use within the group. Table 3.3 presents a potential list of problems of internal integration in a BIM-enabled-construction organisation as adapted from Knobel et al. (2021) and Schein (2010).

Table 3.3. The problems of internal integration in a BIM-enabled-construction organisation (Knobel et al., 2021; Schein 2010)

The problems of internal integration in a BIM-enabled construction organisation	
Common language and conceptual categories.	Consensus on language used in a BIM environment.
Group boundaries and criteria for inclusion and exclusion.	Consensus on BIM team boundary.
Power and status.	Consensus on power and status allocation criteria in a BIM team.
Intimacy, friendship and love.	Consensus on handling of peer relationships in BIM environment.
Rewards and punishments.	Consensus on criteria for allocation of rewards and punishments in BIM-enabled organisation.
Ideology.	Consensus on unexplainable and in explicable issues in BIM-enabled organisation.

The individuals involved must create a method of exchanging information and a common language that allows them to understand and make sense of what is happening within the group. The integration of BIM into organisational settings has resulted in a transformation of the language used in such contexts, as novel standards, naming conventions and specialised jargon that are particular to BIM software have emerged and gained widespread usage (Kensek 2015). The consensus developed on language used in a BIM environment

give rise to the underlying beliefs that eventually become an ingrained component of the BIM culture. Understanding the core beliefs that shape the BIM team boundary is critical in determining the selection of members, the methods employed to achieve this and the rationale behind the exclusion of certain individuals from the group (Knobel et al., 2021). For instance, when a new member is hired to the BIM team, they seek to assess various skills and competencies including (but not limited to) previous experience with BIM, proficiency in BIM software, aptitude for effective presentation, ability to collaborate and work effectively in teams, aptitude for clear communication and coordination skills (Uhm, Lee & Jeon 2017). The process of making judgments about who is in and who is out, and then acting on those judgments, is a way in which culture is formed and reinforced within the group.

Organisations have varying beliefs about how authority is established and the extent to which members can develop close relationships with each other. In a BIM-enabled organisation, a BIM manager has the authority to make ultimate decisions at organisational level, however with the introduction of BIM, power dynamics and hierarchies can be affected (Akintola, Venkatachalam & Root 2017). For instance, at the project level, a project manager has the autonomy to decide what BIM approach to be used (Siebelink et al. 2021). The norms regarding the allocation of power and authority in a BIM setting create a sense of security among group members; these norms gradually become commonly held implicit beliefs and fundamental building blocks of the BIM culture. The shared beliefs concerning criteria for allocating rewards and punishments in a BIM setting constitute major elements of emerging organisational BIM culture (Knobel et al., 2021). For instance, utilitarian rewards such as promotions or monetary gains could enhance the employee performance in a BIM setting (Ma et al. 2020). By analysing the BIM related rewards and punishments in the organisations, the underlying beliefs of BIM culture can be revealed.

3.2.2 Underlying beliefs in organisational BIM culture

When the organisation addresses the external adaptation and internal integration problems, the responses to these problems can reveal underlying beliefs that are held by the people in their organisation. These underlying beliefs should be the potential solutions for a limited set of common human problems as referenced in the Table 2.1. Accordingly, within a BIM-enabled construction organisation, when solving its own problems of external adaptation and internal integration (refer Table 3.2 and 3.2), it is expected that members consistently seek solutions from the range of available options to address these common problems. The

learned and shared responses or the solutions to these problems could discover the organisational BIM culture. Table 3.4 presents a compilation of such common problems that would assist in discovering the organisational BIM culture, originating from the underlying beliefs within the organisations as highlighted by Schein (2010), as well as individual underlying beliefs identified by Kluckhohn and Strodtbeck (1961), and Hills (2002). These problems are categorised according to the cultural dimensions outlined by Schein (2010).

Table 3.4. Cultural problems to be answered to unveil organisational BIM culture

Culture dimension	Cultural problems to be answered
The relationship of a group to its environment.	How do a BIM-enabled organisation and its members interact with the outside world? Is it a domination, submission, harmony?
The nature of reality and truth.	How is truth determined in a BIM-enabled organisation?
The nature of human nature.	How is human nature viewed in the BIM-enabled organisation?
The nature of human activity.	What was the correct way for humans to behave within a BIM-enabled organisation?
The nature of human relationships.	What is the best way to organise the society of a BIM-enabled organisation?
	What is the best authority system for a BIM-enabled organisation?
	What is the correct way to relate to each other, to distribute power and affection within a BIM-enabled organisation?
The nature of time.	What kinds of time units are most relevant for the conduct of daily affairs within a BIM-enabled organisation?

This study proposes to find solutions to cultural problems listed in Table 3.4, through indirect questioning related to external adaptation and internal integration. The responses obtained regarding problems related to external adaptation and internal integration provide insights into the underlying beliefs that need to be explored for each cultural dimension. Table 3.5 maps the external adaptation and internal integration in a BIM-enabled construction organisation with organisational cultural dimensions

Table 3.5. A map of external adaptation and internal integration in a BIM-enabled construction organisation with organisational cultural dimensions

		Cultural dimensions
The problems of external adaptation and survival	BIM mission and Strategy.	The nature of human activity. Human relationships to nature.
	BIM Goals and objectives.	The nature of human activity. Human relationships to nature.
	Means of achieving BIM.	The nature of reality and truth. The nature of human relationships time, space.
	Measurement.	The nature of reality and truth. The nature of human relationships.

		Cultural dimensions
	Correction.	The nature of reality and truth. The nature of human relationships.
The problems of internal integration	Common language and conceptual categories/systems.	The nature of reality and truth time, space.
	Group boundaries and criteria for inclusion and exclusion.	The nature of human relationships.
	Power and status.	The nature of human nature. The nature of human activity.
	Intimacy, friendship and love.	The nature of human nature. The nature of human activity.
	Rewards and punishments.	The nature of human nature. The nature of human activity.
	Ideology.	The nature of human activity. The nature of reality and truth time, space.

As argued in Sub section 2.3.2, the cognitive component of a culture can be seen as the hidden part of an iceberg, which forms the foundation of culture and lies deeper and below the surface, not immediately visible to the observer. Hence, the conceptual framework was developed representing the patterns of underlying beliefs and underlying beliefs of the organisational BIM culture as the foundation of the iceberg as shown in Figure 3.1. The two arrows pointed to the iceberg show the external adoption problems and internal integration problems, which the members of BIM-enabled organisation must deal with for its growth and survival. Under each arrow the specific problems related to external adaptation and internal integration were listed. The learned responses each of those problems will first guides to identify behaviours and patterns of underlying beliefs. Then by analysing these patterns of behaviours and patterns of underlying beliefs against the cultural dimensions (for example, human relationships to nature, nature of reality and truth, nature of human nature, nature of human relationships, nature of human activity and nature of time), the underlying beliefs which constitutes to the core of organisational BIM culture can be found.

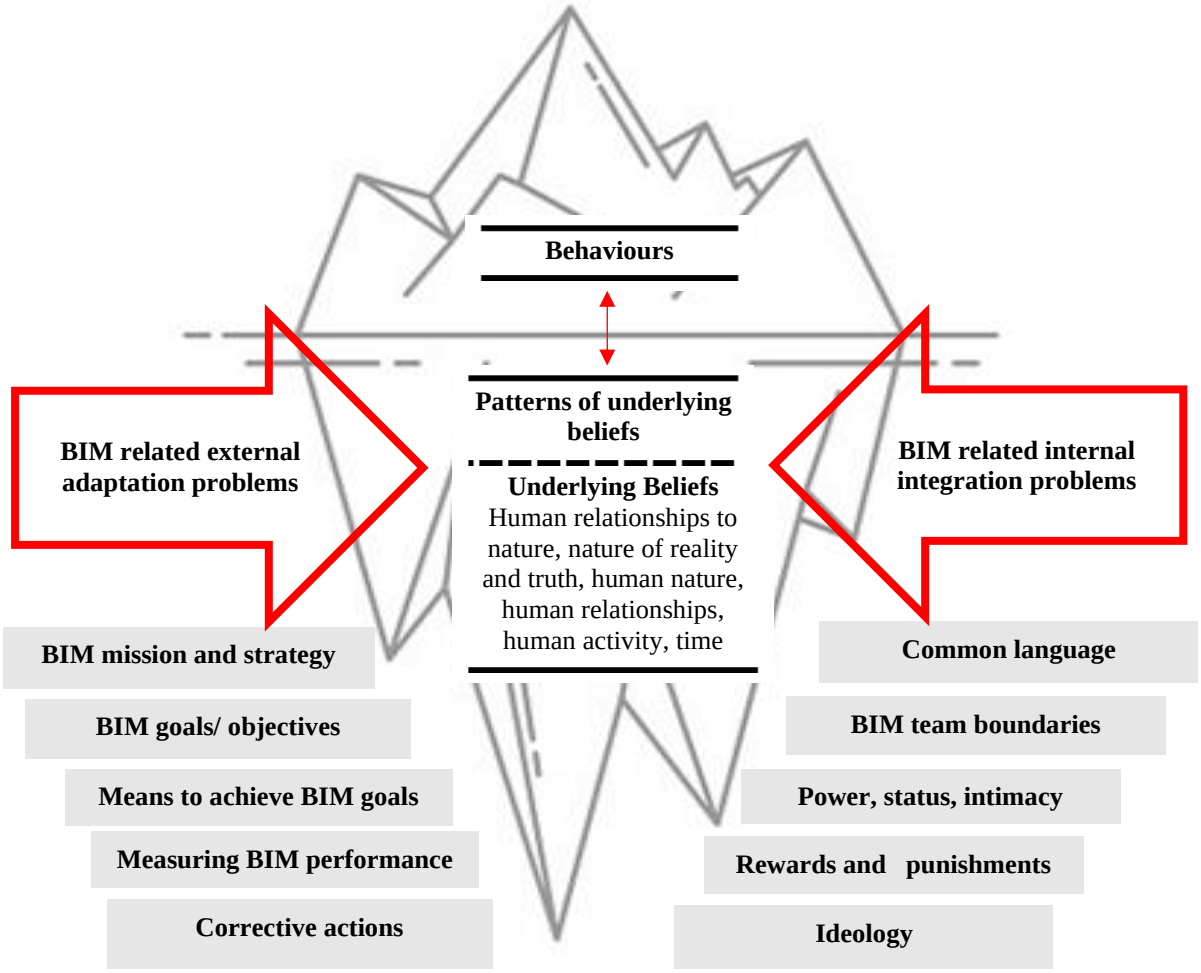

Figure 3.1. Conceptual framework for understanding organisational BIM culture

The above-mentioned concepts can be carefully synthesised to derive a definition for organisational BIM culture. BIM usage leads to the creation of a new organisational BIM culture, which is shaped by the behaviours and shared underlying beliefs of the individuals in the organisation. Herein, the core of the culture is its deeply rooted underlying beliefs, which are manifested in how the organisation addresses external and internal integration issues. Consequently, the organisational BIM culture can be defined as:

> *"The patterns of underlying beliefs guided by behaviours and artifacts, that was learned by members of a BIM-enabled organisation as it solves its problems of external adaptation and internal integration, that has worked well enough to be deemed valid and are subsequently passed on to new members as the accepted and accurate way to perceive, think, and feel about BIM in relation to those problems.*"

Accordingly, the formation of patterns of underlying beliefs regarding BIM stems from employees' experiences both within and outside the organisation. These underlying beliefs are transmitted to new members through direct means, such as observable behaviours and tangible artifacts like BIM processes, rituals and organisational structures. They are also conveyed indirectly using language and the perpetuation of narratives, including stories recounting past victories or failures related to BIM.

3.3 Conceptualising innovative BIM culture

Having an organisational BIM culture is indeed a critical component of successful BIM implementation in construction organisations (Siebelink, Voordijk & Adriaanse 2018). However, it is not merely the presence of an organisational BIM culture that guarantees success; rather, it is the nature of that culture that truly matters. To maximise the benefits of BIM, the organisational BIM culture should be characterised by innovation, with all stakeholders wholeheartedly embracing and utilising BIM technologies and processes (Ahuja, Sawhney & Arif 2018; Schein 1994). Such a culture should exhibit leadership qualities to encourage creativity, embrace change, offer performance-based reward systems, and has dedicated innovation champions committed to implementation. This kind of culture is known to be an innovative culture (*ibid*). In a similar vein, the existing organisational BIM culture of a BIM-enabled construction organisation should be an innovative BIM culture to successfully achieve the desired outcomes of BIM.

Many studies in similar fields have attempted to find the nature of innovative culture in organisations that lead to successful implementation of different innovations. For instance, Ruppel and Harrington (2001) find that when organisations are adopting intranets and aiming to facilitate effective knowledge sharing, they should focus on building an innovative culture characterised by ethics, development and hierarchy. Ethical culture involves fostering trust and demonstrating genuine concern for people within the organisation. In such a culture, employees are more likely to trust each other and share knowledge openly, creating an environment of transparency and integrity. Development culture encourages creativity and flexibility. It means that the organisation values innovative thinking and is adaptable to change. In this context, employees are encouraged to come up with new ideas and solutions, which can be particularly beneficial when implementing intranets for knowledge sharing. Hierarchical culture emphasises the importance of policies and effective information management. In a hierarchical culture, there are clear rules and guidelines in place, ensuring that information is organised and controlled efficiently (*ibid*). Further, Harper and Utley

(2001) emphasise that organisations with a people-oriented culture, which places importance on individuals and their needs, tend to have more successful IT implementation compared to those with production-oriented cultures, which focus primarily on output and efficiency. Peansupap and Walker (2005) highlight the significance of organisational culture in the diffusion of Information and Communication Technology (ICT). They stress the importance of open discussions about how technology is integrated into the organisation, highlighting that the culture should encourage communication and collaboration when adopting new technologies. Hoffman and Klepper (2008) discover that individuals in organisations with high solidarity (strong teamwork and unity), but low sociability (less emphasis on social interaction) are more likely to adapt to and integrate new technology effectively. This suggests that a balance between teamwork and a focus on work tasks is important for successful technology implementation. Iivari and Iivari (2011) found that the adoption of methodologies by information system developers is closely associated with a hierarchical culture that values security, order, and routine. This means that when implementing information systems, organisations should have clear procedures and protocols in place to ensure data security and consistency. These studies are specific and tailored to different type of innovations and therefore does not necessarily suit to understand the innovative BIM culture in construction organisations. Establishing on organisational culture theories, Schein (1994) has made attempts to comprehend innovative culture within organisations and pinpointed ideal underlying beliefs within an innovative culture. Schein (1994) explains how ideal underlying beliefs constitute to an innovative culture for each cultural dimension viz relationship of a group to its environment, nature of reality and truth, nature of human nature, nature of human activity, nature of human relationships and nature of time as explained below summarised in the Figure 3.2.

- **The relationship of a group to its environment**: an innovative culture is ideal when members believe in an optimistic view that the environment can be impacted. Organisations with pessimistic views about being controlled by others or having fixed environments struggle to generate new ideas.
- **The nature of reality and truth:** an innovative culture is strong if it embraces a pragmatic approach to determining truth, rather than relying on moralistic principles.
- **The nature of human nature:** an innovation culture is ideal if it assumes that people are essentially neutral or good and regardless, capable of improvement. Organisations that exhibit cynicism about human nature likely hinder innovation or even mistrust innovators, suspecting hidden motives.

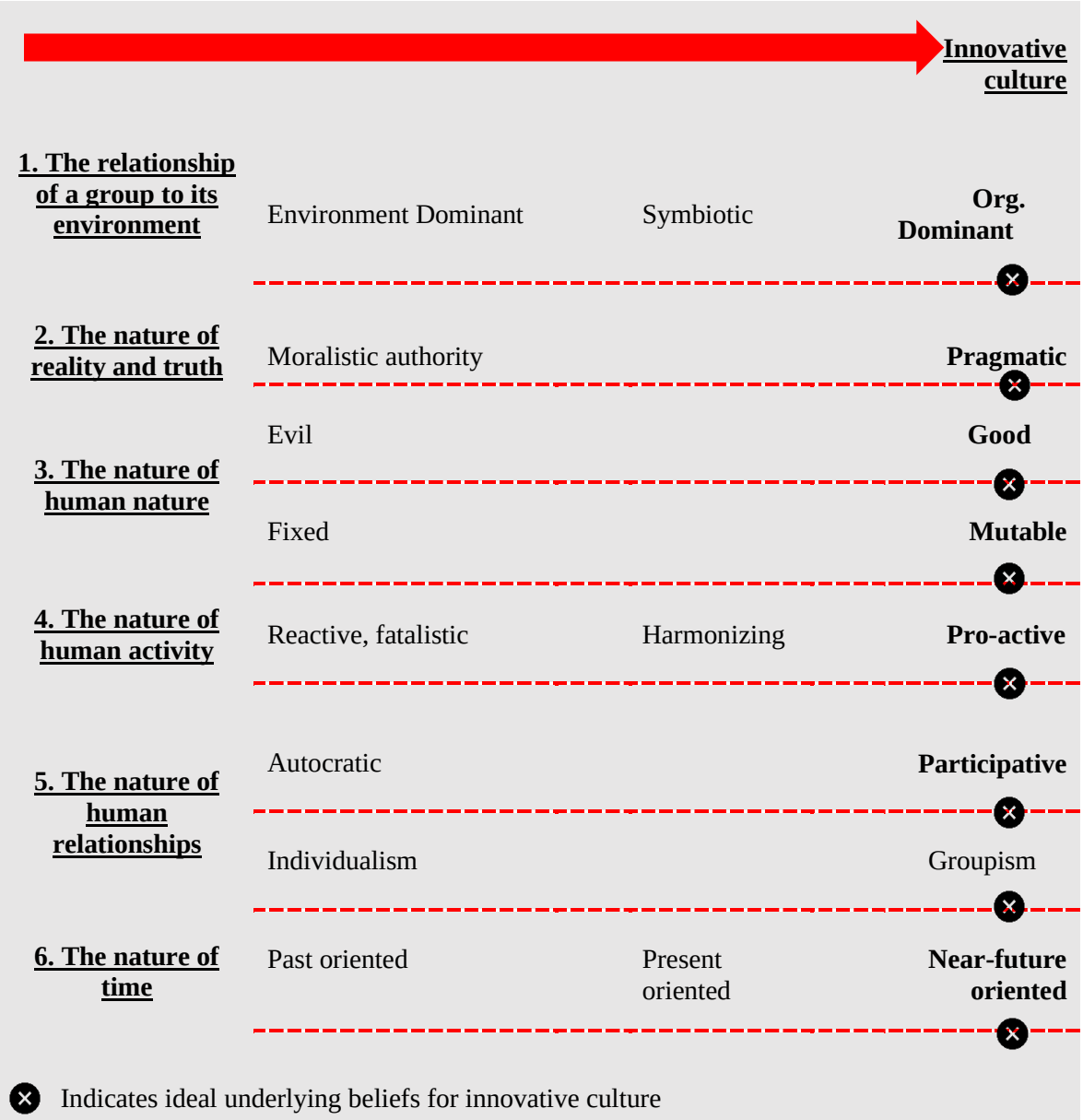

Figure 3.2. Ideal underlying beliefs for innovative culture
(Adapted from Schein 1994)

- **The nature of human activity:** an innovation culture is ideal if it assumes that the appropriate behaviour for its members is proactive, focused on problem-solving, and oriented toward improvement. Conversely, passive or fatalistic organisations cannot spontaneously develop a proactive culture.
- **The nature of human relationships:** an innovation culture grows as it embraces the ideals of groupism and encourages the pursuit of teamwork among its members.
- **The nature of time:** a near future orientation appears most conducive to fostering innovation.

This innovation culture theory proposed by Schein (1994) has been used as the foundation in many studies to explore various cultural contexts and uncover underlying beliefs within groups related to innovation (Dolezal 2013; Kaarst-Brown 2008; Leidner & Kayworth 2006; Lynn Kaarst-Brown & Robey 1999). These studies have used the innovation culture theory in the information management field. Therefore, Schein's innovative culture theory was used in this study to understand the innovative BIM culture. Accordingly, the working definition and the conceptual framework were extended to define innovative BIM culture incorporating the innovative culture theory by Schein (1994). Accordingly, the innovative BIM culture was defined as

> *'an organisational BIM culture, which is giving priority to underlying beliefs of groupism, participative authority, goodness in human and mutability, pro-activity, pragmatism in decision making, organisational dominance, and near-future orientation corresponding to the cultural dimensions viz. nature of human relationships (best authority system, best way to organise, correct way to relate to each other); nature of human nature; nature of human activity; nature of reality and truth; relationship to environment; and nature of time.'*

Based on the above literature arguments, the conceptual framework in Figure 3.1 is refined to produce Figure 3.3 - this presents an extended conceptual framework to understand strong organisational BIM culture with ideal underlying beliefs. As described by Ngulube, Mathipa and Gumbo (2015) a conceptual framework is a structured collection of ideas and concepts that aids in understanding how these concepts relate to each other and impact the phenomenon under investigation. This conceptual framework build the foundation of this study by synergising BIM, organisational culture theories and innovative culture theory and it also support for shaping the research design, methodology, and selection of appropriate research instruments for a study (Rocco & Plakhotnik 2009). Furthermore, Dale et al. (2019) stress the importance as well as emergent potential contributions from the conceptual frameworks in bridging the knowledge (science) and policy divide.

This framework was developed based on the premise that a strong innovative BIM culture corresponds to an ideal innovative culture. The left side of the extended framework (dotted box) shows the existing organisational BIM culture of a BIM-enabled organisation. Sub section 3.2 explains how the organisational BIM culture was conceptualised based on the BIM related external adaptation problems, internal integration problems and cultural manifestations. This component of the framework is a concise summary of Figure 3.1. The

right side of the framework represents a strong innovative BIM culture. A strong culture is established upon deeply ingrained beliefs that are widely shared and upheld throughout the entire organisation. The strength of this culture is determined by the extent to which members of the organisation collectively understand and embrace its guiding principles, norms and values (Thokozani 2017). In a weaker culture, beliefs are not firmly established and broadly accepted within the organisation, making such cultures more unstable. This component of the framework shows desired ideal underlying beliefs needed to achieve a strong innovative BIM culture. When construction organisations transition towards fully embracing BIM, the emerging BIM culture takes different forms along a spectrum of weak to strong (Alankarage et al. 2023; Siebelink et al. 2021). When a BIM-enabled construction organisation leans towards a weaker innovative BIM culture, it is necessary to employ strategies to promote a strong BIM culture that wholeheartedly embraces BIM. Additionally, this process requires an initial assessment to diagnose the current state of the existing innovative BIM culture.

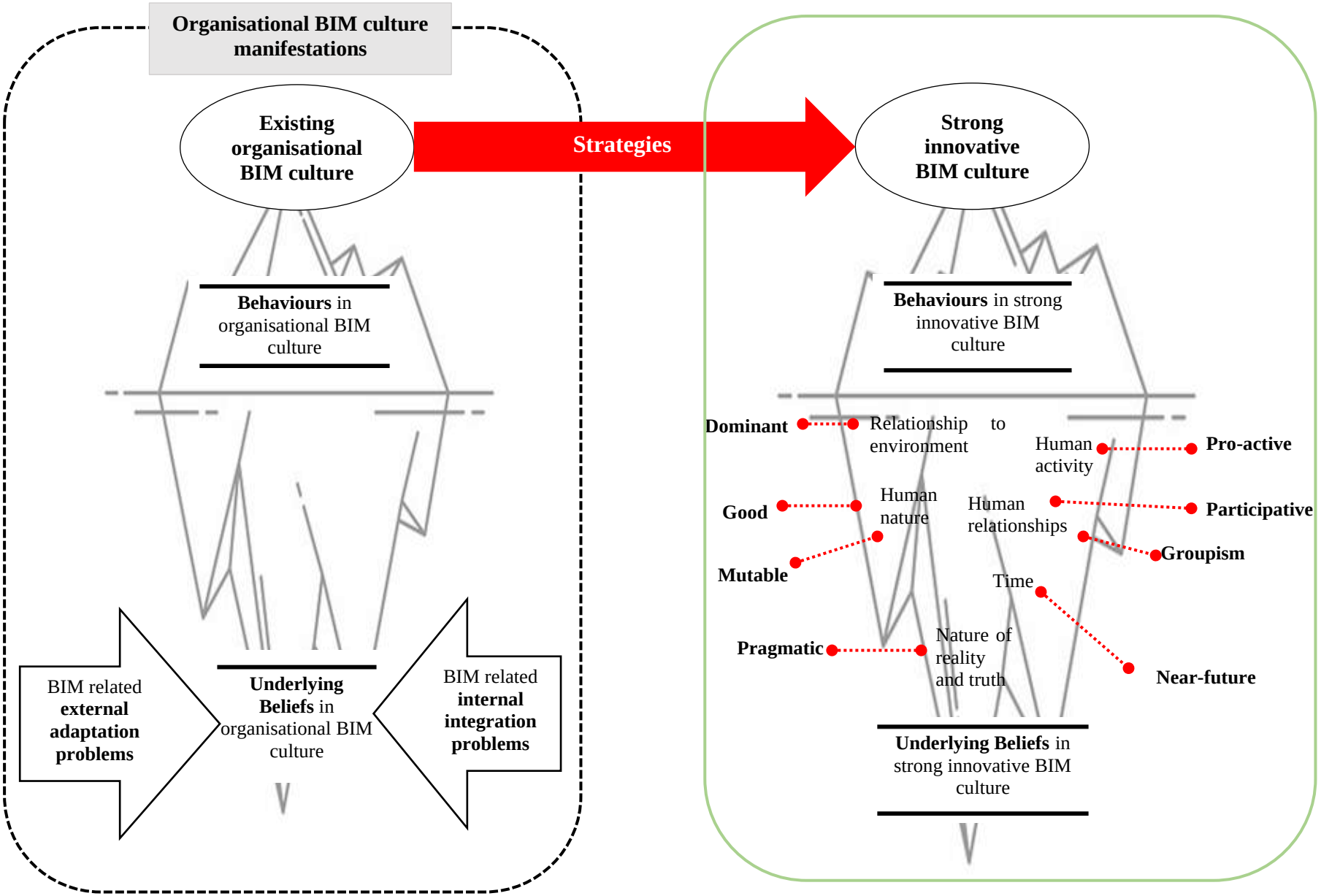

Figure 3.3. Extended conceptual framework to manage innovative BIM culture

3.4 Summary

This chapter outlined the development of the working definitions to understand organisational BIM culture and then modified it to define innovative BIM culture. Further, the chapter proposed a conceptual framework to manage innovative culture in BIM-enabled construction organisations. The conceptual framework was presented in Figure 3.3, combining BIM, organisational culture theories and innovative culture theory. Accordingly, the framework consisted of three parts as existing organisational BIM culture, strategies and achievement of strong innovative BIM culture. The next chapter elaborates the research methodology developed to empirically analyse the organisational BIM culture, to ultimately reach to a strong innovative BIM culture.

CHAPTER 04- RESEARCH METHODOLOGY

4.1 Introduction

The Chapter 03 outlined the development of the conceptual framework to manage innovative BIM culture in construction organisations. This chapter describes the research methodology adopted to achieve the aim and the objectives of the present study. Thus, throughout this chapter the research process adopted is explained in detail together with the justifications to provide the rationale behind selecting the particular methodology and methods within. This starts with introducing the 'the research onion' by Saunders, Lewis and Thornhill (2019), which guides the aspects in selecting and determining research methodology. Next, research philosophies are discussed to establish the philosophical stance of the present study. The stages of the research process included case study research design and selection, data collection and analysis techniques. Trustworthiness of the study results are evaluated in terms of credibility, transferability, dependability and confirmability. This chapter concludes with a summary of the philosophy, approaches and techniques chosen.

4.2 Research methodological framework: the research onion

In a coherent research project, all the elements from inception to completion should fit together. A research methodology is an overarching approach to the research process, encompassing it all from the early theoretical underpinnings to data collection and analysis (Collis & Hussey 2013). Throughout the research process, a holistic methodology to logically undertake the research is necessary to reduce the possibility of failures and pitfalls that a researcher may encounter (Kulatunga, Amaratunga & Haigh 2008). The research methodology design investigates the philosophical perspectives of the study, which aids in determining the overall research strategy (data collection, analysis, interpretation and drawing conclusions), and increasing the compatibility of research techniques and approaches by evaluating them by identifying their limitations (Kulatunga, Amaratunga & Haigh 2008). There are different models developed to demonstrate methodological design that should be adopted during a research. Kagioglou et al. (2000) propose the 'nested methodology' model comprising three layers of research philosophy, research approach and research techniques to follow for a holistic and logical research execution. Saunders, Lewis and Thornhill (2009) enlarge this 'nested' model of Kagioglou et al. (2000) by adding three more layers and come up with a theoretical model called the 'research onion' to define the overall methodology of a particular research. They (*ibid*) argue that layers of research philosophy, research approach, methodological choice, strategy and research techniques should be 'peeled away' in a systematic inquiry to understand the next procedure (refer to

Figure 4.1). This model offers a more detailed demonstration of the procedure than would the nested model. The research onion is the most recently developed concept to explain the methodological framework of research. Accordingly, 'the research onion' is preferred in this study as the framework to the research methodology.

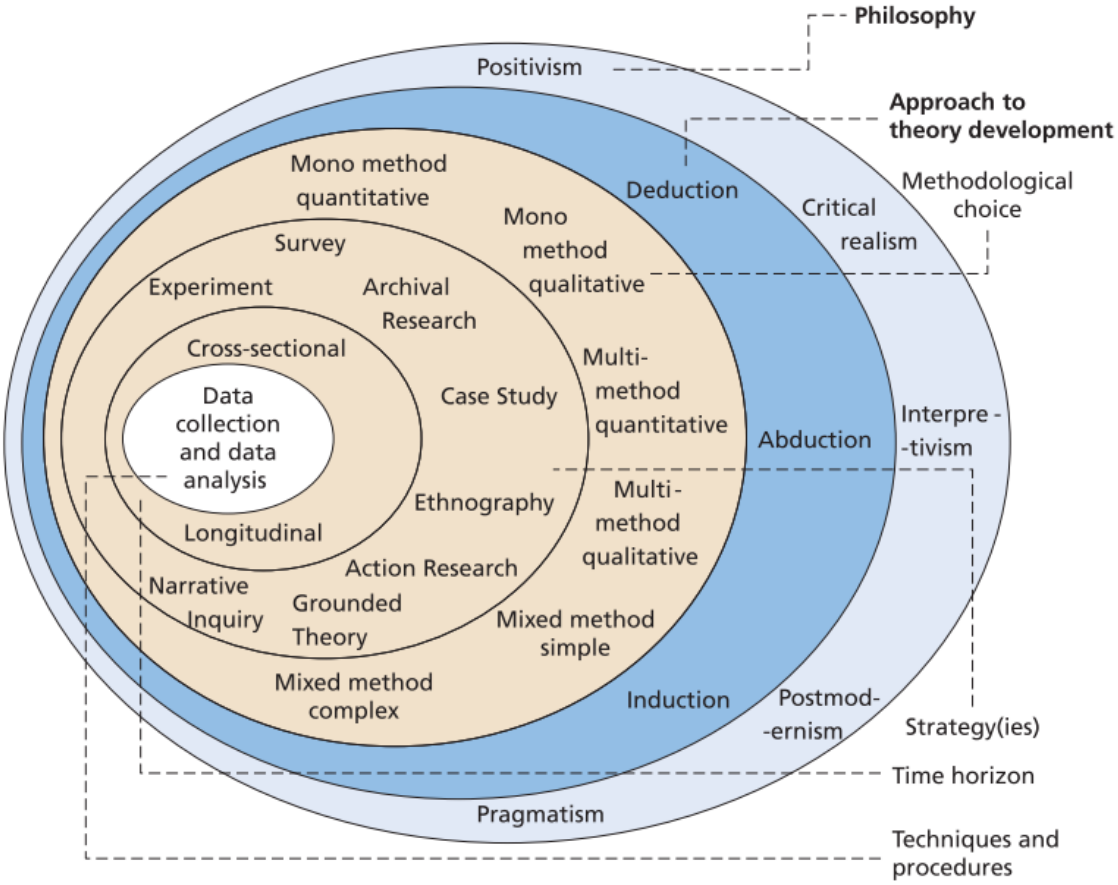

Figure 4.1. The research onion

(Source: Saunders, Lewis and Thornhill (2019, p.130))

The most outer layer of the research onion necessitates an exploration of philosophical stance through the lenses of existing paradigms. This assists the researcher in determining which approach is best suitable to the research topic and in selecting research techniques to perform the research.

4.3 Research philosophical assumptions: ontology, epistemology, and axiology

Understanding the philosophical commitments, which a researcher makes when choosing a research strategy is vital since it affects what the researcher does, and how the researcher comprehends the phenomena being investigated (Saunders, Lewis & Thornhill 2019). A research philosophy underpins the methodological choice of the research, research approach and the techniques of data collection and analysis (Crotty 1998). Research philosophy is

decided based on the assumptions of what, how and why questions a researcher must address throughout the research process (Ormston et al. 2014). Similarly, Saunders, Lewis and Thornhill (2019) opine a research philosophy as a set of beliefs and assumptions about the knowledge development. These assumptions come in three forms: ontology, epistemology and axiology (which cumulatively provide the basis for philosophy).

Ontological assumptions are the deep-rooted beliefs on nature of reality and truth (Brundrett & Rhodes 2010). These assumptions answer the 'what?' question, about the nature of reality and its characteristics and concern the researcher's assumptions about how the world operates (Kulatunga, Amaratunga & Haigh 2006). The spectrum of ontological assumptions has two extremes as objectivism and subjectivism (Saunders, Lewis & Thornhill 2019). Objectivism portrays an existence of a reality independent of the social actors, where the reality is external to the individuals observing them (Brundrett & Rhodes 2013). Conversely, in subjectivism the reality is a product of individuals' perceptions of the world and their actions, where the existence of the reality is not independent of the social actors (Saunders, Lewis & Thornhill 2019). **Epistemology** concerns the way of human knowledge construction, in particular its nature, origin, methods and limits (Fellows, RF & Liu 2015). These assumptions answer the 'how?' question about the acquiring and accepting the knowledge about the world (Kulatunga, Amaratunga & Haigh 2006). As with ontology two extremes are there in epistemology as positivism and interpretivism (Saunders, Lewis & Thornhill 2009). Having a similar meaning, these positions are named by Easterby-Smith, Thorpe and Jackson (2012) as positivism and social constructionism. At the 'positivism' end of epistemology, the scientific knowledge is the only valid and accepted knowledge (Burns & Groove 2014). A positivist is in an assumption that properties of reality are measured objectively rather than subjectively measuring them through sensation and reflection, as in 'interpretivism' (Easterby-Smith, Thorpe & Jackson 2012). Thus, an interpretivist is researching with the epistemological assumption of admiring the views and experiences of people rather than searching for external factors or casual explanations (Kulatunga, Amaratunga & Haigh 2008). Under interpretivism, the choice of how-to study is inferred subjectively based on the human beliefs and interests. **The axiological assumptions** explain the role of values in the research by bringing the researcher's own values. Axiology answers the 'why?' question, about nature of values that researcher placed on the knowledge and valuation judgements (Kulatunga, Amaratunga & Haigh 2006). The continuum of axiological assumptions is in between the two extremes of value-bound and value free (Saunders, Lewis & Thornhill 2019). A positivist is placed in the value free end, where the

researcher is independent from the data and arguments, while an interpretivist is at the other extreme, where the researcher's presence is apparent in the data and its interpretations (Creswell 2018b).

Based on the differentiations in the assumptions made in terms of ontology, epistemology and axiology different philosophical positions have been developed. (Saunders, Lewis & Thornhill 2019) identify Positivism, Critical realism, Interpretivism and Pragmatism as the major types of research philosophies. A comparison of philosophies against to the three basic assumptions of ontology, epistemology and axiology is presented in Table 4.1.

Table 4.1. Comparison of research philosophical positions
(Adapted from Burrell and Morgan (2019); (Saunders, Lewis & Thornhill 2019))

	Ontology: nature of reality	**Epistemology:** what constitutes acceptable, valid and legitimate knowledge.	**Axiology:** role of values
Positivism	External, objective, single reality, independent of social actors.	Only measurable and observable phenomena would produce credible and meaningful data, focus on causal relationships in data to create law-like generalisations.	Value-free.
Critical realism	Objective, external and independent.	Observable phenomena provide credible data, facts.	Value-laden.
Interpretivism	Multiple realities, multiple meanings, socially constructed.	Subjective and social phenomena.	Value-bound.
Pragmatism	External, multiple.	Focus on research questions. Either or both observable phenomena and subjective meanings would produce acceptable knowledge .	Value-driven.

4.4 The philosophical positioning of the research: interpretivism

In this section the ontological, epistemological and axiological assumptions were closely reviewed to determine the appropriate research philosophy of the study from the above-mentioned philosophical positions. Interpretivism was identified as the most suitable research philosophy for the current study (cf. Posillico et al., 2021; Roberts and Edwards, 2022; Bayramova et al., 2023). **Ontologically**, this study assumes that the reality is not pre-determined, however, socially constructed. The organisational BIM culture and the resultant changes in technologies and processes are not independent from organisations and cannot be detached from the operating organisational context and the individuals involved. Different BIM-enabled construction organisations have their own views, capabilities and

objectives regarding BIM; therefore, multiple viewpoints from individuals in various levels of organisations must be collated. Each individual perceives and experiences the reality of BIM implementation in the organisation differently. Individuals' perspectives of BIM use create the multiple realities that differ between people. Thus, the study believes that the world is socially constructed, and meaning is given by people creating multiple realties. These ontological beliefs are going in line with those in interpretivism philosophical stance.

The study accepts the **epistemological assumption** that knowledge can be gathered by examining people's views. Thus, acceptable knowledge is the subjective meanings and social phenomena, which helps the researcher to understand the rationale behind the behaviours. Concerning the culture within a BIM-enabled construction organisation, the present study conducts research on people's patterns of underlying beliefs rather than a positivistic search for absolute reality. People's beliefs and consequent behaviours create the reality of organisational BIM culture. This study encourages the free flow of opinions, ideas and different perceptions of people according to their experience with the BIM use. Hence, the human interaction with the BIM environment is the main driver of the study. Because the study sought out the different beliefs of BIM users within construction organisations and theorised the BIM culture formation based on them, the research is conducted from an interpretivist epistemological stance. Interpretivists accepts studies of people and their behaviours as legitimate sources of evidence that contribute to theory development. The **axiological assumptions** are considered value bound in this study. The study intends to interpret and investigate the subjective reality regarding BIM culture in construction organisations. This necessitates the close interaction of the researcher with BIM-enabled construction organisations, which makes the researcher inextricably linked with the phenomenon under investigation. The researcher's shape the research conducted and cannot be detached. Accordingly, interpretivism was identified as the most suitable research philosophy for the current study.

4.5 The philosophical stance as cultural research

In culture research, the philosophical position of the study can be set, seeing organisational culture in two ways: a variable or a root metaphor (Smircich 1983). Studies that view culture as a variable consider culture something an organisation 'has'. Thus, culture can be an internal or external variable or an independent or dependent variable. For example, culture is one of the organisational variables such as structure, strategy, members and technology contributing to organisation (Hammal 2006). The main goal of examining culture as a variable is to aid generalisability, causality, prediction and control (Smircich 1983). The two

organisational management research areas, such as ‘comparative management’ studies and ‘corporate cultural’ studies, view culture as a variable (Samaraweera, Senaratne & Sandanayake 2017). Comparative management studies typically examine patterns of beliefs, attitudes and managerial practises across different nations whereas corporate culture studies investigate cultural artefacts, including legends, rituals and ceremonies created as by-products of different organisational processes (Smircich 1983). Morgan and Smircich (1980) state that comparative management and corporate culture studies are on the ontological assumptions that the culture is a ‘concrete structure’ or ‘concrete process’. They (*ibid*) contend that such ontological presumptions in social science led to the epistemological position of positivist direct towards a philosophical stance of positivism.

As opposed to the notion that culture is a “variable,” it can also be seen as the “root metaphor” (Samaraweera, Senaratne & Sandanayake 2017). Studies that view culture as a root metaphor consider the culture as something that an organisation “is.” Smircich (1983) claims that culture studies are carried out at the organisational level while considering organisations as thought systems, forms of unconscious processes or patterns of symbolic thoughts. In this philosophical paradigm, the culture is thought of as the organisation itself. When culture is viewed as thoughts, it clarifies how the rules governing the organisation of tangible phenomena, objects, events, behaviours and emotions have been agreed upon by the organisation’s members. Observing the culture as unconscious processes assists in understanding the true origins of social structures by going beyond mere appearance and experience. The purpose of exploring culture as a root metaphor is to understand the fundamental questions of processes and meanings that make organisational life possible (*ibid*). Consequently, in culture research it is essential to determine the philosophical viewpoint of the study between two conceptualisations: culture as a variable or root metaphor.

Accordingly, one could argue that the research is more in line with the belief that culture constitutes unconscious processes of members in a BIM-enabled construction organisation. This is because this study seeks to illustrate how to reveal underlying beliefs of organisational BIM culture which entail unconscious psychological processes of the mind. Consequently, the study takes culture as a root metaphor, with the ontological assumption of reality as a social construction. Thus, the study’s research position is interpretivism, with culture as a root-metaphor as the cultural philosophical position.

4.6 Research approach: abductive approach

A research approach is chosen in such a way that it best answers the research questions and corresponds to the philosophical underpinnings (Blaikie & Priest 2019). According to Saunders, Lewis and Thornhill (2019), the extent to which a researcher is clear about the theory at the beginning of the research determines the research approach employed. They (*ibid*) identify the deductive and inductive approaches as viable to choose from based on the selected form of reasoning. This array of approaches are depicted in the research onion's second outer ring by Saunders, Lewis and Thornhill (2019). A deductive approach is adopted when the researcher tries to develop hypotheses based on theoretical considerations in relation to a specific domain and then tests them empirically. Inductive reasoning is adopted when a researcher tries to build theory from observing the empirical reality. Beside these two approaches, there is abductive approach, which is a combined approach of deductive and inductive approaches – abductive reasoning is akin to the metaphor of a detective, who gathers breadcrumb clues to generate practical conclusions of a phenomenon under investigation. Herein, this study follows an abductive approach, where the inductive approach is dominant. Inductive reasoning is used in the study to develop a in depth empirical understanding of the beliefs and behaviours of BIM users of construction organisations. With the use of deductive elements such as a conceptual framework, the risks associated with the induction approach, such as producing no useful ideas, data patterns or theories, are minimised.

4.7 Methodological choice: multi-method qualitative study

The third layer of the research onion that needs to be peeled away is the methodological choice (Saunders, Lewis & Thornhill 2019). This involves making a methodological choice among quantitative, qualitative research methods or mixed methods. Qualitative and quantitative methods are divided into two categories based on the number of data collection and analysis techniques used, which are mono-method and multi-method. As the name suggests, a single data collection technique and corresponding analytical procedure are used in the mono-method. In contrast, multiple data collection techniques and analytical procedures are used in the multi-method. Mixed methods, which combine quantitative and qualitative data collection and analysis techniques, are expressed in two categories: mixed method and mixed model research. Both qualitative and quantitative data collection and analysis techniques are used in mixed method research, with qualitative data analysed qualitatively and quantitative data analysed quantitatively. However, in mixed model research, these can be combined (*ibid*).

Each of these methods consists of a research strategy as well as data collection methods. Herein, quantitative methods rely on a variety of statistical techniques to examine the context numerically, whereas qualitative methods look at the meanings and relationships that exist within the context and analyse them in ways that emerge naturally from the process (Saunders, Lewis & Thornhill 2019). Quantitative research is often associated with positivism, representing a view of reality as an objective, external reality (Fellows, RF & Liu 2015). It demands a deductive approach, with an emphasis on using data to test a theory. This type of research employs experimental and survey research methods (*ibid*). On the contrary, qualitative research is commonly associated with interpretivism and represents a perspective on social reality (Fellows, RF & Liu 2015). This research method mainly takes an inductive approach to generate a theory using data. Since this study follows interpretivism as its philosophical stance and favours an inductive dominant research approach, it relies on qualitative methods to provide a comprehensive understanding of the context. Given the adoption of a case study strategy, with data collection methods of semi-structured , this study chose the multi-method from methods choices of mono method and multi-method. Accordingly, this study is a multi-method qualitative study. Figure 4.2 presents the methodological choice of the study.

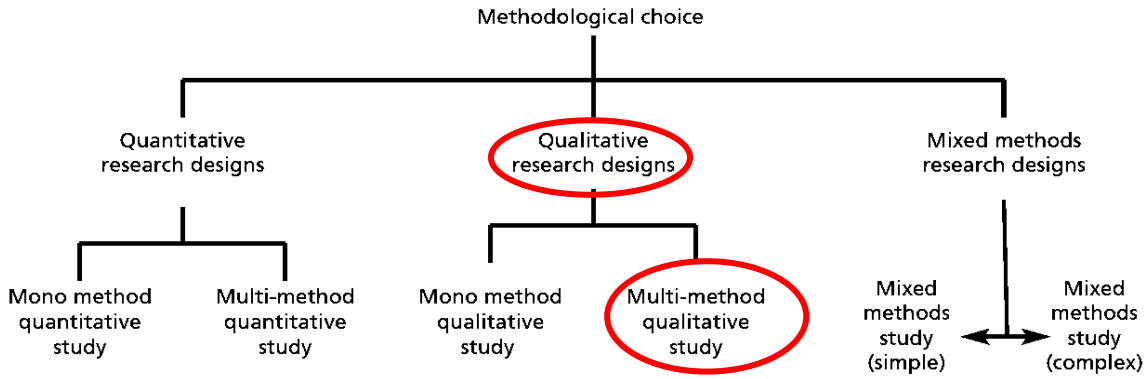

Figure 4.2. Methodological choice of the study

Qualitative research investigates the perceptions of people and their meanings through different research strategies (Bryman 2016). Thus, it is necessary to understand research strategies, which complement the qualitative method to select the most appropriate qualitative research strategy for this research.

4.8 Research strategy: case study method

A research strategy is a plan that a researcher uses to find answers to research question, which is also the methodological link between research philosophy and subsequent data collection and analysis methods (Denzin & Lincoln 2011). This constitutes the fourth layer of the research onion, and Saunders, Lewis and Thornhill (2019) lists survey, experiment,

archival research, action research, narrative inquiry, ethnography, grounded theory and case study as common research strategies. According to Creswell (2018b), the main strategies of qualitative research are grounded theory, narrative research, phenomenology, ethnography and case studies (See Table 4.2).

Table 4.2. Summary of strategies of inquiry used in qualitative research
(Source: Creswell (2018b))

	Narrative	**Phenomenology**	**Ethnography**	**Grounded theory**	**Case study**
Focus	Theory is developed from exploring life of an individual.	Theory is derived from the essence of the experience.	In-depth study of a particular culture/ culture sharing group.	Theory is developed from the grounded data.	In depth study of one or more cases.
Unit of analysis	One or more individuals.	Several individuals sharing an experience.	Group sharing a culture.	A process, or interaction among individuals.	An event, program or activity.
Data collection techniques	Interviews and documents.	Interviews observations and surveys.	Interviews observations and active participation.	Interviews and surveys.	Interviews Document analysis and observations.
Data analysis methods	Storytelling Content review and theme development.	Description of experiences, meanings and theme development.	Interpretation of data and theme development.	Data coding and themes categorisation .	Detailed themes identification and narratives.
The type of problem that is most suitable to be resolved	To tell stories of individual's life experiences.	To describe the interpretation of a shared experience.	To describe/ interpret the shared patterns of a culture.	To develop theory grounded in the participants' views.	To provide an in-depth understanding of a case or cases.

Narrative research is a method to explore the life of an individual. This strategy is best suited to capture life experiences of one or more individuals expressed in told stories, hence is includes studies of biography, autobiography and life histories (Flick 2018). In contrast to the narrative studies, **phenomenology** tries to explain live experiences of several individuals relating to a given concept or a phenomenon. This focuses on peoples' interpretations on events and their sense making about the personal experience. Thus, the narrative research is aimed to provide a narrative on a life of an individual while phenomenology is aimed to describe the real essence of the phenomenon experience (Creswell 2018b). **Ethnography**, as a research strategy necessitates that the investigator should become a part of social phenomenon being studied to understand the behavioural patterns (Fellows, RF & Liu 2015). This strategy uses participant observation to gain insights to determine beliefs, value structures, languages and cultural factors. **Grounded theory** develops concepts to describe

and explain the social phenomenon under study by building theory from scratch (Douglas 2003). This is achieved by entering the research field immediately when the research area is identified to collect and analyse data following the systematic inductive guidelines (Creswell 2018b). **Case study** is a widely used strategy to explore an in-depth experience to gain greater insights (Yin 2018). This is achieved through studying a problem through bounded system of one or more cases.

The introductions and the summary given to each of the qualitative research strategies earlier in this section provide their basic characteristics. Because this study seeks to derive cultural manifestations (patterns of underlying beliefs and behaviours) in organisational BIM culture (based on their views and perceptions of the employees in BIM-enabled construction organisations), it could be argued that the narrative research strategy is not chosen as they are well suited to analyse and interpret the live stories of one or a few individuals (Josselson 2006). Rather than limiting to the narrations by a small number of members, this research looked for responses of members of organisations for external adaptation and internal integration problems in their BIM environment, relying on multiple sources of evidence. Phenomenology was not the choice of strategy for the research since it is suitable to obtain an understanding of the meaning of experiencing a given phenomenon (Creswell 2018b). Hence, it can be concluded that narrative research (useful for investigating an individual's life) and phenomenology (effective in gaining insight into the meaning of experiencing a phenomenon) are not appropriate inquiry methods to be considered for this research.

From the remaining three strategies, ethnography is a suitable strategy to study a cultural group for a prolonged period (Easterby-Smith, Thorpe & Jackson 2012). However, in an ethnography study, the researcher should immerse themselves in the field to become a part of the under-study group. Due to the limited access to participant observation and unfeasible time limitations, the ethnography strategy is disregarded (*ibid*). The **grounded theory** is not best suited for this study because it entails developing a theory with little or no guidance from literature for the empirical study (Charmaz 2006). On the other hand, this study extensively reviews the literature on concepts of BIM and organisational culture to develop a conceptual framework to support the data collection process. Accordingly, a case study strategy is selected over other qualitative research strategies available.

Yin (2018) suggests three conditions must be met before deciding on a research strategy *viz.*: 1) research question type; 2) the extent of the control posed by the investigator on actual behavioural events; and 3) the degree of focus on historical or contemporary events. Accordingly, Yin (2018) explains that a case study approach is preferred when the research

questions are in the form of how and why. This study seeks answers to the research question of '*how to manage organisational BIM culture in BIM-enabled construction organisations towards a strong innovative BIM culture by uncovering its cultural manifestations?'* Hence, depending on the research question being addressed, the present study favours the case study strategy. As the second condition, when a researcher has little or no control over actual behavioural events and cannot manipulate the behaviour of those involved, the case study is the preferred research strategy. In this study, the investigator cannot control the behavioural events of the BIM-enabled construction organisations because they are outside the 'case' construction organisation and does not manipulate the behaviours of employees. Hence, this satisfies the second condition for selecting the case study research. Case study strategy is also suitable when the researcher focuses on contemporary phenomena rather than historical events (Merriam & Tisdell 2015). This study is related to the current perspectives of members in BIM-enabled construction organisations, hence requiring analysis of contemporary data and events.

The study must explore different underlying beliefs of individuals stemming from their shared experience on BIM within the organisation. Thus, a research strategy that allows gathering multiple perspectives and in-depth analysis to secure the meanings from individuals' perspectives is required. The case study strategy offers in-depth analysis of a phenomenon to uncover and determine the meanings of people's views (Patton, E & Appelbaum 2003). It is, therefore, perfectly suited to the present study. According to Proverbs and Gameson (2008), case studies are extremely relevant to an industry like construction, which includes various types organisations. Existing BIM related research has provided significant support to the use of case study strategy, such as understanding BIM implementation barriers in different contractor organisations (Siebelink et al. 2021), measuring the BIM maturity of construction organisations in Hong Kong (Lu et al. 2021), and developing a reference model to assess BIM capabilities using four construction companies as case studies (Yilmaz, Akcamete & Demirors 2019). Further, Alankarage et al. (2023) note that the use of case studies in BIM culture research is limited and there are more avenues for future research. This study, therefore, adopts a case study approach.

Despite the advantages of the case study strategy, it receives much criticism for the possibility of bias, low generalisability and small sample size (Gorard 2013). However, it can be argued that bias can be introduced into surveys and experiments if they are not properly designed (Kulatunga, Amaratunga & Haigh 2008). Even though the findings will not be generalisable, it is hoped that they will show some commonality between

organisations and thus, be relatable to other organisations in a similar context. According to Yin (2018), a case study approach accommodates the ability to use different research techniques such as observations, documentation and interviews. This increases the data's richness while also opening up the possibility of data triangulation (cf. Edwards and Holt, 2010), further strengthening the choice of case study as the research strategy (Kulatunga, Amaratunga & Haigh 2008).

4.9 Case study research design: holistic-multiple case study

The case study research design begins with determining the unit of analysis and the number of cases to be conducted (Kahkonen 2014). Yin (2018) suggested that case studies can be broadly classified as multiple and single and then as holistic or embedded. The basis for this categorisation is the number of units of analysis and the cases selected for the study. If a study was based on one unit of analysis, it was known as a holistic design. If the number of units of analysis is more than one unit of analysis, it is referred to as embedded.

4.9.1 Unit of analysis

Determining the unit of analysis in a case study is a challenge for both novice and experienced researchers (Baxter & Jack 2008). This is because the unit of analysis is the focal point to which the phenomena, variables and research problem all refer and for which data is collected and analysed (Collis & Hussey 2013). In a case study, the unit of analysis can be an individual, a group of people, a relationship or a process (Yin 2018). The following questions help to determine the nature of the unit of analysis:

- Does the researcher want to “analyse” the individual?
- Is it the researcher’s intention to “analyse” a programme?
- Should the researcher “analyse” the process?
- Does the researcher want to “analyse” the organisational differences?

Answering these questions can be a helpful strategy for clarifying the unit of analysis of the case study. Thus, the study’s unit of analysis was selected as the ‘organisational BIM culture’ which is a holistic study with a single unit of analysis.

4.9.2 Single case vs Multiple cases

Saunders, Lewis and Thornhill (2009) state that a single case is preferred in unique scenarios but requires strong justifications to show that the case is critical or unique. A single case study is best suited when: 1) the case is crucial for testing a well-developed theory; 2) the selected cases are typical or representative of the population; 3) the case represents a unique or an extreme case; 4) the case chosen is revelatory; or 5) the case is longitudinal, and the

same case is examined at more than one point of time (Yin 2018). A single case study was not considered because none of the aforementioned criteria met the requirements of the present research for studying the deeply held beliefs of individuals in a construction organisation. A multiple case study was chosen because the evidence from multiple cases is more convincing and thus, the findings generated are more robust than in a single case study (Creswell 2018b). Moreover, the multi-case design has the potential to generate more generalisability than single case studies. According to Merriam and Tisdell (2015) a multi-case study design is appropriate for gaining a thorough understanding of the context and details of each case, as well as identifying aspects that should be compared or contrasted across the cases. Therefore, considering the unit of analysis and number of the case selected, this research can be categorised as a holistic-multiple case design (Creswell 2018b). Figure 4.3 presents the case study research of the study.

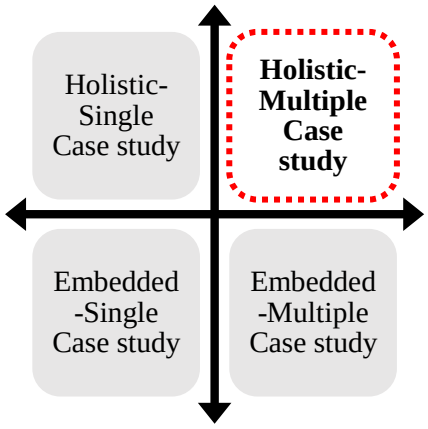

Figure 4.3. Case study research design of the study

(Adapted from Yin 2018)

4.10 Case study selection

According to Dubois and Gadde (2002) and Easton (1995) when conducting a multiple-case study, limited resources demand a trade-off between breadth and depth, as researching more cases may result in a shallower analysis. In such scenario, to effectively identify appropriate final number of cases within time and resource constraints, it is necessary to narrow down the number of candidates (Yin, 2014). However, the benefits of a multiple-case study may not be realised if fewer than four cases are examined (Creswell 2018a; Stake 2013). In accordance with these arguments, the current study chose four cases. Further, the sample size in the majority of qualitative studies is usually premised upon the concept of the saturation point which is reached when new data collection does not shed any further light on the problem under investigation (Mason 2010; Merriam & Tisdell 2015). So, at the saturation point, it becomes counterproductive because nothing new is added to the overall

theory, story, model or framework. In multiple case studies, the number of cases is determined by the "replication" logic (Yin 2018). This is different from the "sampling" used in surveys. The replication is twofold; literal replication and theoretical replication (Yin 2018). The literal replication is based on similar results, whereas the theoretical replication is based on contrasting results but for foreseeable conditions. This study selects organisations with different maturity levels of BIM, assuming that organisations in higher maturity level have strong innovative BIM cultures compared to organisations with lower BIM maturity. To achieve this, the researcher has selected four case studies, with two cases from each end of the BIM maturity spectrum, i.e., low and high maturity groups to conduct a comprehensive analysis of the organisational BIM culture. The study follows both theoretical replications; where two cases are selected from the same maturity level, and lateral replication, where two cases are selected from each maturity level.

4.10.1 Screening the candidate cases: one phase approach

Selecting the final cases to be studied in a case study is a crucial preparatory step. There may be multiple qualified case candidates, and the researcher must choose the final case or cases from among them (Yin 2014). The screening procedure is aimed at ensuring that the final cases are identified properly before formal data collection begins. It is essential to choose the right case or cases before data collection because it can be detrimental to the research if the case turns out not to be viable or represents something different from what the researcher intended to study (Pan & Tan 2011). The selection process must be thorough and aligned with the research objectives to avoid any mishap during the study. This study followed the one phase approach proposed by (Yin, 2014) to screen suitable cases for the study. The process begins by gathering a small amount of information by interviewing people who are knowledgeable about each candidate case. However, it is critical to avoid conducting a lengthy screening process that turns each candidate into a mini-case study. The steps that were taken are detailed below.

1. **Develop criteria for case selection**: before screening potential cases, a set of criteria is established that will be used to determine whether a case is suitable for the study. These criteria should align with the research questions and study's objectives.
2. **Create a list of candidate cases**: a collection of potential cases is created that meet the established criteria. This list can be compiled through various sources, such as literature reviews, expert consultations or organisational databases.
3. **Screen potential cases**: each potential case is evaluated against the established criteria to determine which ones are suitable for in-depth study. This screening

process can involve reviewing available documentation, conducting preliminary interviews, or querying knowledgeable individuals.

4. **Select cases for in-depth study**: After screening potential cases, the most appropriate ones for in-depth study is selected. The final selection should be based on the established criteria and the potential for the case to provide valuable insights into the research questions.

Prior to selecting case studies, preliminary interviews were conducted to gather initial insights and information about the companies that use BIM, as a guide to identify potential cases. The preliminary study used structured interviews as the technique to collect necessary data. According to Saunders, Lewis and Thornhill (2019), structured interviews have the advantage of providing a higher level of response because the researcher can elaborate on the research purpose and goals, as well as explain each question in detail. Interviews were conducted with one managerial level personnel from a single construction firm with a broad overview of BIM developments within their organisation. To select interviewees, the purposeful sampling technique was used. Purposive sampling entails the deliberate selection of individuals based on their ability to provide critical information about the deployment of innovation in construction firms (Padgett 2016). Additionally, during the interview aspects such as types of BIM projects involved, scale and structure of the company (*viz.*: size, annual turnover, number of employees). Recent studies have used different BIM maturity matrix to decide BIM maturity levels of construction firms. For instance, Lu et al. (2021) assess the BIM maturity in Hong Kong based construction company using a multifunctional BIM maturity model. Moreover, Siebelink et al. (2021) use a matrix to measure BIM maturity in a large contracting firm – a similar approach was used in this present study. The candidate case selection process and selection of final cases for this present study is further elaborated in the next section.

4.10.2 Objectives of the preliminary interviews survey

Prior to selecting case studies, conducting a preliminary interview survey is a common approach to gather initial insights and screen potential candidate cases (Pan & Tan 2011). Further, Yin (2014) suggests a one-phase approach to screen case studies, which involves: developing criteria for case selection, creating a list of potential cases, screening potential cases and selecting the most appropriate ones for in-depth study. A one-phase approach provides a systematic and efficient method for screening potential case studies and selecting the most appropriate ones for in-depth study. It also ensures that the cases selected align with the research objectives and provide valuable insights into the phenomenon being studied.

Hence, a preliminary interview survey was conducted with respondent from BIM-enabled construction companies, with an aim to achieve following objectives, *viz.*:

- to shortlist the BIM-enabled construction companies as case studies; and
- to find the BIM maturity level of each eligible case organisation.

4.10.3 To shortlist the BIM-enabled construction companies as case studies

The preliminary study started with reaching out to construction firms, which use BIM. Companies were found using two methods, namely: database searches; and inter-relationships. Initially, databases were searched using keywords related to the topic of BIM use, BIM project, BIM contractors and BIM in Australia. Additionally, the professional online network 'LinkedIn' was used to search for BIM using construction companies and establish connections with them. Company information, such as phone numbers, websites, email addresses and maps, could be easily accessed through LinkedIn. Furthermore, BIM-enabled companies were identified through networking events organised by BIMSA and NAWIC (National Association of Women in Construction). Through these events, connections were made with organisations and contacted for the study. Nine companies agreed to participate in the study and reached out through emails, telephone and in-person contact. It is also essential to define a set of operational criteria for selecting candidates before collecting the screening data (Yin, 2014). Thus, the following criteria were considered when selecting cases:

- Large (Tier 1) Contractor construction organisations in Australia.
- Construction organisations, which operate state-wide.
- Each case organisations had to use BIM.
- Each firm was required to have used BIM in a number of their construction projects (more than 3 projects).

In this study, the researcher conducted nine structured interviews to collect data. One managerial level personnel were interviewed from each construction firm. Out of the total interviews, five were conducted through the Zoom online platform due to Covid 19 constraints and geographical distance, while the remaining four interviews were face-to-face. The structured interview method was employed to ensure that the same set of questions was asked to all participants, which makes the data collection process more standardised and reliable. Table 4.3 summarises the background information on candidate cases and respondents.

Table 4.3. Background information on candidate cases and respondents

	Candidate cases								
Case	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Respondents (R)	R1 General Manager	R2 IT Manager	R3 BIM Manager	R4 Lead Digital Engineer	R5 BIM Manager	R6 Senior Design Manager	R7 IT Manager	R8 BIM Manager	R9 Digital Engineering Manager
Size of the company	Large	Large	Large	Large	Large	Large	Large	Large	Large
Annual turnover	$800m	> $1bn	$1.2bn	> $1bn	> $1bn	$800m	$1.8bn	> $1bn	$1bn
No of employees	>240	>240	>240	>240	>240	>240	>240	>240	>240
BIM projects	Health projects, public-school projects.	Health projects, university projects.	Shopping centre projects, health projects, university projects.	Health projects, library project.	Health projects, stadium redevelopment.	Shopping centre projects.	Metro project.	Shopping centre projects, defence projects, airport project, road project.	Library project.
Years in business	>40	>70	70	>40	>50	>40	>80	>100	>70

4.10.4 To find the BIM maturity level of each eligible case organisation

To evaluate the BIM maturity level of each company, a systematic and structured approach was employed using a maturity matrix. Within the construction industry context, various BIM maturity models have been introduced, each with its focus, some targeting BIM assessment at the project level, while others concentrating on evaluating organisations as a whole (Dakhil, Alshawi & Underwood 2015; Smits, van Buiten & Hartmann 2017). In this study, the research aimed to assess the maturity level of contractor organisations, which led to a comprehensive review of relevant BIM maturity models. A recent systematic review conducted by (Alankarage et al., 2022) revealed three contractor-focused BIM maturity models: BIM Road Map (Khosrowshahi & Arayici 2012), BIM Maturity Tool (Siebelink, Voordijk & Adriaanse 2018) and BIM Quick Scan (Sebastian & Van Berlo 2010). Accordingly, these models were carefully reviewed to find the structure of BIM maturity levels and the criteria used to assess different aspects of BIM implementation in organisations. The key BIM maturity elements identified from the review included organisational mission and goals, BIM vision and objectives, BIM champion, protocols, software, hardware, roles and responsibilities, education, training and change readiness. It was observed that a common practice among these models was the utilisation of six BIM maturity levels, spanning from non-existent to optimised, allowing for a graded assessment of BIM implementation (Alankarage et al., 2022). Subsequently, a maturity matrix was developed, mapping the identified BIM maturity elements to the different maturity levels. The matrix was structured with rows representing the BIM maturity elements and columns representing the distinct levels of BIM maturity. This matrix serves as a fundamental tool to systematically evaluate and categorise the BIM maturity level of each construction organisation participating in the study. The developed organisational BIM maturity matrix is presented in the Table 4.4.

Table 4.4. Organisational BIM maturity matrix

	Low BIM maturity			High BIM maturity		
Maturity level	**0 Non-Existent**	**1 Initial**	**2 Managed**	**3 Defined**	**4 Quantitatively Managed**	**5 Optimizing**
Organisational Mission and Goals	No organisational mission or goals.	Basic organisational mission established.	Established basic organisational goals	Mission address purpose, services, values (at a minimum).	Goals are specific, measurable, attainable, relevant, and timely.	Mission and goals are regularly revisited, maintained and updated .
BIM Vision and Objectives	No BIM vision or objectives defined.	Basic BIM vision is established.	Established basic BIM objectives.	BIM Vision address mission, strategy.	BIM objectives are specific, measurable, attainable, relevant, and timely.	Vision and objectives are regularly revisited, maintained and updated.
BIM Champion	No BIM Champion.	BIM Champion identified but limited time committed to BIM initiative.	BIM Champion with adequate time commitment.	Multiple BIM Champions with each working group.	Executive level BIM support Champion with limit time commitment.	Executive-level BIM Champion working closely with Working Group Champion.
Protocols	No external project BIM processes documented.	Basic BIM process documented for each party.	Integrated high-level BIM process documented.	Detailed BIM process documented for primary BIM uses.	Detailed BIM process documented for all BIM uses.	Detailed BIM process documented and regularly maintained and updated.
Software	No BIM software.	Software capable of accepting BIM data.	Facility data defined and standardised within the organisation.	Advanced BIM software systems.	All software systems available to all personnel.	Program established for continuous updating of BIM software systems.
Hardware	No Hardware capable of running BIM software.	Some hardware capable of running basic BIM software.	Facility data defined and standardised within the organisation.	Some advanced hardware systems with the organisation.	All organisation hardware is capable of running advanced BIM software.	Program established for continuous updating of BIM hardware systems.

	Low BIM maturity			High BIM maturity		
Roles and Responsibilities	No roles and responsibilities documented.	BIM is the responsibility of the BIM Champion.	BIM is the responsibility of the interdisciplinary BIM group.	BIM responsibility lies with each operating unit.	BIM responsibility lies with each person.	BIM Responsibilities are regularly reviewed to ensure they are properly distributed.
Education	No education program.	Ad hoc education as needed.	Formal presentations on what is BIM, and the benefits is has for the organisation.	Regularly conducted employee education sessions.	On-Demand education program established for the organisation.	Education is seamlessly improved through lessons learned within the organisation
Training	No training program.	Training program run by vendors - only for necessary personnel.	Internal training program for all personnel that may interact with BIM.	Regularly conducted and routine training programs.	On-demand training program established for the organisation	Training is seamlessly improved through lessons learned within the organisation.
Change Readiness	No change readiness awareness.	Established need for BIM.	Upper management buy-in.	Operating unit buy-in.	All individuals buy-in.	Willingness to change is part of the culture of the organisation.

During the interview process, each company was presented with the BIM maturity matrix and asked to select the cell that they deemed most relevant to their organisation's BIM maturity level. Thus, the matrix was formulated to gather information about the current organisations of the interviewees, aiming to prevent any potential individual bias in their responses. Subsequently, the company's actual maturity level was determined by thoroughly evaluating whether it met the criteria specified for the selected cell. The tool used a *strict step* principle to evaluate the maturity level of each criterion, where all elements of a particular maturity level description must be fulfilled before moving on to the next level (Lu et al. 2021; Siebelink, Voordijk & Adriaanse 2018). For example, if a company did not meet all aspects of Level 3, even if it satisfied all the criteria for Levels 4 and 5, it would still be evaluated as having a maturity level of Level 2.

An example of Case 2 organisation's selections from the matrix is provided in Table 4.5. Despite having some elements that align with Level 3, Case 2 does not fully satisfy all the criteria for Level 2. Consequently, it was determined that the BIM maturity level of Case 2 organisation is at Level 1. This decision was made based on the strict step principle, which requires fulfilling all the elements of a particular level and those of the preceding levels to be categorised at that level. Table 4.5 provides a concise overview of the BIM maturity level of each organisation participating in the study.

Table 4.5. Summary of BIM maturity levels of cases

Organisation	**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 5**	**Case 6**	**Case 7**	**Case 8**	**Case 9**
BIM maturity level	Level 2	Level 1	Level 3	Level 4	Level 2	Level 2	Level 1	Level 3	Level 2

In addition to identifying the BIM maturity levels of each organisation, the study further classified the nine organisations based on their fulfilment of criteria in levels 0-3 of the matrix as the low BIM maturity group. Conversely, organisations that met the criteria in levels 4-6 were categorised as the higher BIM maturity group. This classification approach is commonly used and has been applied in other studies, such as the one conducted by (Prabhakaran et al. 2021). Based on the outcomes of the initial assessments of BIM maturity levels for the nine organisations, the researcher selected two organisations with low BIM maturity levels and two organisations with high BIM maturity levels as the final cases for the study - refer to Figure 4.4. Furthermore, before conducting the full-scale study with the chosen organisations, a pilot case study was performed with one of the nine organisations.

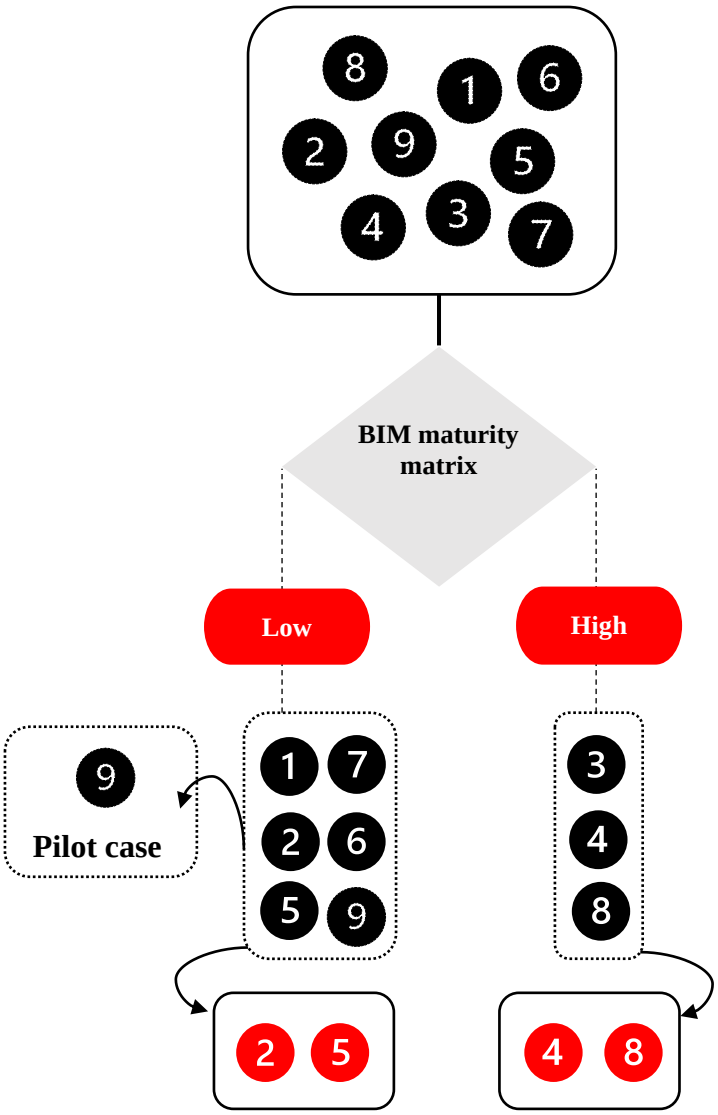

Figure 4.4. Final cases screening process

4.11 Time horizon: cross-sectional

The fifth layer of the research onion is the time horizon which can be either cross sectional or longitudinal. Cross-sectional research represents a snapshot of a specific time period, whereas longitudinal research is a collection of snapshots taken over time (Saunders, Lewis & Thornhill 2019). This research is being conducted to strict university guidelines for timely data collection and presentation of findings and therefore, conducted as a cross-sectional study.

4.12 Research techniques and procedures: data collection

Once all the outer layers of the research onion are peeled away, the core or the innermost layer is the research techniques and procedures. Noor (2008) describes six data collection sources for the case study strategy: documentation, physical artefacts, interviews, participant

observations, direct observations, and archival records. In general, case study research necessitates the use of multiple sources of evidence to construct validity (Kulatunga *et al.*, 2006). Triangulation is enabled by collecting empirical data from multiple sources (Edwards & Holt 2010). Using multiple sources of empirical data in a case study method is best understood as a strategy for increasing the study's rigor, breadth, complexity, richness and depth (Rashid et al. 2019). As a result, three of the data collection techniques, i.e., interviews, documentation and observations were chosen as the most appropriate and feasible for use in the study and the rationale behind the selection is summarised in Table 4.6.

Table 4.6. Data collection techniques and rationale behind the selection

Data collection technique	**Rationale**	**Authors (year)**
Primary Semi-structured interviews.	Provide rich, and thick descriptions needed for cultural study.	(Denscombe 2010; Denzin & Lincoln 2011; Flick 2018).
Secondary Direct observation.	Minimal researcher intervention Allows to identify behaviours, artifacts, and creations.	(Merriam & Tisdell 2015; Yin 2018).
Documentation.	Observable, permanent records Non-reactive data source historical insights.	(Bowen 2009; Merriam & Tisdell 2015; Yin 2018).

The interviews were chosen because this study attempts to investigate a cultural phenomenon that is little known and requires further investigation (Denzin & Lincoln 2011). The primary technique to collect data was selected as the semi-structured interviews. Flick (2018) opines that the semi-structured interviews attract the researchers' interest and allow them to extract the interviewees' views through an openly designed interview. This is more advantageous than standardised structured interviews or questionnaires. In a semi-structured interview, the interviewer has a clear list of topics to cover and critical questions to answer but is willing to be flexible in the order in which these are addressed. Semi-structure interviews allow the interviewee to develop ideas and have the freedom to expand on important topics (Denscombe 2010). Further, this study adopted observations, documentation (secondary data collection techniques) to complement the data collected through semi-structured interviews.

The observations in research allows for a one-of-a-kind view of events and behaviour in the workplace of the interview participants (Bryman & Bell 2003). According to Yin (2018), observation techniques are two folds as direct and participant observation. In direct observation, the researcher does not intend to participate in any of the events under investigation and only observed passively, whereas in participant observation the researcher

participates in a role in the context under consideration. This study followed the techniques of direct observation, and the observations are carried out in the interviewees' offices. Observations were centred on organisational level BIM use to understand the organisational BIM culture. This was done with the case study's boundaries in mind, such as the time constraints of the research and permissions available. An observation guideline was developed to record information during the observation process. This consisted of two separate sections. One section took descriptive notes (descriptions on activities, events and physical settings), and the other section took reflective notes (i.e., personal thoughts of the researcher-feelings, impressions and ideas). The researcher made notes on the building's layout, furniture, spacing and equipment for each visible department. Notice boards with announcements and work schedules were also observed. These boards display the cultural information manifested as the organisation's visions and values.

Documentation was also used as a secondary source to triangulate the obtained data through semi-structured interviews, adding an additional layer to the cultural artefacts discussed in the study. This was chosen as an efficient data collection technique because it is less time consuming, non-reactive, economical, stable and widely available (Bowen 2009). Moreover, Yin (2018) emphasises that "*for case study research, the most important use of documentation is to corroborate and augment evidence from other sources."* According to Merriam and Tisdell (2015), to discover relevant and useful documents an open mind must be kept and documents should evolve around the research topic. In the present study, the documentation was carried out with the documents reflect the BIM use and maturity level of the construction organisations. The same protocol used to collect observation data was also used to record document data. The following documentation were reviewed: meeting minutes, written protocols, BIM implementation/execution plans, home page for company website, electronic media produced by the company and organisational structure. Purposeful random sampling was used to select the documents, which adds credibility to qualitative studies even with small samples (Patton, 2014).

4.13 Ethical considerations

In the area of social sciences research that explores human interactions, it is crucial to prioritise ethical considerations, which can be understood simply as adherence to moral values (Brittain et al. 2020). Therefore, prior to commencing data collection, it is critical to secure the ethics clearance and comply with the ethical principles to respect the participant's rights and values (Rashid et al. 2019). The National Health and Medical Research Council (2007) emphasises

that maintaining the appropriate standards, language, and procedures during human-centric research safeguards the rights, welfare and dignity of research participants.

The ethical considerations suggested by Patton, Michael (2014) were followed as a checklist which delineates the study's aim and focus, securing informed consent and ensuring confidentiality. Accordingly, in formulating the guidelines for data collection in the present study, paramount attention was given to fundamental ethical principles, including trust, accountability, mutual respect, and fairness. The University of South Australia's Human Research Ethics Committee granted ethics approval for the current project on 04/06/2021.

In accordance with the ethics clearance, prior to commencing data collection, an information sheet explaining the purpose of the research, nature of participants' involvement and the study's benefits was provided to each participant. Then a written, signed informed consent form was obtained from the participants to acknowledge that they understand the interviews are audio-recorded for the research purposes (cf. Fisher et al., 2018; van de Meij et al., 2021; Law et al., 2021). The participants were advised that data anonymity and confidentiality are carefully adhered to (cf. Ahmed et al., 2021; Ellis et al., 2021). Throughout the process of data analysis and write-up, pseudonyms were employed for the interviewees to ensure the preservation of their confidentiality and anonymity. The researcher maintained full accountability by reporting the findings from the data collection as the primary data without making any alterations.

4.13.1 Case study interview guideline structure and the process

An interview guideline was developed based on the conceptual framework presented in Chapter 3 entitled research framework (refer to Appendix 1(B)). Using a guide to conduct interviews in a case study improves flexibility to follow different topics in greater depth (Patton, Michael 1990). The questions on the interview guideline were structured to derive responses to internal integration problems and external adaptation problems of the BIM users in construction organisations. The interview guideline follows the classification questions by Patton, Michael (1990) and ethnographic questions by (Spradley 2016). This enabled the interview questions to be sequenced in an appropriate order to improve the quality of the data gathered through interviews. (Patton, Michael 1990) distinguishes question types to be asked in an interview to secure an appropriate response as: demographic questions, knowledge questions experience and behaviour questions, opinion questions and feeling questions. Table 4.7 presents sample questions from the interview guideline mapped to ethnographic interview

questions. The interview questions began by asking background questions about the respondent and their company. Following that, the questions dealt with experiences, behaviours, opinions and events in present, past and future were included - focusing internal integration and adaptation issues. The interview process further discussed in Chapter 05 Pilot case study.

Table 4.7. Example interview questions mapped to different ethnographic interview question types

Question types	Description	Example questions from the interview guideline
Demographic questions	Background questions to identify the characteristics of the interviewee. The responses to these questions assist the interviewer in locating the respondent in relation to other people.	Section A: 2. How long have you been with current organisation and how long have you been working with BIM?
Knowledge questions	Questions to probe the respondent's factual knowledge or what the respondent knows.	Section B: 2. Which BIM tools or systems have you used?
Experience and behaviour questions	Questions about what a person does or has done in relation to a specific topic.	2.3. Have you come across any issue related to BIM systems and processes (software/Hardware/ Networks)? What do you do to address these issues? Who do you contact? What kind of tools and methods you have used? How you use them?
Opinion questions	Questions about opinions, judgments, and values to better understand people's cognitive and interpretive processes.	13. Do you think your language and way of thinking have changed since your organization adopted BIM?
Feelings questions	Questions, which are designed to elicit emotions—emotional people's reactions to their experiences and thoughts.	16. Can you recall what it was like to start using BIM? How did you feel it? Do you believe that BIM will result in improving construction practices?

In each case, the interviews were conducted with the participation of six key members from each organisation. Herein three personnel were selected from the managerial level and three from the operational level, each with a minimum of five years of industry experience and one year of experience with BIM. According to Kumar, Stern and Anderson (1993), informants should not be chosen to represent the members of a studied organisation but rather based on their knowledge of the research issues and their willingness and ability to communicate about them. Therefore, senior managers were chosen due to their involvement in strategic processes and routines and their understanding of the outcomes that the study aims to investigate (Gajendran et al. 2014). Operational level employees are typically the ones who have direct experience with using BIM software and tools, and therefore can provide valuable insights into

the practical implications and challenges (Murguia et al. 2023). Perspectives from various hierarchical levels of the organisation allows to assure internal data validity (Eisenhardt & Graebner 2007).

The study used both purposive and snowball sampling techniques to select potential interviewees for the research. Purposive sampling is employed if a study necessitates the identification of cases that are rich in information and possess extensive knowledge related to the area of investigation (Palinkas et al. 2015). Purposive sampling was employed specifically targeting the managerial level personnel. Contacting the managerial level people first assisted in finding more participants because of their large network of interconnected and informed contacts and the decision-making power in the organisation. The snowballing technique was employed to incorporate participants into the study, whereby at the end of each interview, respondents were requested to refer their colleagues experienced with BIM for voluntary involvement in subsequent interviews. This technique is suitable when the researcher is unfamiliar with the field and thus, lacks the necessary knowledge and connections to recruit personnel based on their eligibility, gaining access to participants and retaining participants until the study is completed (Biernacki & Waldorf 1981). The researcher participated to BIM networks events hosted by BIMSA, to establish connections with industry people. All interviews conducted were tape-recorded with the consent of the interviewees using a digital voice recorder. According to Saunders, Lewis and Thornhill (2009), recording interviews sometimes prevents interviewees from disclosing confidential information. Nonetheless, it brings advantages, of the ability to accurately transcribe the interviews, enabling the interviewer to focus solely on the questions during the interview, and direct quoting from the interviewee when presenting the findings, which ultimately enhances the study's reliability and validity. Interviews were limited 45- 60 minutes.

4.14 Pilot case study

Prior to the actual data collection, a pilot case study was conducted. A pilot study is a small-scale version of an anticipated study that is carried out with a small group of participants who are similar to those who will be recruited later in the actual study (Doody & Doody 2015; Kim 2011). Pilot studies are carried out to allow researchers to test and refine their planned data collection and analysis techniques (Hassan, Schattner & Mazza 2006). The main advantage of accompanying a pilot study is that it allows researchers to make changes and revisions to the main study (Kim 2011). A pilot study identifies problematic areas and deficiencies in the research protocol and instruments prior to full study implementation (Hassan, Schattner &

Mazza 2006). When selecting a pilot case, the main criteria to select a case are convenience and access to the data collection (Yin 2018). The pilot case investigation can have a much broader scope than the final case and the pilot case investigation can address both substantive and methodological issues. The research process to decipher underlying beliefs requires an in-depth inquiry, which is subjective and difficult. Carrying out a pilot case was vital as to explore the viability of the interview questions and to rehearse in-direct questions to get the maximum from the interviewees. This allowed the researcher to improve their interviewing approach, transcribing skills and data-analysis skills to derive behaviours and beliefs from collected data. As for the real case, the pilot case study was conducted interviewing five members of BIM-enabled contractor company.

4.15 Research techniques and procedures: data analysis

Data analysis is heavily reliant on the researcher's empirical thinking and interpretation style, and consists of a process of investigating, categorising, organising and testing quantitative and qualitative evidence to address the study's initial propositions (Yin 2018). Selecting appropriate data analysis techniques and procedures ensures that the collected data is properly handled and produces sound and convincing analytical conclusions. This study used thematic analysis to analyse the collected primary data. Prior to data analysis, audio recorded semi-structured interviews were transcribed and transcripts were reviewed again for completeness and accuracy. Then, following the thematic analysis techniques case studies were analysed considering both within-case analysis and cross case analysis.

4.15.1 Thematic analysis

Thematic analysis was undertaken as the primary data analysis method for this study. It is a process for methodically discovering, organising and providing insight into meaning patterns in a data set (Braun & Clarke 2012). This choice was made because thematic analysis can search for patterns in the data collected and can connect them to meaningful themes that capture the topic under investigation (Braun & Clarke 2012). This method of data analysis is commonly adopted to investigate and derive themes in qualitative data (Fereday & Muir-Cochrane 2006). The qualitative data analysis computer software package NVivo 20 produced by QSR international was used to assist the thematic analysis. NVivo improves the quality of the research through its advanced data handling and manipulation features, which reduce manual tasks and save time in the data analysis process (Hilal & Alabri 2013). This software allows for a thorough and comprehensive data analysis, while ensuring replicability and transparency in data analysis. Easy access to the codes in NVivo, makes revisions much easier and with

NVivo codes can be readily retrieved, ensuring consistency while avoiding duplication. Overall, using NVivo enabled the researcher to spend less time on clerical tasks related to data handling, thus providing more time for the actual analytical procedure. The PhD program's strict time constraints also required an expedient data analysis phase, which provided inspiration for using NVivo. Moreover, (Braun & Clarke 2012) identifies an approach with six phases to thematic analysis *viz.*: 1) familiarizing with data; 2) generating initial codes; 3) searching for themes;, 4) reviewing potential themes; 5) defining and naming themes; and 6) reporting themes. This six-phase approach was adopted in this study. The data analysis process is further explained in the Sub section 5.2.4 in Chapter 05 Pilot case study.

4.15.2 With-in case analysis

In the with-in case analysis technique the data from responses within each case are analysed to discover with-in case patterns (Yin 2018). Within case analysis captures the uniqueness within individual case and provides a wealth of contextual richness that is required to understand the case (Ayres, Kavanaugh & Knafl 2003). Using the with-in case analysis in the research increases familiarity with the case data and reveal unique patterns in each case before generalising these patterns across cases. According to Eisenhardt (1989) there is no standard format for a with-in case analysis and the presentation could be graphical presentations, narrative descriptions or tabular displays. The analysis within each case was conducted for all four cases, adhering to three levels of coding, namely open coding, axial coding and selective coding as proposed by (Douglas 2003). With-in case analysis was conducted to derive underlying beliefs, patterns of underlying beliefs and behaviours of organisational BIM culture in Cases A, B, C and D.

4.15.3 Cross-case analysis

Cross-case analysis is a technique more relevant in analysis of multiple-case studies, which aggregate findings from a series of individual cases. This follows a case-based approach that compares or synthesises any within-case patterns across the cases while preserving the integrity of the entire case (Yin 2018). These cross-case comparisons examine whether there are further literal and theoretical replications. A cross-case analysis requires investigators to look beyond first impressions and examine evidence through multiple lenses (Eisenhardt 1989). In the cross-case analysis the evidence from all four cases (A, B, C and D) were analysed together in terms of the underlying beliefs, patterns of underlying beliefs, and patterns of behaviours. The analysis of the underlying beliefs and patterns of underlying beliefs delineated the conditions that give rise to weak, moderate, and strong innovative BIM cultures. Based on this analysis, a

diagnostic tool was developed, to dissect the innovative BIM culture in a spectrum of weak to strong. Based on the cross-case analysis of patterns of behaviours strategies were deduced to promote a strong innovative BIM culture. Finally, encompassing all the findings and analysis a framework was developed to manage construction organisations towards a strong innovative BIM culture.

The developed framework was validated and refined through qualitative semi-structured interviews with four BIM experts. The interviewees were asked to validate the practicability of the framework to construction organisations based on criteria; fit, applicability, logic and depth. The data was analysed through thematic analysis. Chapter 11 of this thesis presents the discussions regarding the validation of the framework.

4.16 Trustworthiness of the study results: credibility, transferability, dependability and confirmability

When designing their studies, qualitative researchers are concerned with the concept of trustworthiness (Shenton 2004). The trustworthiness of study results must be considered in the study's design and analysis to ensure research quality. In quantitative studies, the concept of trustworthiness is explained as validity and reliability (Lincoln & Guba 1985). Even though different terms are used in different contexts, the concept was developed on the aspects of truth value, applicability, consistency and neutrality. Yin (2018) identifies four tests for confirming validity and reliability in case study research: construct validity, internal validity, external validity and reliability. Lincoln and Guba (1985) maintain that these terms are inappropriate in qualitative research and instead use terms such as credibility, transferability, dependability, and confirmability.

4.16.1 Credibility-internal validity, truth value

The concept of credibility involves the process of instilling confidence in the accuracy of the results obtained from a specific investigation (Lincoln & Guba 1985), thereby substantiating its credibility. Credibility of the research results was enhanced in this study in different ways.

- Interviews were conducted with different people from hierarchical levels of the organisation (managerial and operational).
- Engaging well-experienced participants (industry and BIM) in the interviews.
- Use of three types of data collection techniques including semi-structured interviews, observations and documentation, which allowed to emerge same data from various sources. This led to proper data triangulation thus, increased the credibility of the results

- Throughout the study, field notes were kept, and analysis took place concurrently to data collection, enabling a continuous focus refinement for subsequent data collection.
- The comparison of findings against the broader body of literature was done under the discussion chapter.

4.16.2 Transferability- external validity, applicability

Transferability involves assessing how applicable the results of a specific study can be to other contexts and corresponds to the concept of generalizability commonly used in quantitative research (Merriam & Tisdell 2015). However, it is noteworthy that achieving generalisability in a statistical sense is not feasible in qualitative research (Lincoln & Guba 1985). Therefore, this study utilised methods recommended for establishing relevance in qualitative research, aiming to extend the applicability of findings beyond the immediate case study such as,

- Detailed and explicit descriptions of data and methods have been provided. Lincoln & Guba (1985) claim that 'thick description' allows readers to assess the transferability of findings to their own context.
- Used multiple cases (four cases).
- Use of literal replication logic.
- Quotes from interview transcripts were incorporated when presenting findings from, thus allowing readers to relate the experiences of the interviewees to their own personal experiences.

4.16.3 Dependability- reliability, consistency

Dependability refers to the potential to produce consistent findings if the research is replicated using similar procedures, as indicated by (Lincoln & Guba 1985). To ensure that a thorough audit could be conducted, if necessary, to establish the dependability of the findings, all records, including transcripts, audio-recordings, notes, and process descriptions, should be securely maintained. To achieve this, the researcher implemented the following measures:

- Having a consistent sample of interviewees from every case including nine participants from each case.
- Interviewing all the participants based on the same interview guideline.
- Developing interview transcripts after tape recording the interviews.
- The methodology chapter was developed to explain the data collection and analysis techniques used, detailing the decision-making processes employed throughout the research process.

- Providing a clear audit trail for the research findings.

4.16.4 Confirmability- construct validity, neutrality

Confirmability pertains to the degree to which research findings are devoid of the researcher's biases, motivations, interests, and perspectives (Lincoln & Guba 1985). This was achieved through several procedures outlined below:

- Using data triangulation methods.
- Interviewing 6 participants from the same unit of analysis.
- Conducting semi-structured interviews further increased the credibility of the research as the researcher got the opportunity to get the clarifications done on the issues while interviewing.
- Providing a clear audit trail for the research findings.

4.17 Research methodological framework

Throughout this chapter the research methodology followed in the study to address the study's aim and objectives was discussed along with the justifications. Figure 4.5 presents the research methodological framework by summarising the steps used for the study.

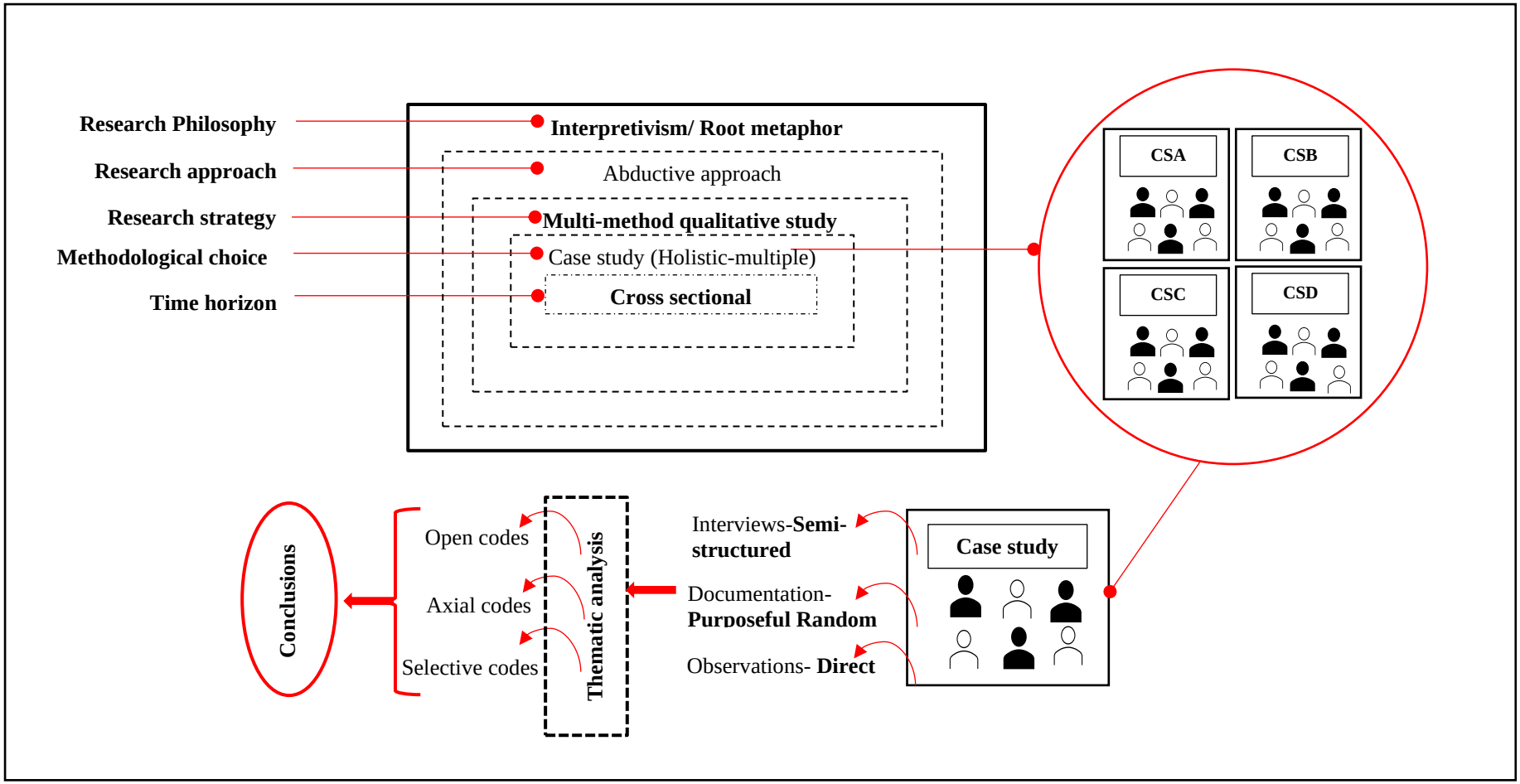

Figure 4.5. Research methodological framework

4.18 Summary

This chapter outlined the rationale for using the qualitative multiple case study methodology to conduct this research. Organisational BIM culture was identified as the unit of analysis and four BIM-enabled construction organisations were selected as cases. Semi-structured interviews were used as the primary data collection technique and direct observations and purposeful random documentation were used as secondary data collection techniques. Preliminary interviews were conducted to screen candidate cases and a pilot case study was conducted to refine the data collection and analysis process by identifying methodological issues. Data analysis was undertaken using the thematic analysis technique with the support of NVivo software. The next chapter will discuss the preliminary studies carried out.

CHAPTER 05 – PILOT CASE STUDY

5.1 Introduction

The Chapter 04 outlined the research methodology adopted in the current study and this chapter presents the findings from the pilot case study conducted before the main study. This sheds light on the methodologies employed and the invaluable insights gained through this initial exploration. This chapter is aimed to explore the viability of the interview questions and rehearsing in-direct questioning to determine if the researcher's interviewing approach and transcribing skills are viable and to verify the analysis approach to be used in deriving cultural manifestations in terms of underlying beliefs, patterns of underlying beliefs and behaviours in organisational BIM culture from the collected data.

5.2 Pilot case study: addressing theoretical and methodological issues

5.2.1 Objectives of the pilot case study

A pilot study is a smaller-scale version of an intended study that is carried out with a select number of participants who are comparable to those who will be recruited later in the actual study (Doody & Doody 2015; Kim 2011). Pilot studies are carried out to allow researchers to test and fine-tune their data collection and processing procedures (Hassan, Schattner & Mazza 2006). The main benefit of conducting a pilot study is that it allows researchers to make improvements and updates to the main research (Kim 2011). Further, prior to completing study's implementation, a pilot study reveals problematic areas and flaws in the research procedure and instruments (Hassan, Schattner & Mazza 2006). Accordingly, a pilot case study is conducted to address both theoretical and methodological concerns in the main research. The pilot study was developed and conducted in a way to achieve the below objectives and the following sections present the details on how each of the objective was achieved.

- To explore the viability of the interview questions and guide.
- To rehearse in-direct questions.
- To see if the researcher's interviewing approach, transcribing skills and data-analysis skills are viable.
- To make certain that the necessary preparations were made before commencing the data collection.
- To verify the analysis approach to be used in deriving cultural manifestations in terms of underlying beliefs, patterns of underlying beliefs and behaviours in organisational BIM culture from the collected data.

The pilot case study provided several benefits, which improved the progress and eventual outcomes of the study. For instance, the pilot case study ensured that the appropriate interview guideline structure and process were in place and it made certain that proper preparations were made prior to start collecting data. It facilitated: a practise run for conducting semi-structured interviews while ensuring that the interview guide was adequate and relevant; an opportunity to complete preliminary transcriptions and provide an indication of the time required for transcribing; and confirmed the method to be used to analyse data collected from the semi-structured interviews and drawing conclusions.

5.2.2 Background of pilot case

The case selected for the pilot study was a South Australian originated construction company that began in 1983. They have over 30 years of experience in providing building solutions to a variety of industry sectors such as office and commercial, residential education, restoration and heritage, aged care and health. This has now grown into an industrial construction business with offices in Adelaide, Brisbane, Gold coast and Perth, employing over 250 people. The organisation is tasked with delivering projects of varying size and complexity for commercial and public sector clients within the Australian construction market. The main business strategy of the organisation is based on long-term client relationships. They work with prominent construction businesses, to strengthen their capabilities and investing in various initiatives to deliver better projects and more value to clients. Thus, most of their works are repeated clients. The company is led by the Managing Director and the General Manager, who are the topmost layer of the organisational structure, and there are eight main divisions to support the top management, including procurement, construction, IT, commercial, finance, design and construction support service.

BIM usage on projects in the company has started with using 3D modelling technology being used during the design phase. BIM is used by the company to provide clients a virtual tour of new facilities - especially use as a platform for teams to collaborate with the consultants and clients to gain a more understanding of clashes in services and potential operational and maintenance problems. Their choice of BIM application was Revit and Vasari. They use the information to coordinate safe construction methodologies and logistics plans. Five interviews were conducted within the organisation, with two from the senior managerial level and three from the operational level. Table 5.1 summarises the details of interviewees of the pilot study company. The notation ECS was used for the pilot case considering it as an exemplar case study (ECS).

Table 5.1. Details of interviewees in pilot case study

Interviewee	Job function	Industry experience	Experience with BIM
Interviewee ECS-1	General Manager	36 years	5 years
Interviewee ECS-2	IT Manager	10 years	5 years
Interviewee ECS-3	Contract Administrator	4 years	4years
Interviewee ECS-4	Construction Manager	9 years	3 years
Interviewee ECS-5	Project Manager	15 years	5 years

5.2.3 Exploring the viability of the interview questions and rehearsing in-direct questioning to determine if the researcher's interviewing approach and transcribing skills are viable

The pilot case study's primary objective was to ensure that the questions being generated for the interviews are relevant and robust. This is important because the developed interview guideline is for extracting behaviours and beliefs of the organisational BIM culture through an approach of in-direct questioning. The process of developing interview questions was led by the working definition of organisational BIM culture, which is made up of patterns of underlying beliefs created as members of a group solve internal integration and external adaptation and survival problems. The external adaptation and survival problems include BIM strategy, BIM goals, means to accomplish goals, criteria to measure performance and remedial actions. Internal integration problems of BIM using organisations related to common language, group boundaries, power allocation and status, intimacy, reward allocation and punishments and ideology were mainly focused when developing the interview questions. Table 5.2 includes sample interview questions for each external adaptation and internal integration problems.

Table 5.2. Sample interview questions for each external adaptation and internal integration problems

The Problems of External Adaptation and Survival in a BIM-enabled organisation	Sample interview questions
1. Mission, strategy and goals - organisational BIM Strategy and objectives	1.1 How did the idea of implementing BIM come about? How did the decision make? Who were the key players? 1.2 What was the key reason for using BIM in your organisation? What were the primary justifications for investing in BIM?
2. Means of accomplishing goals	2.1 How do you think BIM implementation has affected the existing organisational structure? How is the BIM team structured in the organisation? 2.2 How do employees in your organisation communicate with one another in the BIM environment? Who decided on those? Do you think current communication methods are effective in accomplishing BIM objectives?
3. Measurement and correction actions - BIM performance evaluation	3.1 Have your company's BIM performance and practises been evaluated? When? What tools and strategies do you employ? What are the metrics? 3.2 How do you get to know that you are not meeting goals and targets in BIM implementation?
The Problems of Internal Integration in a BIM-enabled organisation	**Sample interview questions**
4. Common language and conceptual categories	4.1 Do you think your language and way of thinking have changed since your organisation adopted BIM? 4.2 Did use of BIM resulted to create shared language of jargon and acronyms? What are some examples?
5. Group boundaries: who is in and who is out?	5.1 Can you recall what it was like to start using BIM? How did you feel it? Do you believe that BIM will result in improving construction practices? 5.2 How the use of BIM resulted in changes in staff roles and responsibilities? What steps were taken to make sure that staff transitioned smoothly into new roles and responsibilities?
6. Power, status, and intimacy,	6.1 What kind of meetings are held in related to BIM? How often the BIM meetings are held? 6.2 Who speaks at BIM meetings? Is everyone involved? How are the decisions made in BIM meetings? In a BIM meeting do you feel encouraged or discouraged to voice your disagreement face-to-face?
7. Rewards and punishments	7.1 In the BIM environment of your organisation, what is considered as a reward or a punishment? Does your organisation use any rewards to encourage BIM use? 7.2 What signals do you pay attention to so that you can understand how you do when using BIM?
8. Ideology	8.1 Can you explain any area in BIM implementation that was least under the control of the team members? 8.2 What changes would your organisation make if it were to implement BIM systems again?

Answers to these questions will give rise to the underlying beliefs of the actions of people in a BIM-enabled construction organisation. These beliefs are supported by the predicted cultural beliefs in general as of Schein's organisational culture theory. Schein (2010)

presents six cultural dimensions around which an organisation's beliefs develop (refer to Chapter 2, section 2.3.3). Therefore, these interview questions should allow for identifying underlying beliefs of the organisation. Table 5.3 presents how the interview questions support to Schein's predetermined cultural dimensions. Accordingly, the interview guideline was developed to capture entire experience while letting the interview to represent the core of the experiences of the interviewees.

Table 5.3. Mapping of interview question categories to underlying cultural beliefs

The Problems of External Adaptation and Survival	**Cultural dimensions**
BIM mission and strategy.	The nature of human activity. Human relationships to nature.
BIM goals and objectives.	The nature of human activity. Human relationships to nature.
Means of achieving BIM.	The nature of reality and truth. The nature of human relationships time, space.
Measurement.	The nature of reality and truth. The nature of human relationships.
Correction.	The nature of reality and truth. The nature of human relationships.
The Problems of Internal Integration	**Reflection of underlying beliefs**
Common language and conceptual categories/systems.	The nature of reality and truth time, space.
Group boundaries and criteria for inclusion and exclusion.	The nature of human relationships.
Power and status.	The nature of human nature. The nature of human activity.
Intimacy, friendship and love.	The nature of human nature. The nature of human activity.
Rewards and punishments.	The nature of human nature. The nature of human activity.
Ideology.	The nature of human activity. The nature of reality and truth, time, space.

Considering the pilot case study, data collection methods were revisited to accommodate digging deeper to the BIM organisational culture and find hidden underlying beliefs, patterns of underlying beliefs and behaviours. Accordingly, changes were made by modifying and revising the questions, developing prompts for each interview question, adding new questions on critical situations and asking for examples to elaborate answers. Further, improvements to observation and document protocol were made.

- Modifying the interview guideline and developing prompts

Conducting the pilot study allowed for modifying, adding, removing or revising interview questions that do not provoke appropriate responses or enable obtaining rich data. It was

evident that some of the interview questions required modification and revision to give a clear picture to the interviewees and secure a richer answer from them. For an example, the question "*What performance evaluation systems are used in your organisation*?", which was asked under the '3. Measuring Performance' was amended to: "*3.1 Have your company's BIM performance and practises been evaluated? When? What tools and strategies do you employ? What are the metrics?*" in an effort to make the meaning clearer and specific to the BIM context. The question *"Do you consider who is an insider and who is an outsider? What this means for your interactions with those people?* was also changed and divided into two questions as "5.*2 How the use of BIM resulted in changes in staff roles and responsibilities? What steps were taken to make sure that staff transitioned smoothly into new roles and responsibilities?* and *6.4 How do you assign BIM-related roles in your organisation? What methods and tools are employed?*' to clarify the question. These modifications in phrases allow for participants to narrate through their perceptions and experiences.

The interview guideline's exact sequence could not be followed sometimes during interviews because some interviewees answered questions listed later in the guideline earlier. Therefore, some of the questions were merged and re-ordered to avoid confusion to the interview participants. During the pilot study interviews, it was noted that some interviewees were prone waffle on about non-specific matters when the question is not properly understood by them. Therefore, the interviewer had to provide prompts for questions posed to secure a fuller and richer answer. Taking this into account, the interviewer developed prompts for each interview question following the pilot study. Prompts were helpful to avoid misunderstanding of questions by the participants due to theory-based terminologies used in questions (i.e., mission, vision). Table 5.7 contains a few examples of prompt questions. Further, probing questions were used sparingly and appropriately, while giving space to the participants to contemplate their answers to the interview questions. This technique of filling voids with probes is very effective in eliciting additional responses.

Table 5.7: Sample of prompt questions used in interviews

Question in the interview guideline	Sample of prompt questions
What is the fundamental mission statement of your organisation?	What is the purpose of your organisation? What is the function? What business are you in?
What is the Building Information Modelling (BIM) vision of your organisation?	What are you trying to achieve through BIM use in that organisation? What are you trying to become via the use of BIM? What is the desired future state of the company in terms of BIM?
What are the main objectives and goals specific to BIM implementation in your organisation?	What are specific measurable actions you must take to achieve BIM mission? What is desired result you want to achieve in short term and long term?
From where did these BIM objectives come from? Are they entirely based on logic and formal reasoning or are they influenced by the beliefs and biases of someone in the organisation?	Who set the BIM objectives? Who make decisions on BIM implementation?
How do you think BIM implementation has affected the existing organisational structure?	Are there any changes in organisational chart due to BIM? How is the BIM team structured in the organisation?
What performance evaluation systems are used in your organisation?	What are the systems you have to measure employee's contribution to the work?

- Questioning on challenges, obstacles, or critical situations along with the reasons and examples

It was discovered through the case study that questioning on challenges, obstacles or critical situations also allowed for in-depth exploration of the cultural context in the BIM environment. To surface the hidden beliefs of individuals it was necessary to ask for reasons for their responses. When the interviewer repeatedly asks for the reason, the interviewees reach a point where they are unable to provide another reason, and the given reason becomes the hidden belief. As a result, the following questions were added to the list of questions concerning internal integration and external adaptation issues:

> "Have you faced any challenges, obstacles or critical situations when using BIM? What were the challenges/obstacles/ critical situations? What were the reasons? How did you resolve the issues? What tools, techniques, and strategies were employed? Why was it done? What were the results? Do you believe that there is a solution to every problem that arises?"

Even though the interview questions were effective as a guideline, the respondents were asked to provide informative examples when answering to make sure to collect rich data for

analysis. Provided examples helped clarify and justify the answers given by the interviewees for the questions.

- Refining observation process and document analysis process

Direct observation of the organisation is beneficial to uncover the organisational BIM culture. This permits the interviewer to understand the physical setting of the organisation thoroughly. This allowed a grasp of how the arrangements are made for interviewees to work in a BIM environment. Therefore, it was decided that the direct observation of building's layout, furniture, spacing, equipment, notice boards with announcements and work schedules for each department are visible cultural manifestations that should be observed. Further, the list of documents to be reviewed was refined including: guidelines, meeting minutes, written protocols, BIM implementation/execution plans, the home page for the company website, electronic media produced by the company, organisational structure and templates.

5.2.4 Testing the ability to derive beliefs and behaviours from collected data

To begin analysing the collected data, recordings were used to manually transcribe the interviews in verbatim using MS Word. Once the transcripts were organised, they were skimmed at first to secure an understanding on the content and to become familiar with the data. Later, the transcripts were iteratively reviewed, and the re-reading of the transcripts facilitated note taking while reading. Re-listening to recordings and reviewing transcripts individually allowed the researcher to refine and/or determine interview technique, the suitability of the interview guide and the decision to proceed. A major aspect of conducting the pilot case study was the realisation that the transcribe time needed for audio recordings and the time needed to go through the process of data-analysis to develop relevant codes. This awareness helped the researcher to avoid the underestimation of time and prepare for the process. Data coding was done using NVivo 20 software. Here, coding of transcripts initiated with open codes and later combined to form axial codes. These axial codes categorised to form selective codes to create the final study themes. In the coding process, the distinction between beliefs and behaviours was made by determining whether the interviewee was explaining why a particular action was taken or simply repeating the details of the action. In either case, the belief and actual behaviours were so closely related that they occasionally overlapped. However, both are equally helpful in determining the level of unconscious organisational BIM culture.

The pilot case study served as an exemplar case study (ECS), demonstrating how the analysis was conducted. Figure 5.2 presents an extract of three levels of coding done for the ECS.

First, open coding (first-level coding) was undertaken considering the similar incidents and interpretations found in interviews, observations and document analysis, and they were correspondingly coded. This was followed by axial coding (second-level coding) to extract the patterns of beliefs. Finally, in the selective coding (third level coding), underlying cultural beliefs were derived by analysing the beliefs identified in axial coding against cultural dimensions. A code was given for each underlying belief providing: 1) a notion for the case study; 2) underlying belief number; and 3) number for patterns of belief. For example, ECS.1.1 was used for the first underlying belief of the exemplar case study (notation for the case study is ECS, hidden cultural belief number is therefore ECS.1, and the number for patterns of belief is ECS.1.1.).

An extract from the analysis of transcribed data to derive hidden cultural beliefs using the coding system is as follows:

- Patterns of behaviours (ECS.1.1.1).
- Patterns of underlying beliefs (ECS.1.1): unless forced otherwise, the best way to survive is to maintain the status quo.
- Underlying belief (ECS.1): humanity's relationship to nature is submissive.

It was found that this cultural group believes the best way to survive is to maintain the status quo unless forced otherwise. As indicated by ECS-03, the use of BIM was encouraged in this company only when called upon to do so by a third party. They expected that an external party should provide the impetus to use BIM. It came up repeatedly during the interviews that BIM is only used in a project setting if the client, consultants or the contract dictate its use. They all used different phrases to explain the trigger behind using BIM including *if it's pushed on us, if it's forced on us, if it was contractual*, and *it should come as a government mandate*. According to ECS-04 the demand to use BIM in projects should be come from the client. Even they were willingly prepared to incur additional costs to meet client demand. Once, they purchased CostX to prepare estimates as per the request by the client. However, after about 9 to 12 months, the demand for software subsided, and they stopped paying the annual fee. ECS-02 mentioned that use of BIM in projects is bound by the consultants implementing it. The participant explained that they have only completed three BIM projects for the last 10 years and it is not a huge thing for the company at the moment.

ECS-04 found it should come contractually to use BIM and pointed out that if BIM model is not contractual, they cannot rely on it, and they cannot build anything off the model. The example used by ECS-05 to explain the need of powerful force to trigger them to use BIM

was the use of documented quality assurance procedures. ECS-04 explained that a long time ago, they did not have any documented quality assurance procedures in place. Everyone just went around, doing it their own sort of way, nothing was regimented. This changed when the Australian Standards started to be implemented, and if they wanted to do certain projects and work for certain clients, they needed to have a quality management system. Thus, certain clients insisted that they have a documented system, and the government certainly did. Then, in addition to having a documented system, it was necessary to be compliant with the Australian Standard and demonstrate that the company was audited. PS-05 made a similar argument, claiming that they should be forced to use BIM as well and said, *"so, you know, these things were forced upon us to adopt these sorts of things. So, is BIM going to be forced upon us? And what's it going to be forced upon us to do? How are they going to say you got to use BIM? Or what are we going to use it for?"* Accordingly, it is evident that the individuals at ECS see themselves as subservient to the environment because they change their natural order of things due to the external forces. The group is only willing to use BIM when it is mandated by external parties, such as clients or regulatory bodies, and not because they see the technology as an essential tool for improving their own operations. These behaviours and beliefs are governed by the cultural belief that the human relationships to nature is submissive.

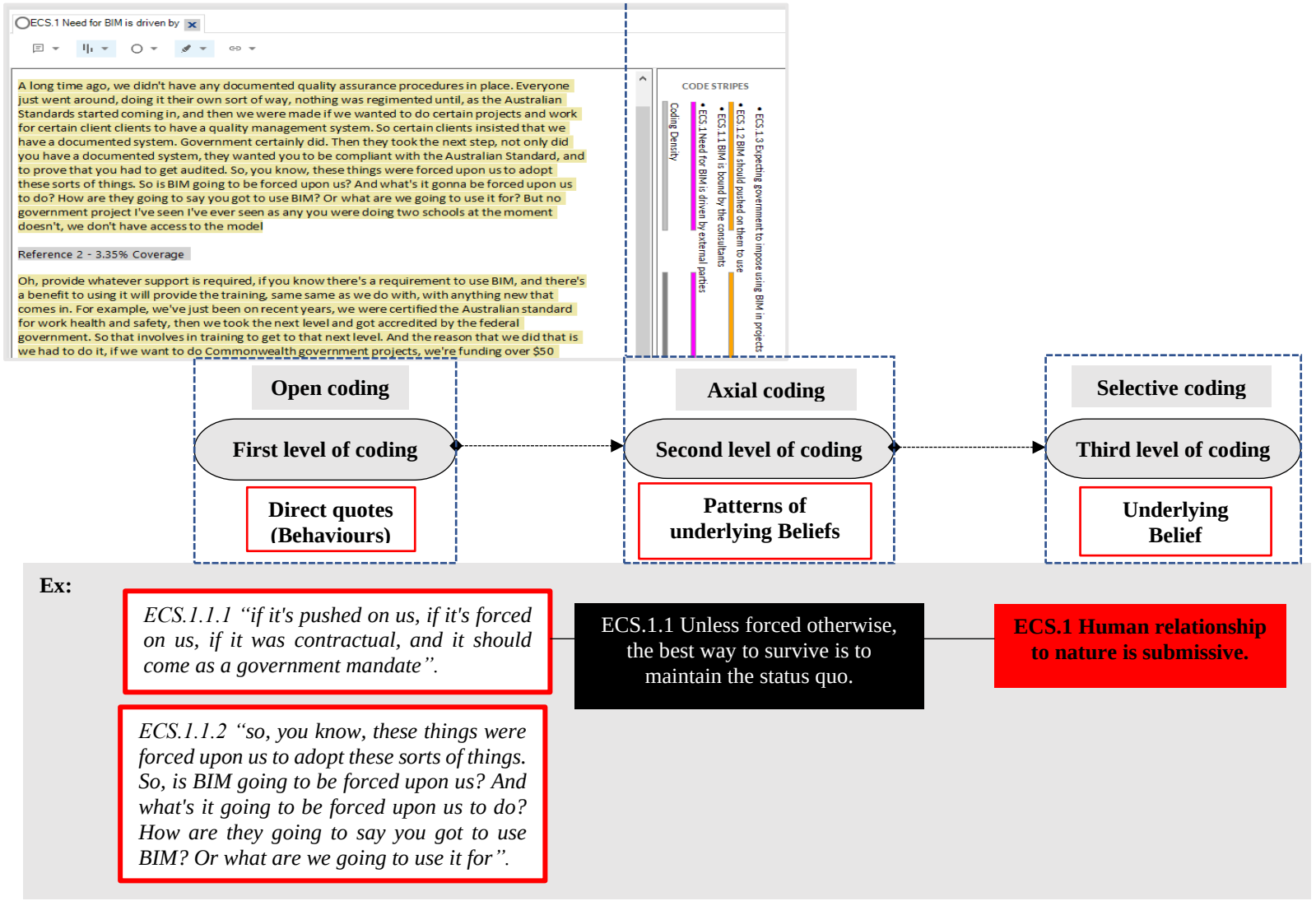

Figure 5.1. Coding levels

5.3 Summary

This chapter detailed the pilot study that was conducted prior to data collecting. The pilot case study was carried out to achieve the following objectives *viz.*: to explore the viability of the interview questions and guide; to rehearse in-direct questions; to see if the researcher's interviewing approach, transcribing skills, and data-analysis skills are viable; to make certain that the necessary preparations were made before commencing the data collection; and to verify the analysis approach to be used in deriving behaviours and hidden beliefs in organisational BIM culture from the collected data. Accordingly, the interview guideline was modified by adding, merging and removing questions and rephrasing. Further, prompts for each interview question were developed to assist the interviewees to understand the questions.

CHAPTER 06- WITHIN CASE ANALYSIS OF ORGANISATION A

6.1 Introduction

The Chapter 05 presented the findings of the pilot cases study. This chapter offers a detailed within case analysis of organisation A. Initial sections of the chapter present background information of organisation A and organisational structure, highlighting key departments and roles related to BIM. Subsequently, the chapter presents the details of the interviewees involved in the study. Next, an overview of the responses collected from them regarding the external adaptation and internal integration problems faced by organisation A in the BIM environment is presented. In the following sections of this chapter, the underlying beliefs, and patterns of underlying beliefs supported by behaviours discovered in organisation A within the BIM environment are provided.

6.2 Background information of organisation A

Case study organisation A (CSA) is one of Australia's largest construction companies with a rich history. Since being founded in 1918, this privately owned building company has delivered over 5,000 high-quality commercial and institutional projects. Currently, CSA is specialised in variety of sectors including health, commercial, education, defence, community, fit out and refurbishment, hotel and entertainment, retail, industrial, justice and police, residential and senior living. The company employs over 600 people and is one of the IBIS World Top 500 Private Companies, with an annual revenue exceeding $1 billion. The current mission statement of the CSA is to expand and diversify within the construction industry by leveraging the organisation's knowledge of age and agility of problem solutions for all assigned projects. The mission statement emphasises the company's commitment to delivering high-quality construction projects that contribute to the development of Australian cities, while also providing exceptional client service and maintaining a safe and supportive work environment for its employees. CSA is a company built on values with their vision to become one of Australia’s leading commercial building companies. The company has four key values as integrity, respect, excellence and innovation, which guide the company's operations and interactions with stakeholders.

Integrity as a core value at CSA underpins its approach to conducting business with transparency, honesty and ethical behaviour. This reinforces the company’s expectations on its employees to act with integrity in all their relationships with clients, partners and each other. The value given on the respect for diversity and inclusion informs the company’s commitment to treating all individuals with respect and dignity. This allows them to promote

a culture of mutual respect and inclusivity in its workplace. CSA strives for excellence in all its endeavours, from the quality of its construction projects to the level of service it provides to its clients. The company is committed to continuously improving and innovating its processes and practices.

Innovation is a fundamental value that drives CSA's need to constantly explore new technologies and systems that can improve the efficiency and quality of its work. This includes using advanced BIM systems, 3D printing, drones, and other tools to improve construction processes and reduce waste. CSA has been at the forefront of introducing innovation to construction practices, recognising that innovation is time-dependent and essential for staying ahead of the competition. They began with an in-house management platform to integrate geographical data with project planning and management systems. They used BIM to streamline the way they managed construction projects. This enabled their project team to work more effectively and efficiently, while also streamlining communications between multiple stakeholders. Their current main choice of BIM application is BIM 360 by Autodesk but also Revit and Navisworks. Revit software is used to create detailed structural, electrical and mechanical drawings, which are later converted into BIM models and integrated. Upon integrating all the drawings, such as electrical and mechanical, the 3D models are combined and analysed using Navisworks.

Figure 6.1 shows the formal organisational structure of the CSA. This organisational structure was built based on the findings from the interviews when discussing components such as structure, communication, company website and the organisational chart provided by the interviewees. It is worth to note that the CSA has no designated "BIM division", and the BIM Manager and the BIM Coordinators are attached to the services department.

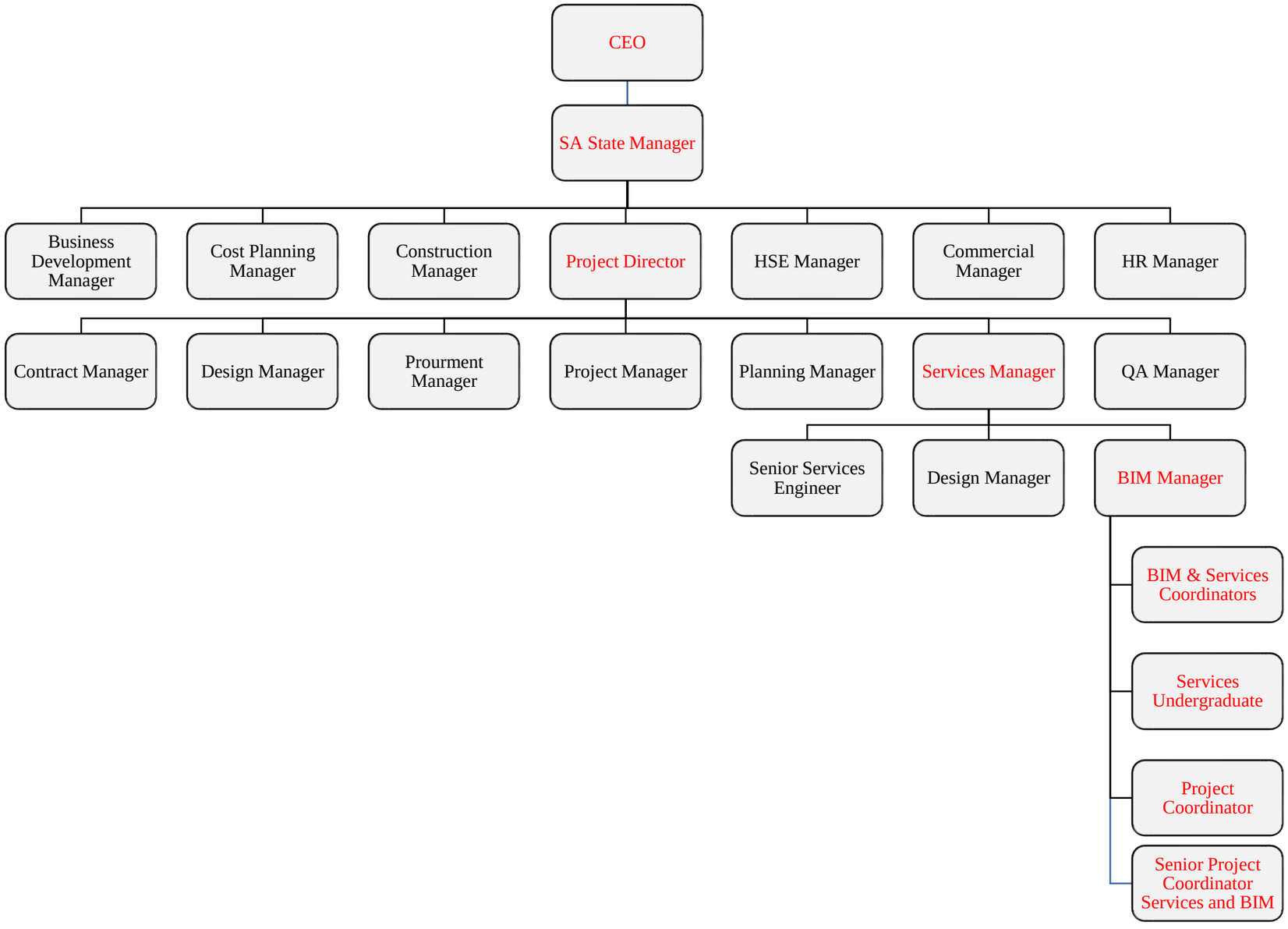

Figure 6.1. Organisational structure of organisation A

Six interviews were conducted within the company, with organisational roles presentative of the two levels of the organisational structure: senior management level and operational level. Accordingly, six interviews were conducted within the organisation, with three from managerial level and three from operational level. Table 6.1 summarises the details of interviewees of the CSA.

Table 6.1. Details of interviewees in Case A

Interviewee	Job function	Industry experience	Experience with BIM
Interviewee CSA1	Construction Manager	34 years	6 years
Interviewee CSA2	BIM Manager	33 years	10 years
Interviewee CSA3	Senior Project Coordinator Services and BIM	23 years	4 years
Interviewee CSA4	Design Manager	15 years	4 years
Interviewee CSA5	Project Coordinator	3 years	1 year
Interviewee CSA6	Site Engineer	3 years	1.5 years

CSA1 holds the position of Construction Manager at CSA and is responsible for overseeing projects and Project Managers with regards to project delivery and tendering. Having been in this role for 12 years, CSA1 was involved in the decision-making process when the organisation introduced BIM eight years ago. Along with introducing BIM, CSA1 is also responsible for managing personnel who work with BIM and ensuring that the outputs derived from its use are of high quality.

CSA2 is the BIM Manager at CSA and has extensive expertise in 3D modelling dating back to 2000, having accrued initial experience with Revit, as a BIM platform was in 2011. CSA2 is responsible for managing the entire BIM process, including internal users and external collaborators. CSA2's role involves documenting digital engineering processes, developing execution plans and customising them to suit each project.

CSA3 functions as the Senior Project Coordinator Services and BIM and has been working in this role at CSA for two years. CSA3 is assigned to projects to ensure that all models designed by subcontractors and consultants are delivered on time and synchronised into a single cohesive unit.

CSA4 works as a Design Manager at CSA, with a tenure of three years. With 15 years of experience, CSA4’s main role is to coordinate the design team at the head office and project teams to provide essential drawings and specifications.

CSA5 is a Project Coordinator at CSA, working on a hospital project for the past year and is using BIM to manage defects and safety issues. CSA5’s primary responsibility is to

identify defects, take photos, plot them on the floor plan and send them to subcontractors for resolution.

CSA6 is a Site Engineer at CSA who has been involved in projects with a site management role. Primarily, CSA6 uses BIM to track RFIs, close out issues and manage subcontractor documentation such as their ITPs and quality assurance records.

6.3 Overview of responses to external adaptation and internal integration problems

According to the working definition developed in Sub section 3.2.2, organisational BIM culture is the: *"patterns of underlying beliefs and thinking guided by behaviours and artifacts, that was learned by members of BIM using the organisation as it solved its problems of external adaptation and internal integration."* The external adaptation problems in BIM-enabled-construction organisation include BIM mission and strategy; BIM goals and objectives; means to be used in achieving BIM strategy; BIM performance evaluation and remedial actions to ensure that members meet the BIM mission and strategy (Schein 2010). The internal integration problems include language used in a BIM environment; BIM team boundary; power and status allocation criteria in a BIM team; peer relationships in BIM environment; allocation of rewards and punishments and unexplainable and in explicable issues (ideology) (Schein 2010). The patterns of underlying beliefs were found by questioning how the group responded to these internal integration and external adaptation problems. The following is a short summary of the key responses to such problems:

BIM strategy and objectives - CSA has invested significant effort over the years to develop and achieve its goal to diversify the construction sector with a desire to grow and take on new challenges in the industry while valuing the accumulated experience and efficiency in project delivery. The primary goal of utilising BIM at CSA is to establish a centralised, CDE that allows for the effective dissemination and sharing of knowledge across the entire supply chain. This ensures the smooth progression of information throughout the supply chain through BIM.

Means of accomplishing BIM goals - CSA places a significant emphasis on investing in BIM, as evidenced by their three-year strategic partnership with Autodesk, a leading global technology provider. This partnership is specifically aimed at optimising access and utilisation of Autodesk's cloud collaboration and desktop platforms, in alignment with CSA's National Innovation Strategy that prioritises providing a superior project experience for both staff and clients. To bolster their employees' BIM skills, CSA offers in-house and on-the-job training programs.

BIM performance evaluations and remedial actions - the company has no structured process for evaluating BIM performance of the employees and at present, CSA has only established HR evaluation systems. However, at the project level the data from BIM 360 is used to generate digital reports to assist project tracking and assessment. This is facilitated through an in-house IT team responsible for developing an intranet and associated systems that support data mining activities. These project evaluations enable the reviewing of system usage and identification of potential issues. CSA is currently undergoing significant change to enhance data mining activities, utilising tools such as Power BI and the Autodesk API available on the BIM 360 platform.

Common language - the language at CSA has been changed since the adoption of BIM. For instance, the term "BIM" is now frequently used to refer to the building information model itself rather than the whole process of managing information in building process. The complex concepts such as level of information (LOI) and level of details (LODs) on the field's vocabulary are seen as intimidating to newcomers.

BIM team boundaries - the hierarchy of the BIM team at CSA starts with the National BIM Manager, who is responsible for developing and implementing BIM strategies and managing BIM resources. Under the National BIM Manager there is a State BIM Manager assigned to each state of Australia, who closely work with BIM Coordinators and project teams to provide support and training. BIM Coordinators are responsible for the day-to-day management. They are also responsible for coordinating and resolving issues that arise during the design and construction process. When recruiting new employees, the company looks for candidates with BIM related competencies prior to assigning them to BIM project roles. Core competencies include knowledge of BIM software, proficiency in 3D modelling, and familiarity with BIM protocols and standards.

Power and status allocation criteria in a BIM team – at the organisational level, the State BIM Manager had the power and responsibility to make decisions related to BIM implementation and use. At the project level, the Project Manager also has a significant amount of power in deciding the extent to which BIM use in each project. However, all the decisions were subject to approval from top management including Chairman and the Board of Directors, who have the ultimate authority to make decisions that affect the entire organisation.

Rewards and punishments - there are no rewards or punishments placed at CSA about BIM use at individual level. The only reward was that the effective use of BIM should provide a

better project outcome. However, sometimes verbal acknowledgement is visible when the budgets and the time constraints that are put upon the project are achieved.

Ideology - the clients that CSA work with tend to be poorly informed about BIM use and its benefits. When the clients engage the consultants to undertake work on their behalf, the way that this contractual arrangement is structured is not ideal. So, by the time CSA become engaged in the project, the client and consultants have already got their contract signed and made a whole host of decisions such as what the key project deliverables are. To understand the implications of these responses, one must seek the underlying beliefs on which the CSA was based.

6.4 Underlying beliefs of organisation A

The underlying beliefs that exist within an organisation create a cultural paradigm which serves as the foundation for all aspects of organisational life. These beliefs shape the behaviours of individuals within the organisation and influence how they interact with one another and approach their work. Interviewees' responses to internal integration and external adaptation issues in the BIM environment reflected different patterns of underlying beliefs. These patterns were analysed against the cultural dimensions viz. human relationships; organisation's interaction with the environment; the nature of reality, time; the nature of human activity; and the nature of human nature to reveal the underlying beliefs of the CSA (Refer to Table 6.2).

6.4.1 The nature of human relationships

The underlying beliefs that dictate how individuals within the group interact and relate to each other are considered under this category. These beliefs pertain to the interactions between employees, power distribution, competitive and cooperative nature of relationships. Thus, the beliefs solve the problems related to best authority system, best way to organise and correct way to relate to each other.

Best authority system

The underlying beliefs within this category are geared towards answering the question of whether an autocratic or participative authority system is the optimal approach for organisational operations. The best authority system at CSA exhibited autocracy, where the top management including the BIM manager wielded significant powers over the ultimate decision making. The BIM manager within the BIM team holds a powerful position and is considered a top-level managerial role.

Employees at CSA believed in a leader-centred authority system and showed the pattern of underlying belief that **presence of a powerful leader is critical in a BIM setting.** It was evident that without a designated champion to lead the way, it is challenging for employees to adopt and integrate new systems successfully. CSA1 explained that it is essential to recognise that investing in human capital is just as important as investing in technological infrastructure. Hence, hiring and having someone with the skills and expertise to implement and manage BIM systems was necessary. According to CSA1:

> *"We actually have to make the investment to employ someone who does that [use BIM]. And then, have to rub off on everybody else to expand the knowledge, you don't actually make that commitment and spend the money to have someone just expect people to pick up a system and run with it without a champion."*

CSA employs a centralised BIM Manager who is held in high esteem for being extremely knowledgeable and competent in BIM-related matters. The BIM Manager is based at the head office, and employees across the organisation approach him when they encounter an insuperable problem. They refer it to the BIM manager for assistance. All interviewees emphasised that the BIM Manager is an approachable subject expert, with CSA3 stating that:

> *"In house, our BIM Manager is at head office, he is a very knowledgeable person with BIM. Sometimes if we feel that he can solve it, we refer that problem to him, and he always reverts with the solution."*

This was also confirmed by the BIM Manager who stated that: *"when people have crashes on their computer and that sort of thing, they might then want to contact myself in terms of trying to work out software issues."* The BIM Manager is not only act as a technical expert but also as a mentor to new employees. CSA1 added that the BIM Manager is the first point of interaction to new employees and provide BIM familiarisation training and instruction, allowing them to appreciate the project quickly with their available BIM skills. The BIM Manager considers this work a true passion and exudes confidence in the BIM space, having progressed and evolved over time with BIM. Further, CSA employees value the BIM manager's ability to expediently identify and address issues. The proactive approach of BIM manager towards problem solving has resulted a more stable work environment, where employees are comfortable and face fewer issues. According to CSA4:

> *"The BIM Manager identifies where the problem might be, and then go and chase up the right person to address that issue, in a way better than what it was like nowadays, it's way more stable and people are more comfortable, say get heaps less issues."*

This affirms the BIM Manager's concerns for comfortability of the employees, where emotional well-being is prioritised. Even with an autocratic nature in authority system at CSA a sense of kindness and goodwill towards their employees were visible when making decisions.

At CSA, employees also believed that **ultimate decision-making power resides with the authority positions.** In the decision-making process, the involvement of rest of the BIM team is conspicuously minimal. Instead, the top management exclusively collaborates with the BIM Manager, relying heavily on their knowledge and expertise to make informed and strategic decisions pertaining to the provision of support for BIM implementation. The BIM Manager controlled the BIM operations and had decision-making power invested in them by upper management. Consequently, weighty decisions could be made regarding BIM standards and requirements to both external and internal groups. For instance, the BIM Manager (with the support of the National BIM Manager) developed and defined standard operating procedures for BIM workflows, which are reflected in their Digital Engineering Execution Plan (DEEP). DEEP establishes the templates and protocols for BIM model components, such as naming conventions and level of detail standards, which further contribute to the standardisation and control of BIM workflows. Thus, the employees are bound by these protocols and even though they are not given power or opportunity to determine the organisation's BIM policies and protocols. When the BIM Manager was questioned during the interview who makes the BIM related objectives in the company, they mentioned that:

> *"Our BIM objectives are probably driven right from the top. So, from the Chairman of the Board, down through our national BIM Manager, and then out through our individual state, BIM Managers out into the organisation."*

The BIM Manager stated that BIM objectives are driven from the top, meaning that the highest level of management, the Chairman of the Board, is likely involved in setting these objectives. CSA has a well-defined hierarchy when it comes to decision-making related to BIM implementation. This ensures that top management is aware of and involved in the decision-making process, which can help to ensure that decisions align with overall organisational strategy and goals. This was also echoed in the comment by CSA6 viz.:

> *"So, it's [decision to use BIM] definitely a top-down idea. So obviously, BIM's been around in the industry for a while now. However, as times have gone on, and we're getting more into the age of internet and electronically managed spaces, we're using less printouts on site. Essentially, that innovation of having to get into the modern era make everything more digitalized, sort of pushed the BIM sphere into construction and CSA. But then we've had clearly some management, upper*

> *management who have realized that this is the direction the construction industry is going in. And they've supported CSA's interest in this area and innovation in the BIM space."*

At the project level, the decision-making power is with the Project Manager. For instance, communication processes are facilitated through them because they are responsible for overseeing the implementation of BIM on their respective projects. It seems that the BIM Manager and top management provide guidance on how BIM should be utilised and implemented, but ultimately, it is up to the Project Manager to decide how much they will engage with BIM and how it will be used on their project. Consequently, the methods of communication used will likely vary from project to project, depending on the preferences and approaches of individual Project Managers.

Best way to organise

To understand the underlying beliefs of CSA concerning the nature of human relationships, it is necessary to examine the employees' beliefs about the most effective way to structure society. This involves determining whether CSA leans towards individualism, which prioritises personal freedom and achievement, or groupism, which emphasises group interests and interdependence among individuals. CSA's underlying belief on the best way to organise was centred on 'groupism' to achieve success in BIM-related matters. Employees held the pattern of underlying belief that **discussions gave results**. This was observed in regular meetings held at CSA, such as the BIM kick-off meetings and BIM coordination meetings. These meetings enabled constant communication among team members, allowing them to develop consensus to solve problems in the BIM environment. CSA exhibited an appreciation of the contributions of each team member, regardless of their discipline and proactively encourages them to raise their concerns. For instance, as explained by CSA4:

> *"Every Tuesday we have a meeting called BIM coordination meeting, all the engineering, all the drafting people from each engineering discipline join this meeting, and each of them raise their concern about maybe a clash or maybe a missing information from design documents, from the consultant documents, any difficulties in modelling. So, we discuss everything in that meeting."*

Team meeting discussions were effective and produced positive outcomes, as they considered a diverse range of perspectives when making a decision. CSA3 provided an example of a recent decision to expand their use of technology beyond BIM 360 to include point clouds and drone deployment at a BIM meeting held at the head office.

The level of informal interactions and discussions at CSA appears to be restricted. This limitation can be attributed to several factors, including the physical separation of the BIM manager at the head office and the attachment of other BIM team members to different projects. Another contributing factor is the significant power held by the BIM Manager, resulting in a hierarchical communication structure within the team.

Additionally, CSA believed that the **organisation's interest prevails above any personal interests**. The CSA BIM Manager emphasised that the company shifted from an individualistic approach to a more collective approach after starting to use BIM. The BIM Manager mentioned that:

> *"We're trying to use integrated data now in terms of the whole digital engineering BIM processes, that it's not just whether the workflow that's been adopted by the company suits me as an individual, it's whether it suits the company as a whole."*

The employees further highlighted the importance of adopting a team-oriented approach towards workflow management, where employees are motivated to follow a particular workflow not just because it makes their job easier, but because the company benefits. This approach requires a change in employee mindset where individuals are willing to prioritise the collective interest over their personal preferences. CSA6 believed that implementing a CDE and adhering to established data protocols and workflows for a more integrated approach can help dissolve departmental silos and foster better collaboration and emphasis on collaborative working towards a common goal.

Further, the sense of groupism was also evident in how the CSA has arranged its office layout. The design of a completely open office space environment with no walls was designed to specifically facilitate teamwork. Even in rooms with their own ceiling, the walls do not reach the building's ceiling to maintain an open floor feeling. The only separate rooms were the CEO office and conference room but even those rooms have glass walls and doors. All other work areas have low height separating walls.

Correct way to relate to each other

Examining employees' underlying beliefs about the appropriate way for them to relate and interact with each other, and distribute power and affection provide insights into their underlying beliefs about the nature of human relationships. This can be determined by assessing whether the contractor emphasises competition or cooperation as the correct way for team members to relate to each other. CSA emphasised on cooperative relationships between members rather than competitive ones as the best way to relate to one another. Thus,

they held the pattern of underlying belief that **mutual interdependence is best suited to problem solving.** At CSA, there is a strong sense of teamwork, resembling a close-knit family, where mutual support is deeply ingrained. This willingness of colleagues to offer guidance and share knowledge reflects the cooperative nature of the organisation. CSA3 expressed that at CSA:

> *"Everybody works as a team, like a family. So, everybody encouraged not only from higher management, even the colleagues, if it's something that you are not aware of everybody is prepared to give you a full guidance and share knowledge with you. They are very openly do it."*

The employees are expected to show concern for both the company and fellow employees as the suitable level of engagement. CSA5 explained that they organise BIM sessions to share the lessons learnt from BIM projects and support knowledge transfer and ongoing learning, and stated that:

> *"if someone asked me a question related to BIM, let's say, someone come to me and ask, we have an issue on level 8 at this location, how we find this issue. Then, rather than I tell them the solution directly, I teach him how to check it and tell him about the solution. So, everybody learning something every day from others because we share our knowledge between others."*

Colleagues' willingness to openly share their knowledge and provide guidance reflect the underlying belief in cooperation. The mutual encouragement to use BIM was also apparent among employees. They demonstrate not only support but also encouragement to one another to maximise the utilisation of digital tools, supplanting traditional tools. CSA6 indicated that:

> *"Most of the people who use digital tools, they are asking why to use hard copies? Open your laptop and put it on the screen and see. This is the encouragement we are given. Always ask why don't you use BIM?"*

This exemplifies how they as a group encourage each other to learn and grow from one another. At CSA, employees relied on the organisation's internal IT department to oversee the upkeep and upgrading of the hardware and networks necessary for their operations, and they collaborated with the department in a cooperative manner. The importance given to continuous improvement and learning create a cooperative atmosphere among BIM users that extend to include out-group members as well.

6.4.2 The nature of human nature

People at CSA held the solid underlying belief that the nature of human nature is 'good', and humans are perfectible. This was reflected in their patterns of underlying beliefs that

employees are viewed as being inherently self-motivated and **employees are viewed as being capable of governing themselves**. These patterns of beliefs galvanised CSA's commitment to give employees full autonomy, believing that they are capable of continuous improvement if they follow the correct approach. This reflects the company's level of trust in its employees considering their nature as good. This was reiterated by CSA3 who commented that:

> *"It's much better if they make [employees] that change by themselves, then they're motivated to do it, not that they're doing it because they have to, but they're doing it because they can see an advantage, they understand there is an advantage and so they can then get better buy into it. So, I think that's probably what we sort of trying to do."*

People at CSA are trusted and respected since they are expected to be self-motivated to do their jobs. This affords opportunity for them to grow as individuals. CSA2 commented that once people get going, they will learn how to use BIM and find their own information. Management provides a small amount of guidance, but individuals are expected to lead in their own learning and development. CSA2 further mentioned that:

> *"We give them a leg up to show them how to get in there and give them access to the models and provide them with the means of accessing their models, and then sort of somewhat, letting them run with it in terms of how they can, how much they can learn and adopt and do."*

This way people become self-taught, continuously improving their knowledge and ability to use BIM more efficiently over time.

The level of BIM use by employees at CSA is determined by their own experiences and comfort level, allowing for a more personalised approach to technology adoption. Therefore, CSA management does not impose BIM usage on individuals but rather appreciates their individual choice and encourages their self-growth. This was affirmed by CSA1, the Construction Manager at CSA, who noted:

> *"As technology catches up, and people's skill sets start to meet that requirement, I think it's powerful, but you can't force people to use it, who have got extensive experience and are comfortable using some drawings and referring to the drawings to understand the process. (...) And those around us who are using it are getting the benefits of that use, but you can't force it on. As a manager, I can't force it on them to say you learn how to use BIM because you're a project manager. And that's why the world doesn't work that way."*

Even the BIM Manager (CSA2), acknowledged that they cannot compel people to use BIM, stressing their role provides essential tools only and whether individuals choose to utilise BIM or not is entirely their choice. CSA2 emphasised that 'forcing BIM usage' would go

against these beliefs and lead to disenchantment and lack of acceptance of the process. Furthermore, CSA2 commented that:

> *"If it's adopted by the project, then people get in there and use it. And again, I think it's this idea of, I feel you're going to get more, disenchantment and lack of acceptance of these processes, if it's forced upon people."*

Organisational belief in the fundamental goodness of human nature has contributed to the level of trust and autonomy given to individuals. Management does not force employees to use BIM and often given the freedom to work independently to achieve the desired result. Because of the company's optimistic beliefs regarding human nature, it appears that no reward system or punishment structure was implemented at CSA. Instead, the company emphasises trust in individuals' capacity for growth and self-directed learning, rather than relying on external incentives or punishments to motivate employees. The company's approach to handling mistakes is to view them as opportunities for learning and growth, rather than grounds for immediate termination. This reinforces and recognises the value of mistakes as a means to improve performance within the organisation.

6.4.3 The nature of human activity

The underlying beliefs of nature of human activity are evident in the actions and behaviours of the employees at the workplace, and their responses to the work environment. Three fundamental activity orientations can be identified as doing, being-in-becoming and being. The activity orientation of CSA employees was based on a 'doing' orientation. This was apparent in attempts to achieve the mission in the spirit of taking initiatives and anticipating opportunities. People at CS believed that **being proactive in the BIM environment was the proper way to behave.** This pattern of underlying belief was evident in the way that CSA started to use BIM. BIM adoption at CSA was driven by a proactive approach from the top management, who recognised the benefits of using BIM. Stimulus to use BIM was driven from the top to bottom and the company's CEO played a key role in this process. As a Construction Manager who was involved with the initial discussion regarding the BIM implementation in the company, CSA1 claimed that eleven years ago the CEO spoke with State Managers and Construction Managers to initiate the process. CSA2 mentioned that the BIM objectives of CSA remain primarily driven by senior leadership, including the Chairman of the Board, the National BIM Manager, and State BIM Managers who disseminate these objectives throughout the company. Further, CSA2 commented:

> *"In some areas, there's a request that come through which drive change organically from users that sort of want to access data in different ways and so that they can sort*

> *of generate its own areas of interest. And then you know, probably in a fairly limited way it's also driven by a clients' requests."*

This means that change directives and initiatives are issued by upper management rather than grassroots movements within the organisation. Being proactive, CSA has heavily invested in BIM development, even with no specific BIM deliverable requested by the client. For example, CSA4 mentioned that the company used BIM in a $183 million medical centre project even though the client had not originally prescribed it. BIM usage in this project enabled CSA to bring prefabrication methodology (i.e., offsite manufacturing of doors, windows, risers and walls) to the table. Consequently, the original design was modified to include steel-framed offsite fabricated modular bridge segments, which is a cost effective and faster construction solution. Ultimately, taking the initiative to use BIM in conjunction with alternative construction methodologies benefited both the construction team and the client. At the embryonic stage of BIM use, CSA was engaged with consulting firms that were working actively with BIM. The transition to BIM required CSA to identify areas for improvement and make changes to their processes and systems.

The pattern of underlying belief that **quality delivery is the main priority** was visible in the BIM practices at CSA. With a 'doing' orientation, CSA was always accountable for the quality of work completed and attention was given to detail. They use BIM for quality management because it allowed data management systems to be integrated with quality checklists and approvals in an automated way. The interviewees elaborated on their experience with BIM in quality assurance. CSA4 has been using BIM and related tools to identify and address problems that may occur on and off the construction site before they actually happen. CSA performs clash detections and run multiple simulations of the building to ensure that the building design meets all the necessary requirements and compliance codes CSA4 continued saying that:

> *"In the design office, we run our clash detections basically check and run multiple simulations of the building to check that it meets all the requirements and compliance codes so obviously if you can detect that before you're constructing it out on site or it's just it makes for a much easier process going forward."*

As a Site Engineer at CSA, it is notable that CSA6 possesses extensive experience in utilising BIM tools for the purpose of quality assurance. By using BIM tools such as Autodesk BIM related software for quality assurance, CSA6 was able to identify incomplete works or defects, which could then be raised with the client and consultants through the model or drawings. Through BIM, the location and issue could be sent directly to the responsible party, allowing for prompt resolution of the issue. CSA6 explained: *"you can send that*

location along with the issue directly to who's responsible and address the issue directly straight away into BIM." This streamlines the process of tracking and managing tasks related to quality assurance and approval, reducing the need for manual tracking and oversight. CSA6 also added that, BIM was primarily used in CSA for RFI (request for information) tracking, to close out issues, track defects and to essentially manage subcontractor documentation, like ITPs (inspection and test plans). CSA5 also agreed that BIM is highly effective at recording, storing, and organising information, which ultimately supports to management in monitoring various aspects of construction projects, including quality assurance (QA) tasks. Through BIM, management can easily track the number of quality reports that have been generated, which can provide useful insights into the overall progress and performance of the project. CSA5 commented:

> *"I can see straightaway, if we've been checking concrete, floors, how regularly we've been checking them, and so on, and see how many safety audits the Safety Managers and I can see the inductions that we've done. It's really easy for management to see what we're doing in our job and track our progress."*

These patterns of underlying beliefs and behaviours displayed their activity orientation on 'doing' and their top priority is delivering high-quality work to clients, which motivates them to constantly strive for excellence in their work. This dedication to quality is reflected in their ongoing efforts to do their best and achieve exceptional results.

6.4.4 The nature of reality and truth

Every organisation has beliefs about the nature of reality and methods to identify that reality. These beliefs guide individuals on how to identify relevant information, how to interpret it, and how to determine when they have enough information to decide whether or not to act, and how to act. It was evident during the interviews that CSA determines whether something is true or not, through a pragmatic approach. Therefore, it holds the pattern of underlying belief that **problems should be approached and resolved pragmatically**. In the BIM space, employees at CSA always focused on practical solutions. For example, the organisation relied on the available and accessible technical support and resources to assist in the resolution of software issues. As expressed by CSA3:

> *"We have an online services team; we can lodge our issue in there. If it takes little time to get an answer, they have pre-prepared solutions in the system. So, if you encounter, let's say, you can't filter something. So, if you search on the website, it straightaway gives you the answer."*

The presence of an online service team demonstrates that the organisation believes in rapid problem resolution and is willing to invest in technology to facilitate it. This is consistent

with the belief on pragmatic orientation in finding truth and reality, which focuses on finding effective solutions to problems. Change management in construction projects for instance, is a challenging and time-consuming task which involves extensive paperwork, coordination and communication among many parties, which is prone to delays and changes (Matthews *et al.*, 2017). Therefore, at CSA, the BIM model is used to streamline the construction process. CSA4 commented:

> *"Change management is a key area we're trying to hone in on. So, to compare models, and document development, digitally, as we go through just try to capture what may have changed, so that's, you know, so we can baseline things against tendered model, and then do comparisons on that, digitally to find out what's changed, because the quantities that are changed to the actual constructed model."*

At CSA, employees appreciated efficiency, even if it meant taking on extra responsibilities related to BIM usage. As expounded by CSA5:

> *"When we go to the site, sometimes you need to carry a bunch of drawings in your hand. Now it's one equipment, one, just one iPad, your everything is there, all the drawings, model, all the emails, everything. So, it's far easier than before. And in the meantime, sometimes, let's say for an example, one of the contractors is asking, let's say they have an issue somewhere, with the information we have then and there on our iPad, we can give him a solution straight away. Because we can take the other models, other drawings, it's very easy. Otherwise, those days we need to come back to the office and open the computer and go through the documents and take an action."*

In contrast to traditional methods of working, which required carrying numerous drawings and returning to the office to take action, CSA has placed an importance on speed, convenience and flexibility in work practises, which takes a pragmatist orientation. The pragmatic approach was evident in the approach they use to solve the problem at hand by first understanding the root cause of the issue and then finding a solution that works best for the individual's specific needs. According to CSA2, it is necessary to question their behaviours always to improve the efficiency and mentioned that:

> *"So, try to address what the problem is by saying, are you using the tool in the correct way, is there a better way better workflow we can do to achieve the goals, if you're not happy with, you know, the results you're achieving, or you're feeling it's frustrating you whatever else then to try to come up with, with an alternative method or a better method or whatever else to strive to?"*

The approach of examining whether someone is using a tool correctly and identifying a better workflow or alternative method to achieve their goals is highly pragmatic. This approach ensures that the individual is not wasting their time and effort on an ineffective method. This was also echoed in the comment by CSA6 *viz.*:

> *"You know, obviously, with the while I say that the technology has really come along, there are still always little glitches in there, there's always little things that go wrong, that don't quite work. And so, people get frustrated, and I guess it's time to then find out what's caused the frustration. And is there a solution that we can provide, you know, through the technology? Or is it something I need to get it about? Or is it training that we need? Just to get people past that pain point."*

CSA approach technology frustrations in a pragmatic way by solving the underlying problem rather than simply addressing the symptoms. They attempt to identify the root cause of the issue and exploring solutions that are tailored to the specific needs of the individual.

Apart from the pragmatic approach to determine truth, there were instances CSA relied on objective tests and wisdom when making decisions. Thus, they had the pattern of underlying belief that **objective tests and wisdom are sources of truth**. When evaluating the BIM performance in the projects, CSA is using a variety of IT-based systems to extract and evaluate data from various sources, including BIM 360, and using that data to create project-based evaluations. This data is then being dash boarded and shared with state management teams and the top management to provide different levels of information based on the data coming in. CSA is embracing data mining and reporting methods like Power BI to get a better understanding of project performance and identify any issues that need to be addressed. This helps company make more informed decisions and drive better outcomes. According to CSA1:

> *"We're using a lot of data mining or from our other available systems like BIM 360 etc, to extract data out of that, and to use that as an evaluation on projects, so that can then be dashboard and back up through our state management teams and onto our, onto the board. (....) we can track you know, how much people have used the systems or, and also where, where issues may lie. So, I guess we're getting more into that field now. It's going through going through a bit of a, there's a quite a bit of change happening at the moment. As we speak, we're starting to roll out more of that data mining through the so using things like Power BI and you know, the, the Autodesk API, which is available through on the BIM 360 platform, which is one of the reasons we've used that to try to start extracting data out of that, and then dashboarding that data so that people can have access to it. And then like, you know, in terms of reviewing where projects are at how it's tracking, we would use a lot of that sort of reporting methods. So digital reporting, basically, yeah."*

Dashboards can be used to extract specific metrics and analyse whether certain issues are being resolved or not. The effectiveness of this approach is contingent on the particular objectives at hand, as some goals may have more clearly defined metrics than others. For example, as explained by CSA2, CSA has set an objective to decrease the frequency of design clashes during a project. To measure progress towards this goal, a specific metric that can be tracked is the number of design clashes identified and resolved at each phase of the

project. Utilising data extracted from various systems, such as BIM 360, a dashboard can be developed to present this metric in real-time, facilitating project managers' ability to monitor progress towards the objective and take necessary corrective measures. This approach enables the organisation to make informed, data-driven decisions and continually enhance its processes to attain its objectives. However, while certain metrics can be extracted to measure progress towards objectives, there are other areas that are more subjective and difficult to measure through data analysis alone. In such cases, a combination of intuition and observation is necessary to identify areas where upskilling is required. According to CSA2:

> *"So, I guess through the dashboarding, we can take certain metrics out of things and work out from that, whether things are being addressed or not. So, it would, it would depend a lot on what it was that the objectives were. So, there are things that we have, we can have very clear metrics on. And other areas that are more subjective, and harder to you can't necessarily measure by extracting some data. So, I guess there's a mixture of how we can have how we can understand where, where things are being used and adopted. But a lot of it is probably through intuition, like just being observant on the jobs and working out what questions people were asking, and whether people are comfortable in finding the information for themselves or were they looking for other people to find that information for them. So, I guess you then you sort of got to try to work out who needs to be upskilled in, in different areas, depending on the questions that might be coming through. Yeah, so it's a multi-faceted way of trying, I guess, trying to understand where people are at. Yeah."*

Therefore, understanding the adoption and usage of BIM in CSA is a multifaceted endeavour that requires a combination of objective and subjective measures.

6.4.5 The nature of relationship to the environment

The underlying beliefs on a BIM-enabled construction organisation's relationship to its environment are determined by whether the organisation's members believe they harmonise, dominate or are dominated by their external environment. The external environment of CSA is its stakeholders including client, consultants and subcontractors in the setting in which it operates. The company hold a dominating perspective with its environment believing that it has the power and control to shape and manipulate the environment to suit its own interests. CSA understood that sector competition is intense, and that **BIM use provides a competitive advantage**. This was confirmed by CSA3 *viz.*:

> *"There is a really big competition among the contractors, main contractors. So, they try to show the clients we are far ahead technologically far ahead than others, we use advanced technology to construct buildings, for management, for designing things. So, because of that, every company, they're looking for advanced system to go ahead."*

By using BIM, CSA showcases their advanced technological superiority to clients, which can help them stand out in a competitive market. CSA1, the Construction Manager, explained how they leverage the tender process to win projects, by show casing their design concepts, and construction processes using the BIM model to the clients. They effectively use the BIM model for presentation and communication purposes. They perceive BIM can as an aid in building reconfiguration and provide insight into access and egress requirements, as well as material handling procedures during construction. CSA1 stated that:

> *"We also use BIM from a presentation point of view, when we do tender interviews and like that and wherever type of clients through the model as it stands, we also use it to reconfigure buildings, and also provide us with the ability to show access and egress requirements and how the material handling takes place. So, you can use it beyond just the detailed design, you can use it to showpiece, what you're trying to do."*

The use of BIM by CSA serves as a tool to demonstrate their capabilities and win competitive advantages in the market. CSA3's statement suggested that clients may not be well-versed in the technicalities of BIM but recognise its advantages in achieving defect-free quality buildings. This underscores the importance of effective communication and presentation of BIM models to clients, which can serve as a means of enhancing client confidence in a company's capabilities and securing project contracts.

Moreover, the environment dominating view was evident during the BIM coordination meetings with the consultants and sub-contractors, where CSA played a leadership and controlling role. The team at CSA holds regular meetings to review conflicts and resolve problems detected through Navisworks, a BIM software tool. During these meetings, the group discuss and try to reach to a consensus on the assignment of responsibility for resolving specific problems. If the parties involved cannot resolve an issue collaboratively, CSA come forward and make the ultimate decision. They use their power as the head contractor to the project and try to dissolve the issue. Accordingly, CSA2 explained:

> *"Sometimes these coordination type issues need to be referred back to the design team, from the construction team back to the design team to say we can't fit these particular elements within this space, we need to have a solution here, or we need to lower the ceilings and all those sort of things, obviously, then we would be the ones that would decide we're going to have to refer this back up further, there is no resolution here, that can be made at the construction team. So that might have to be referred back to the design team, we're going to come up, have to come up with another more radical solution to resolve the issue."*

This highlights the company's belief in their ability to control and manipulate their environment to achieve their goals.

The perspective of environment dominance at CSA was also attested in their pattern of underlying belief **using BIM for visualisation is an effective way to persuade clients.** Employees at CSA believed that by providing clients with information and resources can help them make informed decisions and better understand the products and services they are receiving. This can lead to improved outcomes and a stronger relationship between the company and the clients. They assumed that stakeholders, including clients, can be engaged and impressed by the use of BIM tools for 4D simulations and visualisations. CSA4 said:

> *"We have done some full sort of movie type outputs for client engagement, stakeholder engagement. What Hollywood BIM, if you like, pretty pictures, it just to sort of sell the process but sort of capture that a lot of that sort of the 4D processes whether that's be done through Navisworks timeline or as the power project or use fuser if we're going to do the full-on simulations."*

The cinematic-style presentations using BIM model as a part of their efforts to engage clients and stakeholders further reinforces their need to convince the clients. CSA5 reflected on this that explaining this approach in design and construct projects and elaborated *viz.*:

> *"In the past, in the past 10 years, especially in the past five years, CSA has enjoyed using BIM in the designing construction projects a lot. So CSA enjoys using it through the tender phase of a designing construct project, because they can build a model of what the building is going to look like at each stage of the construction phase, and show the client, what the building is going to look like at certain stages and also explain the program to the client, helps them understand why certain phases of the project, take certain amounts of time as well."*

CSA1 also agreed that BIM gives them the ability to visualise the building, in a graphical sense, which, and interact with the building sense. CSA1 emphasised that visual aids provide a better understanding of the construction process and are more effective than traditional 2D graphics, as they allow for 3D representations that can be rotated to show various perspectives and aspects that would be difficult to demonstrate otherwise. In reflection, CSA1 said:

> *"So, you know, this is how trucks will come in, concrete pumps will work. This is, this is the load that's getting used, you can see goes up a building, so they can actually get a feel for the methodology around building a building, which it's very difficult to explain that in 2D dimensional graphical format, was not 3D graphical format, you can actually show that and spin the building around it, show them a whole lot of things that they normally wouldn't be able to see."*

6.4.6 The nature of time

Employees underlying beliefs on time could indicate a past, present or future orientation. With regards to the underlying beliefs on the nature of time unit, both present and future were important at CSA. The orientation towards present was apparent on CSA's expectations on immediate and tangible benefits of BIM. Hence, they believed that **people are motivated by the desire for instant gratification and immediate results**. Consequently, they prioritise strategies that result in quick wins and assume that those wins, and tangible benefits build momentum resulting an improvement in BIM. They believe that this approach is effective because it allows employees to see the demonstrable value of BIM first-hand (*as indelible proof*), rather than just being simply told that it is the way forward (*as a leap of faith*). CSA4 noted:

> *"I think, people need to see the benefits of the process before they're going to invest in it. And until that's sort of seen in a working live environment, it's hard to, it's hard to get people to engage in it. And I guess up until now, because it's been seen as a, as a BIM has been sort of seen as a construction tool. It hasn't so much been seen as a you know, as a virtual building that can you know, we can exploit all of the information into the future."*

This was also echoed in the comment by CSA2 who stated:

> *"I think probably a more effective way than trying to force it through is to introduce people to it in a way there's an easy win and so that once you once you get people to see how an aspect that affects their project, can be better handled through digital processes /BIM."*

Seeing how these tools can make their work easier, more efficient and more effective leads to greater buy-in and enthusiasm for BIM, making it easier to introduce more comprehensive changes in the future. Experience on BIM allowed CSA3 to intuitively see that BIM was a better way of doing things. CSA3 noted:

> *"I sort of saw that connection, you know, between data here in a virtual piece of duct work it was or virtual piece of pipe work. And then I could see that go out to a machine and develop. (…) I think it's just a change of mindset when you see that, and I think some people have the advantage of it and some have challenged by it, is to actually just intuitively understand that this is a better way of doing it. I don't need you to prove to me with facts and figures that it's a better way of doing it, I can look at it. And I can say that's a better way of doing it. So yeah, I've had a great experience because of that."*

However, even with a focus to present, CSA tries to build a foundation of trust and comfort in the BIM environment by demonstrating the value of BIM tools through easy wins. These incremental successes anyhow pave the pathway to build a broader transformation in future.

Table 6.2. Patterns of underlying beliefs of Case A

Organisational culture dimension	Questions need to be answered	Patterns of behaviours	Patterns of underlying beliefs	Underlying beliefs of CSA
The nature of human relationships.	Would an autocratic or participatory authority system be more effective?	• Centralise decision-making authority with the BIM Manager. • BIM Manager provides the technical support and training. • Approach the BIM Manager for assistance with insuperable problems. • BIM Manager acts as the communication channel between top management and general employees. • BIM Manager is responsible for mentoring new employees. • BIM Manager controls the BIM operations. • Hold the BIM Manager in high esteem for their expertise. • BIM Manager develops standards, protocols and procedures. • Top management exclusively collaborates with the BIM Manager. for strategic decisions on BIM implementation. • Top management set BIM objectives. • Project Manager makes decisions at project level. • Minimal involvement of BIM team in decision making. • BIM team is dispersed in different projects. • Employees are bound by the established BIM protocols and lack power to determine BIM policies.	• Presence of a powerful leader is critical in a BIM setting. • Ultimate decision-making power resides with the authority positions.	Autocracy Leader-centred.
	Would it be more effective to structure society based on individualism or groupism?	• Hold regular meetings. • Employees are proactively encouraged to raise their concerns in meetings. • Consider a diverse range of perspectives when making decisions. • Encourage formal communication. • Share the lessons learned. • Limited informal communication among the BIM team members. • Include relevant BIM specialists during discussions. • The open office environment and design with minimal walls.	• Discussions gave results. • Organisation's interest prevails above any personal interests.	Groupism.
	What is the ideal way for individuals to interact with one another? Is life characterised by competition or cooperation?	• Offer mutual assistance and support to colleagues without hesitation. • Share the lessons learnt from BIM projects through BIM sessions. • Encourage continuous learning and a growth mindset. • Open to change and willing to adapt their approaches for the greater good of the team. • Everyone feels accountable for the success and takes ownership of their roles and tasks. • Team members trust each other, feel safe to express themselves. • Conflicts are addressed openly and constructively, seeking resolutions that benefit all parties involved.	• Mutual interdependence is best suited to problem solving.	Cooperation.
The nature of human nature.	In this organisation, how is human nature viewed; perfectible, immutable, good, neutral, or evil?	• Employees are trusted to do their job. • Empower self-motivated staff members. • Deliberate nurturing to instil self-belief and self-directed learning. • Encourage continuous learning and development. • Mistakes are allowed and no punishments available. • Employees have the full autonomy on using BIM. • Employees are trusted and respected for taking ownership of their work. • View mistakes as opportunities for learning and growth, not grounds for immediate termination.	• Employees are viewed as being inherently good. • Employees are viewed as being capable of governing themselves.	Good, perfectible.

Organisational culture dimension	Questions need to be answered	Patterns of behaviours	Patterns of underlying beliefs	Underlying beliefs of CSA
The nature of human activity.	Is the group focused on doing, being, or becoming?	• Proactively adopt BIM driven by top management's recognition of its benefits. • BIM objectives primarily driven by upper management. • Change directives and initiatives issued by upper management. • Heavy investment in BIM development, even without specific client requests for BIM deliverables. • Identify areas for improvement and make changes to processes and systems. • Accountability for quality. • Attention to detail. • Use BIM to integrate data management systems with quality checklists and approvals. • Use BIM for clash detections and multiple simulations. • Use BIM for easy tracking of quality reports. • Use BIM for Request for Information (RFI) tracking, closing out issues, and managing subcontractor documentation like Inspection and Test Plans (ITPs).	• Being proactive in the BIM environment was the proper way to behave. • Quality delivery is the main priority.	Doing. Proactive-quality driven.
The nature of reality and truth.	How is truth determined? What is the source of truth, and how does it come to light? By tradition, wisdom, conflict and debate, pragmatic criteria, scientific method or social consensus?	• Rely on available and accessible technical support and resources. • Use BIM model to streamline change management in construction projects. • Encourage to take extra responsibilities to improve efficiency. • Use technology to provide quick and effective solutions to issues on-site or in the field. • Identify the root cause for problems and providing appropriate solutions. • Focus on speed, convenience, and flexibility of working. • Use BIM to find alternative methods of working. • Encourage problem solving attitude. • Emphasise on BIM benefits. • Data-driven decision making. • Use IT-based systems to extract and evaluate data from various sources, including BIM 360, to create project-based evaluations. • Adopt data mining and reporting methods like Power BI to gain a better understanding of project performance. • Use dashboards to extract specific metrics and analyse progress towards objectives in real-time. • Rely on intuition and observation to identify areas that require upskilling or improvement.	• Problems should be approached and resolved pragmatically. • Objective tests and wisdom are sources of truth.	Pragmatic. Scientific method and wisdom.
The relationship of a group to its environment.	How do the organisation and its members interact with the outside world, particularly the external market of the organisation's services? Is it a domination, submission, harmony?	• Use BIM as a tool to showcase their advanced technological superiority to clients, gaining a competitive edge in winning projects. • Use BIM models during tender interviews and client presentations to showcase design concepts, construction processes, and building reconfiguration options, enhancing client confidence and securing contracts. • Takes leadership and control in BIM coordination meetings. • Control the decision-making process at construction project level. • Use BIM as a marketing strategy. • Involve early in the design process. • Use BIM in Design and Construct projects.	• BIM use provides a competitive advantage • Using BIM for visualisation is an effective way to persuade clients.	Domination.
The nature of time	Is the organisation's basic orientation toward past, present and future? What does time mean to this organisation?	• Seek immediate benefits. • Need to gain the buy-in from employees. • Do not use BIM if the benefits are not proved.	• People are motivated by the desire for instant gratification and immediate results.	Present

6.5 Summary

This chapter presented an in-depth within-case analysis of Organisation A, focusing on the extraction of underlying beliefs across six distinct cultural dimensions. These dimensions encompass the nature of human relationships, the nature of human nature, the nature of human activity, the nature of reality and truth, the relationship of a group to its environment and the nature of time. Through a meticulous process of open and axial code analysis, behaviours and patterns of underlying beliefs were identified, subsequently leading to the extraction of specific underlying beliefs. CSA believed in autocracy of a BIM leader, groupism, cooperation, goodness, perfectibility, doing orientation, proactivity driven by quality, pragmatism, scientific method, wisdom, domination of environment and present time. The next chapter presents the within-case analysis of Organisation B.

CHAPTER 07- WITHIN CASE ANALYSIS OF ORGANISATION B

7.1 Introduction

The Chapter 06 outlined the within case analysis for case A. This chapter offers a detailed within case analysis of organisation B. Initial sections of the chapter present background information of organisation B and organisational structure, highlighting key departments and roles related to BIM. Subsequently, the chapter presents the details of the interviewees involved in the study. This includes information on their positions within the organisation, their roles and responsibilities, and relevant demographic characteristics. Next, an overview of the responses collected from them regarding the external adaptation and internal integration problems faced by organisation B in the BIM environment is presented. In the following sections of this chapter, the underlying beliefs, and patterns of underlying beliefs supported by behaviours discovered in organisation B within the BIM environment are provided.

7.2 Background information organisation B

Case study B (CSB) is a leading international construction enterprise that was founded in 1978. Since then, the company has expanded its operations and enhanced its ability to deliver projects, pioneering innovative construction methods, adopting advanced technologies, ensuring client satisfaction, and constructing some of the world's most renowned projects. The company operates in the construction, engineering and infrastructure sectors, and has a reputation for delivering innovative, sustainable and high-quality projects internationally. As a company with a global presence, the company employs more than 13,000 people and has an annual revenue of over £3 billion. CSB’ s unique identity is derived from its purpose, which is to push the boundaries of what is possible in the service of humanity, and its core values of care, integrity, and courage. Care refers to the company's commitment to the health, safety and wellbeing of its employees, clients and the communities it serves. It also encompasses the company's dedication to sustainability and its responsibility to minimise its impact on the environment. Integrity refers to the company's commitment to honesty, transparency and ethical behaviour. CSB strives to maintain the highest levels of integrity in all of its interactions with stakeholders, including clients, suppliers and employees. Courage refers to the company's willingness to take risks, embrace innovation and challenge the status quo. CSB aims to lead the industry in adopting new technologies and methods of construction, and it is committed to continuously improving its processes and operations.

CSB has established a goal for 2025 to be acknowledged as the premier organisation for excellence and innovation within the field of construction. The company has invested heavily in research and development to develop innovative construction techniques and materials, such as its Design for Manufacture and Assembly (DfMA) approach, which uses offsite manufacturing to reduce waste and improve efficiency. The implementation of DfMA has had a significant impact on the use of BIM and digital engineering tools within the company. In order to pursue DfMA, it was necessary to have a BIM model to achieve the necessary level of detail in design. Consequently, 15 years ago BIM was adopted in CSB as a mean to design, plan, and execute projects with a greater level of accuracy and precision. By leveraging BIM, CSB was able to create a virtual construction environment that allowed them to design and plan the construction process in intricate detail. This approach enabled the client to visualise the solution and provide feedback throughout the design process. Their slogan for their approach with BIM technology was ‘building the project twice’. This refers to the process of creating a virtual model of the project using BIM technology before starting the actual construction. The company use many BIM software applications including SYNCHRO, Autodesk CAD, Autodesk Revit, Autodesk Navisworks, Rhino, Bentley open building system, Tekla and 12D. Herein, Navisworks, and Revizto, are used in viewing the model and for coordination, and Revit 12D, AutoCAD SketchUp are used to produce models. In addition to the aforementioned software tools, there are also several productivity and commercial tools that are operated in the background. Examples include Caustics, Candy, P6, and Procore, which are often utilised for construction management and information management purposes. Other software tools such as Aconex are also commonly used for managing project data and facilitating communication between project teams. The use of BIM at CSB mostly focused on planning, health and safety, design, commercial aspects.

Figure 7.1 shows the formal organisational structure of the CSB. This organisational structure was built based on the findings from the interviews when discussing components such as structure, communication, company website and the organisational chart provided by the interviewees. It is worth noting that the CSA has a designated central digital team focused on digital engineering, which is headed by the Digital Lead Engineer who is directly reports to the Technical Director.

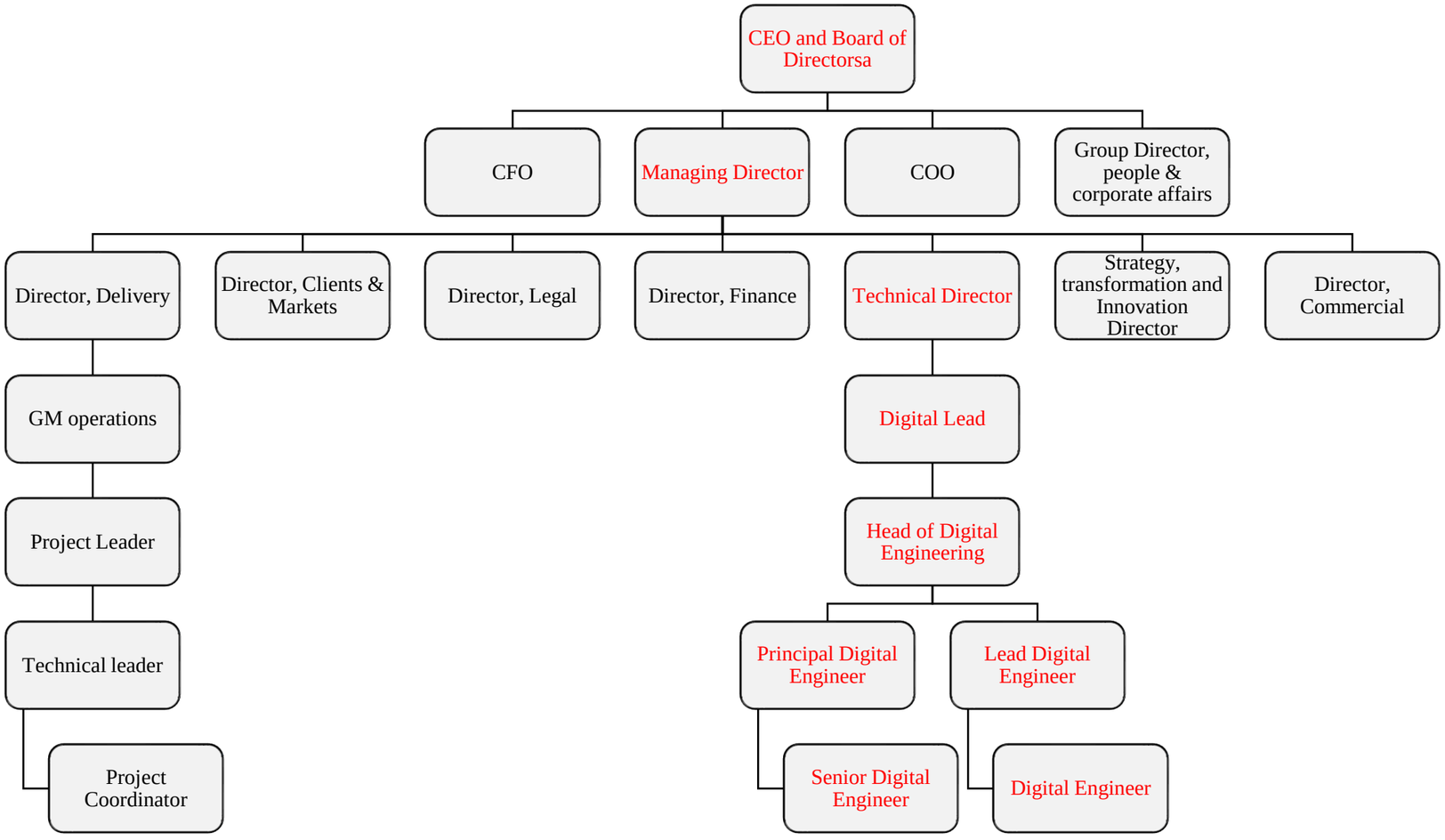

Figure 7.1. Organisational structure of organisation B

Six interviews were conducted within the company, with organisational roles presentative of the two levels of the organisational structure: senior management level and operational level. Accordingly, six interviews were conducted within the organisation, with three from managerial level and three from operational level. Table 7.1 summarises the details of interviewees of the CSB.

Table 7.1. Details of interviewees in Case B

Interviewee	Job function	Industry experience	Experience with BIM
Interviewee CSB1	Lead Digital Engineer	16 years	12 years
Interviewee CSB2	Senior Digital Engineer	13 years	9 years
Interviewee CSB3	Digital Engineer	8 years	5 years
Interviewee CSB4	Senior Project Engineer	23 years	4 years
Interviewee CSB5	Site Engineer	8 years	4 years
Interviewee CSB6	Project Coordinator	5 years	2 years

CSB1 holds the position of Lead Digital Engineer at CSB and is responsible for leading the delivery of digital engineering duties on construction projects. CSB1 has to work with clients to understand their requirements, and then ensuring that those deliverables are met during design and construction and for handover. CSB1's years of experience split between design and delivery roles. During the first eight years of their career, they worked as an Architect, and in the subsequent eight years, they have worked for main contractors in a similar role.

CSB2 is the Senior Digital Engineer at CSB and is responsible to create accurate digital models of building based on the sophisticated design models provided by the design partners. CSB2 has been working at CSB for 3 years and reports to the Lead Digital Engineer and assists in managing and coordinating project digital engineering deliverables. CSB2 also in charge of ensuring that BIM modelling (3D), construction sequencing (4D) and cost management (5D) are successfully implemented and delivered.

CSB3 is a Digital Engineer at CSB, where his primary responsibility is to provide digital engineering support and produce outputs such as 4D animations or limited modelling. CSB3 is accountable for monitoring, reviewing and reporting on the progress of digital engineering to the project leadership and management of CSB in a project setting. Major tasks implemented include defining and documenting processes, collaborating with stakeholders, leading meetings, and managing data that originates from the construction team, such as cost or time data, and integrating it into the digital models.

CSB4 functions as the Senior Project Engineer and has been working in this role at CSB for 2 years. CSB4 is responsible for keeping the managers informed about project progress and

providing technical support to supervisors as needed; key responsibilities include: managing the scope of work; and delivering it within the schedule using defined work methods.

CSB5 is a Site Engineer at CSB who has been involved in projects with a site management role. CSB5 primarily uses BIM to track RFIs, close out issues and manage subcontractor documentation such as their ITPs and quality assurance records.

CSB6 is a project coordinator at CSB and has been working in this role at CSB for 2 years. CSB6 is responsible for to assisting the team in clash detection and issue resolution during the construction process.

7.3 Overview of responses to external adaptation and internal integration problems

According to the working definition developed in Sub section 3.2.2, organisational BIM culture is the '*patterns of beliefs and thinking guided by behaviours and artifacts, that was learned by members of BIM using the organisation as it solved its problems of external adaptation and internal integration'*. The external adaptation problems in BIM-enabled-construction organisation include BIM mission and strategy; BIM goals and objectives; means to be used in achieving BIM strategy; BIM performance evaluation and remedial actions to ensure that members meet the BIM mission and strategy (Schein 2010). The internal integration problems include language used in a BIM environment; BIM team boundary; power and status allocation criteria in a BIM team; peer relationships in BIM environment; allocation of rewards and punishments and unexplainable and in explicable issues (ideology) (Schein 2010). The underlying beliefs were found by questioning how the group responded to these internal integration and external adaptation problems. The following is a short summary of the key responses to such problems:

BIM strategy and objectives - the emphasise on BIM at CSB is coming from the top management and many of the top-level managers and directors come from a design and engineering management background, which may explain their focus on taking BIM design to the next level. CSB's mission for 2025 involves taking their construction process to a highly advanced level of digital design and coordination, possibly beyond typical BIM models, with the ultimate goal of having a final as-built model for every project. This objective is a key strategy for the company's 2020-2030 plan, which seeks to achieve digital build models (a fully designed 3D BIM models) for all projects, including handover documents.

Means of accomplishing BIM goals - CSB places a significant emphasis on investing in BIM and use different BIM authoring tools. From basic CAD to the SYNCHRO, which is like a

4D tool, they use Autodesk Revit, Autodesk Navisworks, Rhino, and Bentley open building system. Sometimes, as providing licence to everyone in the company is expensive digital engineers at CSB create free versions of models for their team to use. They select few free tools and convert files to be compatible with those tools. They have developed a digital engineering strategy to facilitate the BIM delivery in projects.

BIM performance evaluations and remedial actions - the company is doing their own audits and there is a team that conducts audits internally to ensure compliance with industry standards and regulations, utilising team members who have completed relevant courses and have experience in auditing. This allows for greater control and oversight over the projects. The company prioritises in providing training to the employees. Those include attending webinars, regular requests to sit in online learning sessions, and participation in industry-wide meetings to keep up with the latest developments. The company also supports attending training sessions hosted by software providers like Autodesk.

Common language - the language at CSA has been changed since the adoption of BIM. Even the term BIM appears to be on the decline within the organisation, with a shift towards the usage of terms ‘digital’ or ‘digital engineering’ to replace it. Further, they opt for plain English rather than the use of acronyms or technical language, such as ‘4D,’ ‘5D’ and ‘6D,’ preferring to describe the specific applications of BIM in planning, commercial cost management and facility management.

BIM team boundaries - the hierarchy of the BIM team at CSB starts with the Technical Director, who is responsible for developing and implementing BIM strategies and managing BIM resources. Under the Technical Director there is the Lead Digital Engineer assigned to each state of Australia, who closely work with Digital Engineers and project teams to provide support and training. The digital experts on projects and strategic roles that manage information and innovation within the company have been emerged as a mean to achieve their overall strategy.

Power and status allocation criteria in a BIM team – at the organisational level, the Technical Director has the power and responsibility to make decisions related to BIM implementation and use. However, the central digital team headed by Lead Digital Engineer also has the power to govern the BIM use. The digital team is responsible for supporting the implementation of BIM to achieve best practice deliverables, ensuring completion of monthly project overviews to a high standard, and contributing to the establishment of the BIM Execution Plan, Protocols, CDE and federated model for the project.

Rewards and punishments - There is no rewards or punishments placed at CSB about BIM use at individual level. However, verbal appreciations and celebrations of BIM use were visible.

Ideology - one of the primary difficulties often encountered is when client requirements lack clarity in terms of project objectives. It becomes challenging to initiate the project without a clear understanding of what is needed, what resources are allocated, or what the client truly wants. In addition, resourcing, especially when engaging subcontractors or design partners, has become a significant concern these days. There are instances where client-level requirements are not properly addressed, and there may be a lack of awareness regarding those requirements. This can result in the selection of a design partner who does not possess the necessary level of experience. Consequently, there is a learning curve involved in bringing them up to speed, putting pressure on other areas of the project.

7.4 Underlying beliefs of organisation B

The fundamental underlying beliefs that exist within an organisation create a cultural paradigm which serves as the foundation for all aspects of organisational life. These beliefs shape the behaviours of individuals within the organisation and influence how they interact with one another and approach their work. Interviewees' responses to internal integration and external adaptation issues in the BIM environment reflected different patterns of underlying beliefs. These patterns were analysed against the cultural dimensions viz. human relationships; organisation's interaction with the environment; the nature of reality, time and space; the nature of human activity; and the nature of human nature to reveal the underlying beliefs of the CSB (Refer to Table 7.2).

7.4.1 The nature of human relationships

The underlying beliefs that dictate how individuals within the group interact and relate to each other are considered under this category. These beliefs pertain to the interactions between employees, power distribution, competitive and cooperative nature of relationships. Thus, the beliefs solve the problems related to best authority system, best way to organise and correct way to relate to each other.

Best authority system

The underlying beliefs within this category are geared towards answering the question of whether an autocratic or participative authority system is the optimal approach for organisational operations. The best authority system at CSB had elements of both autocratic and participative authority systems. The preference on autocracy was visible in the pattern

of underlying belief that **ultimate decision-making power resides with the authority positions.** Even though the ultimate decision-making power is rested with the authority figures, the digital engineering team had the opportunity to involve with the decision-making process. This is going in line with their pattern of underlying belief **skills and expertise serve as sources of power** and justifies the inclination towards participative authority system.

When it comes to significant business decisions, the decision-making process remains primarily autocratic at CSB, with the executive group having the final say. Therefore, the CEO and Board of Directors are responsible for making most business decisions at the organisational level. The introduction of BIM at CSB exemplifies the organisation's top-down approach to decision-making. The decision to adopt BIM was initiated by the top management as a part of their strategic vision for the organisation. The introduction of BIM to CSB was done as an imperative measure to facilitate the implementation of DfMA in their projects. When the respondents were asked about who set the BIM strategy and objectives in CSB, they all replied that the senior director level, specifically the Technical Director, was responsible for setting the objectives.

Once the BIM was implemented, some of the autocratic power vested in the top management was subsequently delegated to a centralised digital team. This digital engineering team is headed by the Technical Director and composed of engineers who possess extensive skills and expertise in BIM. The members of the digital engineering team are highly proficient in the use of various software tools related to BIM. They possess a deep understanding of the functionalities and capabilities of different software applications used in the BIM process. They are also capable of applying their knowledge and skills to effectively manage and execute BIM projects. Confirming this CSB3, a Digital Engineer, claims that:

> *"Our team itself, is quite experienced. So, we know where the failure points are, we also make sure that we're constantly speaking to software vendors, to make sure we know sort of where the industry is going."*

The digital engineering team is now responsible for making decisions related to BIM, which means that the top management has relinquished some of their decision-making power in this area. The digital team is consulted for their input during the decision-making process. Still the ultimate decision-making power resides with the technical director. CSB6 explained:

> *"We do have an entire division related to digital engineering. So, the ultimate decision rests with the guy that heads that up."*

Notably, significant issues pertaining to BIM practices typically undergo executive-level review, despite the digital engineering team's involvement in such decision-making processes. It is noteworthy that top management in the organisation all come from either a design background or an engineering management background. CSB2 expressed:

> *"I think I've seen few people on the organisation chart at the top level. They all come from the design background itself. And engineering management level background. Yeah. And they want to take the take the BIM design to the next level. They have got experience as Design Managers, Design Engineers."*

This explains the high value placed by the organisation on individuals who possess both technical expertise and leadership skills when considering candidates for leadership positions. Also, CSB3 mentioned that the employees are advanced through their careers to come to leadership positions. For instance, the Technical Director has progressed through various positions, such as Engineering Managers and Directors, before being appointed to their current role as the head of the team. This progression suggests that the individual has gained extensive experience and skills in the field of engineering, as well as in leadership and management. Having a well experienced Director as the head of the team endowed the digital team with more power and authority. This emphasises the CSB's pattern of underlying belief on skills and expertise serve as a source of power. Thus, at CSB, innovative decisions are made by those who possess either technical expertise or power.

Best way to organise

To understand the underlying beliefs of CSB regarding the nature of human relationships, there is a need to examine their assumptions about the most effective way to structure society. This involves determining whether CSB leans towards individualism (which prioritises personal freedom and achievement) or groupism (which emphasises group interests and interdependence among individuals). Responses from interviewees revealed the presence of groupism in their pattern of underlying belief of **having a sense of belonging is necessary.** The employees at CSB were well aware about the organisation's mission to be the recognised leader for innovation and excellence in the construction sector in 2025 and they were capable of explicitly mentioning it. For example, CSB1 stated: *"look, there is something around the company wanting to be seen as the most innovative company in construction by 2025*" and CSB3 expressed: *"our mission is to become a recognised leader for Innovation and Excellence."* This shows that everyone is working towards the same objectives and lead to greater cohesion and success within the organisation. Having a clear mission also helped employees understand how their individual contributions fit into the

larger picture. This gave them a greater sense of belonging. This resulted to employees to see the organisational structure as just a governance to function and manage the company and the interactions between employees go beyond and adhere to a more familial dynamic. CSB6 echoed that sentiment by saying:

> *"Yeah, there's an obviously an organisational structure and there's a structure for a reason for governance purposes, but in terms of how we interact. It's probably more than just collaboration, but a lot of us view our colleagues as family. So, this is reasonably rare for a building company, for any company that I've ever worked for. But do feel a little bit more than just colleagues a little bit more than just collaboration. It really is that family feel."*

This familial atmosphere promotes a sense of groupism and camaraderie among employees. Therefore, employees in the organisation must develop personal relationships with each other beyond just their work-related duties. Building personal connections and relationships with colleagues was explained by CSB3 as:

> *"Well, I guess we know each other personally. And it's, you know, the conversations around work, just around work, you know. And for example, that you know, mate sits next to me, his kids, kids, he's got three, three young boys. And I asked about them all the time. I know, when they're having issues at school, I know what sports they play all those sorts of things. Yeah, we, you know, and we laugh, we have fun, we interact outside of work, all of those sorts of things."*

This is a form of groupism, where employees view each other as more than just co-workers, but also as friends or even family members.

It was also evident that CSB believed use of BIM is reliant on the collective efforts of the employees, rather than being the responsibility of any particular job role. Therefore, employees held the pattern of underlying belief that **BIM success is a collective responsibility**. The responsibility was rested upon everyone within the organisation. Each member of the company has a role to play in acquiring the necessary knowledge and skills to effectively implement BIM in their work. This includes both formal training opportunities and informal learning through collaboration and experience sharing. Therefore, it is incumbent on all members of the company to take ownership of the learning process and to actively participate in the development of their BIM-related competencies. This was echoed in the comment by CSB4:

> *"So, it's no one's job, per se, to actually make sure to use BIM, but it's something that's common. Now that we will do some form of it. If we're purely talking about BIM, we still do that on all of our projects, but it's just the level of what we're using it for, whether it's a coordination or something. But it comes down to the more than individual on the project, whether they see value on it and actually doing it."*

The employees at CSB commonly expressed the notion that 'it is also not one person's job, it is everyone's job within the company' when explaining the responsibility of using BIM. CSB gives a high importance on all team members to work together and collaborate towards achieving the goals of the organisation, even though certain tasks may require specific skills or expertise. According to CS1:

> *"So, every person within our company has a job to demonstrate efficiencies and innovation. So, it's not just the digital person's job to do this, it's everyone's job to do this. It's just supposed if you're thinking BIM is more 3D, 2D stuff, it's then it starts doing probably more the digital person skill, but they'll they will have each their responsibilities making sure that they're working closely with all the teams to drive the value seen in using the model and the value of information management."*

Accordingly, every individual in the company has a role to play in promoting efficiencies and innovation, rather than these responsibilities being solely assigned to a particular department or job role. This further conveys the CSB's underlying belief of 'groupism' to be the best way to organise in the BIM setting.

Correct way to relate to each other

Examining employees' underlying beliefs about the appropriate way for them to relate and interact with each other, and distribute power and affection provide insights into their underlying beliefs about the nature of human relationships. This can be determined by assessing whether the contractor emphasises competition or cooperation as the correct way for team members to relate to each other. CSB emphasised on cooperative relationships between employees rather than competitive ones as the best way to relate to one another. Thus, they held the pattern of underlying belief that **mutual interdependence is best suited to problem solving**.

It was evident during interviews that employees in CSB heavily relied on their colleagues for assistance with tasks related to BIM, primarily due to the substantial learning curve associated with this field. They were aware of their own limitations and were willing to seek help and support from others when needed. According to CSB2, a majority of the employees, about 80%, are proficient in using the BIM model, while the remaining 20% depend on the expertise of those who are well-trained and experienced in using it. They rely on their colleagues for assistance with using the BIM model. CSB2 further explained:

> *"They will go and ask the questions from other people because maybe they're too busy to do the exercise or maybe they're too busy to come up with the training, what they do, they will go back and depend upon the other people who are doing the training and stuff like that, they'll go and talk to them, they'll ask them because we hear stories, those stories, asking a guy ,this guy came to me asking for this*

> *information of the model that he is not in the same team. So, those 20% of the people a lot of times depend upon the people who we are training."*

This knowledge sharing behaviour across different teams through mutual support promotes a cooperative work environment. If employees face any issues or difficulties while using the BIM model, they tend to seek help from their colleagues as their first point of contact. This is true even if the one who seeking assistance is older and more experienced than the colleague providing the help. In fact, the age or seniority of the colleague providing assistance was not a major factor, as the most important factor is the colleague's proficiency in using the BIM model. Thus, regardless of age or seniority, employees rely on their colleagues for help and guidance with the BIM model. CSB3 shared their personal experience, stating:

> *"I didn't grow up with a laptop in my lap. Computers came around, around about the time that I was at uni. I guess it's just familiarity with the thing. And I do that sort of tongue in cheek a little bit. But it was really just, you know, that the younger generation showing me how to use a lot of the software that they've been using for a lot longer than I've been at CSB."*

The cooperative nature of the organisation was further exemplified by the pattern of underlying belief held by its members that they are like a family. This belief suggests that there is a strong sense of unity and mutual support among the employees, which goes beyond just the work they do together. This familial approach creates a positive work environment where employees are willing to go the extra mile to help each other and work towards common goals. Supporting this, CSB5 mentioned that:

> *"I've always probably, that's probably exaggerating a little bit, but it was you know, it's new. It's something that I've not done before. But I guess because it's when you boil it down, it's essentially a digital version of what I used to do manually. It's not as scary as it first appears. And I guess probably because of the family nature of the company, and their willingness of colleagues to help it you know, anything you need help with. It wasn't a daunting task to become familiar with all the pieces of software and whatnot that get us there in the business."*

The centralised digital engineering team also always was willing to support employees when they encounter issues with hardware or software. The team is always available to help colleagues, and sometimes they are even asked to do other IT jobs outside of their scope of work. Due to their hands-on experience with a wide range of digital tools, they are often seen as go-to people for digital and IT-related issues within the organisation. CSB2 asserted"

> *"If there's a problem with hardware or software, maybe they usually they usually come to the digital team, if they have any issues using the software because we got experience using those tools, we're really trying to fix them. Almost like 88 percent of time we fix them. And if it's something to do with IT, ID access and stuff like that,*

> *we will raise a request to IT as a part of the BIM team, and then they will respond to us. Because we know the problem, we know how to solve it and they will ask us to fix it. So usually, we are there to help them always. Sometimes on the funny side sometimes a lot of people ask us to do a lot of IT jobs as well. They say Hi, I'm Lia this is not working, can you see my computer? My screen isn't working, it's things like that as well. So, at the end, we will end up as IT person as well. So, because we got hands on experience with a lot of things, yeah."*

CSB5 explained a situation where guidance was sought from a Digital Engineer on how to perform cutting a section through a building and measuring dimensions using Navisworks viz.:.

> *"The information I might be trying to find is, you know, cutting a section through a building or measuring a dimension from here to there, or whatever. But because I'm really a novice when it comes to using Navisworks. I'm often asking questions of the digital engineer how to do this, how to do that. So, for example, how do I cut a section through this part of the of the building? Or, if I want to measure from this point to that point, what's the best way to pick up those points rather than scrolling in and trying to get as accurate as I can? Is there a shortcut to doing that? Those types of questions. It's really what I spend most of my time asking someone that knows how to use the software."*

The company also tries to promote a more approachable environment for everyone to encourage employees to seek help from someone nearby who is knowledgeable in that area. This was supported in the statement given by CSB6:

> *"If a colleague is having an issue, and it's someone next to him is really good in the same thing, they will just go and ask them that's for sure. They will get someone to help them out. We use iPads on site. So that means every person is having a model in his head. So, it is like more into the BIM, using the BIM. So, that is one of the objectives as well like to try the team to use this digital tool in their daily tasks instead of going and doing it in a conventional way, and everyone is like, more approachable to everyone. So, yeah."*

7.4.2 The nature of human nature

People at CSA held the solid underlying belief that the nature of human nature is 'good' and humans are perfectible. This was reflected in their pattern of underlying beliefs that **employees get motivated by appreciations**, **employees should be open for learning and continuous growth** and **employees could be perfectible through training**. The underlying belief that employees are inherently good aligns with the practice of verbal appreciations at CSB. Even though the company does not have a formal rewards system for employees who use BIM in their daily tasks, during weekend catchups, the team acknowledges and appreciates those who have started using BIM. For instance, CSB2 mentioned that:

> *"When there is a very experienced aged person, and he started using a BIM tool in his Site Manager role, and then we just say, good to see Mark using the model on site, which is like giving an encouragement to other people to use it as well, because*

> *it would be 25 years of experienced person using the BIM model on site, at age 60. That means people at 35, 40 they can think about themselves and start using the BIM models. Giving an initiation to the people who are using in front of everyone will give some insight."*

This serves as a positive reinforcement for the employees' efforts to use BIM. By recognising these employees and their use of BIM, it encourages others to consider incorporating BIM into their own work as well, as they see the benefits it can bring to their work and the team as a whole. This approach assumes that employees are inherently motivated to do good work and contribute to the success of the company, which ultimately reinforces their underlying belief in good in human nature.

Appreciations and recognition at CSB are not limited to weekend catchups. The company has various channels and systems in place to celebrate and acknowledge employee contributions and achievements. For instance, if an employee comes up with an innovative idea, it is celebrated and recognised by the company. The innovative idea is shared through the company's internal communication channels, such as the Gamma, which is a chat room for all the employees of the company and weekly emails that circulate company news. CSB3 explained the scenario by stating:

> *"Yeah, so any type of innovation is actually celebrated around the business. So, we get an email, generally, once a week with all of this type of, it's almost like a newspaper, you think of where we highlight these types of innovations, or what happens around in the business or whatever. And bring them to the attention of the entire business. And by the entire business, I don't just mean the Australia hub, I mean, the entire global business. So yeah, innovation and all that sort of stuff. It's actually celebrated."*

CSB's faith in humanity was also apparent in the way the company trusted its employees and encourage them to take an active role in identifying areas for improvement and suggesting solutions. The employees' suggestions are generally listened and incorporated in decision making. According to CSB5:

> *"If anybody can see any improvements or tweaks that they want to have done to software, all they need to do is raise it. And generally, it gets incorporated in the software is pretty good. And a lot of people just take it for what it is and use it the way it is. But there are other people that I guess I had to think that way, you know, and they, and they come up with better ways of doing things or have suggestions to improve things. And typically, that gets listened to and adopted. And there are only minor tweaks, and they only need to be monitored tweaks. But I guess the good thing about CSB is that you know, we do listen, and anything that's a good idea and can be easily incorporated or has benefit to be incorporated, it gets incorporated."*

This statement reflects the underlying belief that employees are inherently good and have the potential to contribute positively to the company's growth and success. This was guide

by their pattern of underlying belief **employees should be open for learning and continuous growth.** Moreover, there were no accusations or punishments to those who do not use BIM and mistakes were tolerated, however the company expected the genuine willingness of employees to use BIM. CSB2 described how the top management would express disappointment when an employee is found to be following traditional practices instead of BIM as follows:

> *"Sometimes our Directors get upset, or Managers get upset to see drawings going around, because you got a model, you got the drawings on the computer, why you're using a paper or something like that."*

CSB believed that employees possess positive character traits such as openness to learning and new experiences. Thus, they encourage the employees to develop their skills in using BIM through a willingness to learn and adapt, even if they don't have a specific background in design or the required set of skills. CSB2 emphasised that:

> *"It's not necessarily a requirement for site engineers to have specific skills in using BIM software, but rather it's more about their willingness and openness to learning new things. Even if they don't have a background in design, they still use a 3D model and navigate through it. So, it's more about having the character trait of being open to learning and using new technology, rather than having a specific set of skills."*

The emphasise on having good character traits was also echoed in the statement by CSB5 *viz.*:

> *"The company is very supportive of trying new things, but ultimately, it's up to the individual to have the willingness to learn and adapt to new approaches. It's important for the person to have the mentality of wanting to learn and improve, and to take on new challenges with enthusiasm. So, it's not just about having the necessary skills, but also having the right mindset and attitude towards learning and development."*

CSB3 exemplifies a strong desire for continuous learning and improvement, emphasising the value of hands-on experience over theoretical knowledge alone. CSB3 recommends using the software and exploring its capabilities as a practical way to learn, and suggests that seeking guidance and asking questions, when necessary, can also be beneficial. According to CSB3:

> *"I can always learn more. And really, as I said before, a lot of it is just playing with the software as you need it and when you need it. And asking questions, after you've broken up, generally asked a question before we break it, but the best way to learn is to actually play with it."*

CSB has a fundamental expectation for their employees to perform their roles with excellence. Further, they hold the underlying belief that humans are perfectible, and this is rooted in the pattern of underlying belief that people can always improve, and this growth is

possible through a commitment to continuous learning and development, which entails possessing positive attributes such as openness to new ideas and skills acquisition. The underlying belief that humans are malleable was evident in their approach used in training employees. They hold the pattern of underlying belief that **employees could be perfectible through training.**

The digital team takes responsibility for training employees on new systems, such as Navisworks, Revit, and AutoCAD. They ensure that the teams have the necessary skills to use these systems before rolling them out. The company provides training sessions for each project team at the beginning of the project to teach them the minimum basic functionalities of how to use a BIM model. This is because not all employees in the company have prior experience with BIM models and may not know how to navigate them or find what they are looking for. Instead of giving them the design model, the company provides a simplified version in the form of a Navisworks file, which can be viewed on their computers. The training is done regularly, every six months, to monitor the progress and usage of the BIM models. CSB2, a Digital Engineer described how the company utilises a structured approach to train their employees *viz.*:

> *"Yeah, we run training sessions in batches, we as BIM experts, me, as a digital engineer, we are the BIM experts. Like we know how to use this model, we know how the model is done. So, we take that, and we see what the deliverables in the project and we are organise a meeting with the leaders saying, we have to train the engineering coordination team or the Site Engineers or Project Engineers, so they can use this BIM model. So, and then we start evaluating, like how to help easily, how they can easily get into it, instead of learning it from scratch, just showing the few buttons on what they want to click. So, they can see the model itself. So, the training sessions are breaking down into basic level, intermediate and the proficient level so we just make sure they understand the basics first, and then they will go to the next level after a couple of months."*

Accordingly, the first step is to evaluate which team or department needs the training and then determine what deliverables they need from the BIM model. The training is then tailored to help them easily understand how to navigate the model by showing them which buttons to click to achieve their goals. The training is broken down into three levels: basic, intermediate and proficient. Employees first learn the basics before progressing to the next level after a few months of training. The company has recently given all employees access to LinkedIn Learning, which provides structured training for various skills. They believe that by providing a structured training approach, employees can gradually learn and adopt BIM techniques and processes, which even help to reduce frustration and resistance to change.

CSB5 expressed how the company use structured approach to train employees to ensure that they use BIM effectively:

> *"If the company is forcing them to use BIM, that there may be frustration, that is optional to use, then we cannot guarantee, and we don't know whether they will be using it. But thing is, if we give them that approach for the next project, they start saying again, we're going to do this in different way for the next project, start learning this one, start learning and start using these things now. So, you can use it, they have to have a structured way of teaching people as well, not just like, forcing them to do it. You should have a structured way of approach of developing BIM environment in a company, we can't just push it up to people."*

7.4.3 The nature of human activity

The underlying beliefs of nature of human activity are evident in the actions and behaviours of the employees at the workplace, and their responses to the work environment. Three fundamental activity orientations can be identified as 'doing', 'being-in-becoming' and 'being'. CSB employees exhibited a combination of all three orientations in their approach to activity. Their 'doing' orientation was apparent in attempts to achieve the mission in the spirit of taking initiatives and anticipating opportunities. They believed that **being proactive in the BIM environment was the proper way to behave**. The way CSB initiated the use of BIM clearly reflected this pattern of underlying belief, as the adoption of BIM was spearheaded by top-level management at the company. CSB2 recalled the story of BIM adoption stating that:

> *"It was driven from the top management itself, because CSB is a UK based company and what I heard from the other colleagues is like the senior management, the senior directors, they are very interested in the BIM models and having it is from the higher management."*

As a UK-based company, the senior directors recognised the value of implementing BIM and took the initiative to incorporate it into the company's practices. This showcases their active involvement and commitment to leveraging BIM for improved project outcomes.

CSB1 explained that typically, BIM adoption at CSB stem from two main factors. Firstly, if a client specifically requests the use of BIM, it becomes a client-driven requirement that is communicated to the Project Director and subsequently filters down to the team. However, even in cases where BIM is not explicitly required by the client, CSB still implements it. This decision is mandated from the top, with the Managing Director advocating for BIM as a smarter way of working. This exemplifies their need to be proactive in the BIM setting. Consequently, the directive to use BIM is communicated to all team members, and while it may not be someone's specific responsibility to enforce it, it is a shared understanding and common practice within the organisation.

The company consistently viewed BIM as a smart approach, recognising that companies utilising BIM are considered more smarter in the industry. Hence, they embraced use of BIM models during construction, which demonstrates a proactive stance. They recognised the potential value of the models as valuable assets and information sources. Rather than relying solely on external sources to provide models or being driven by client demands, CSB2 took the initiative to see the value in BIM themselves. They recognised that BIM models could assist them in streamlining their construction processes, optimising project outcomes and enhancing overall efficiency. Instead of passively waiting for models to be provided, they actively sought to incorporate BIM models into their workflow. CSB1 further elucidated upon this point *viz.*:

> *"So we never used to be given models from designers, it never used to be a thing that all of a sudden, all our design teams were producing models and we saw and then the smarter construction companies saw value in that they could see in that whether it's being used for quantities or using it for staged handover or be able to use it for so it kind of like, naturally came from either the designers providing it to us, or it came from us, the client requiring it as part of the handover. And then therefore, we were using it during construction. But these days, it's typically come from us seeing value in it as an asset or information being an asset, and then us being able to use it to assist us."*

CSB's 'doing' orientation in activity was also reflected in their pattern of underlying belief that and **BIM is a tool for efficiency**. Their primary purpose of BIM implementation was to streamline project delivery, reduce delivery time, increase construction efficiency, and minimize wastage. Therefore, they actively explored methods to optimise time, cost, and delivery possibilities through BIM methodologies. This pattern of underlying belief encouraged them to think innovatively and outside the box, seeking ways to improve their processes further. By leveraging BIM's capabilities, CSB aimed to achieve significant time and cost reductions, resulting in more efficient project delivery. This was clarified by CSB2 as follows:

> *"The main purpose of BIM use in the company is to do delivery to reduce the delivery time and increase the efficiency in the construction and reducing the wastage. That is how, that is where you will start thinking out of the box. And maybe that is that is where they started thinking, okay, how can we make this better? It has reduced the time and the cost and delivery possibilities methodology here."*

CSB4, a Senior Project Engineer added how BIM made the life at CSB was made easier. Accordingly, use of BIM has reduced the manual effort and time required to access and manage various project-related information. All is now readily available within the digital platform, simplifying the workflow and eliminating the need for extensive paperwork or separate systems. This increased accessibility and integration enhance efficiency, facilitate

better coordination, and contribute to a smoother overall project management experience. CSB4 expounded:

> *"We could use that software to mark things off once and that software can then be linked to something else that he would have had to fill out manually previously was. With this BIM software, for example, with the quality it's all electronically linked, and I can access other pieces of software and information through that digital platform. Everything from program to the drawings to specifications to photos to you name it. It's all in there. It's all linked. So, if anything, the use of technology has actually made life easier, which I guess at the end of the day is what it's supposed to do."*

This goes in line with the company's mission to become the industry leader in innovation. This drive for leadership in innovation has motivated them to develop and adopt various technologies, including BIM and other software tools as they recognise that these technologies have the potential to revolutionize their operations and improve efficiency. Therefore, these tools are carefully chosen to align with their objective of enhancing efficiency and effectiveness. CSB4 continued to state:

> *"I guess it's part of CSB makeup is that we want to be the industry leader in innovation. So, all of these types of technologies and that's probably why we're developing it. There're several other bits of software that would fall into this category as well that we use across the business, we use a vast number of software to do various sorts of tasks. We use a digital platform that we created for managing temporary work. So, the reason we do it is to make our job easier, and also to be the industry leader in what we do."*

The pattern of underlying belief that **Quality delivery is the main priority** was visible in the BIM practices at CSB. With a 'doing' orientation, CSB was always accountable for the quality of work completed and attention was given to detail. They use BIM for quality management because it allowed data management systems to be integrated with quality checklists and approvals in an automated way. The CSB5 elaborated on the experience with BIM in quality assurance stating that:

> *"So mostly as an engineer, on a construction site, we would use BIM, predominantly, really, for tracking and monitoring of quality. That's probably the biggest use of it. Second, only to the actual digital model itself. So, the drawings and how to actually build the thing, but certainly from an engineering point of view, quality plays a big part in our digital strategy."*

Thus, the quality management was a key component of the organisational digital strategy. By leveraging BIM, they effectively monitor and manage quality throughout the construction process. The digital model serves as a reference point for ensuring adherence to design specifications, standards, and regulations. It allows for enhanced visualisation and analysis of the project, aiding in identifying potential quality issues, clashes, or deviations.

CSB4, with extensive hands-on experience in utilising BIM for quality management, outlined their processes and adoption of digital alternatives to the traditional method of manual quality paperwork *viz.*:

> *"We've got a software called Fieldview. And it's effectively it's a digitized version of the quality paperwork that used to fill out by hand. So, all of our ITPs (Inspection and Test Plans), ITRs (Inspection Test Reports) are uploaded into field view. And we use that, use tablets go into the field. We can access the drawings we can access, obviously the ITRs themselves, fill them out, as we go. So, for example, when we're about to pour reinforcing for a slab, we can go out there, pull up the drawings, check what's done on site, go through the ITRs, fill that out, take photos, attach those to it. If there's any issues that need to be fixed, we can generate correspondence that goes out to the person that needs to fix it in time by. So, it's all captured in this one piece of software."*

The software allows for real-time entry of inspection results, the attachment of photos as evidence, and the generation of correspondence, all in one integrated platform. The digital approach not only speeds up the process but also ensures that all relevant information is securely stored and easily accessible in one place. This eliminates the risks associated with misplaced or incomplete paper-based records. CSB4 further added that:

> *"It's undoubtedly so much easier using digital software to manage quality. Previous to that it was all paper. So, you would have to bring the plans, print the plans out and bring them out with you. You'd record with a pen, you'd have the RTR and you'd go through it with a pen, you then have to go back to the office and generate any correspondence that you'd need to send out to, for example, if someone needed to fix something, none of those pieces of paper are linked other than if you put a staple through them. So, if you got to pick them up, at some time in employment in the future, there's no guarantee that all the information that you've recorded or gathered will actually be in one spot at that time. So not only is it quicker. And it's a lot, I guess, safer from any information gathering point of view."*

CSB prioritised delivering the highest possible quality in their work. They took pride and satisfaction in their efforts, ensuring that they met and exceeded clients' requirements and expectations. The emphasise on client's priorities have strongly influenced CSB's approach, leading them to consider and incorporate the specific requirements and goals of each client when formulating their management plan. CSB1 went on to say that:

> *"If the client is asking for certain things like we will set up as part of our management plan, we'll make sure that our goals and objectives align with the clients. If they don't, we have a number of our own internal sort of mandated requirements around like information management, 3d models and digital processes. So, we will typically look at those and then set up workflows around that."*

In addition, the employees at CSB held the pattern of underlying belief that **continuous improvement was deemed essential**, which reflects their 'being-in-becoming' activity orientation. With this orientation they understand the importance of constant learning,

embracing change, and personal growth to stay relevant and achieve ongoing success. As explained by CSB2, new tools, workflows, systems, and hardware technologies in BIM field emerge regularly, and they have a direct impact on how employees work:

> *"I suppose most people are using it for what they see value in it, or where they see value. And it's constantly changing, though. So that changes with new tools being made available. So as there's new workflows developed, a new system looked at new hardware technology system software developed. So, things like drones, or things like laser scanners, or things like just iPhones with cloud capabilities or 360 cameras. Yeah, so as new technology is made available, people's roles are constantly changing at the moment. So, and therefore, people's roles are constantly changing."*

With this understanding CSB supports the employees to learn new skills, acquire knowledge about the latest technologies, and adjust their workflows to leverage the value provided by these advancements. CSB1 described how the company supported the continuous learning by ensuring that employees have access to different platforms such as LinkedIn learning and well-structured training sessions. According to CSB1:

> *"Everyone has access to LinkedIn learning now within our company. So, they can do more structured training, if they want to. Say that though, like, it's the digital team's responsibility to train up the staff around it. So, we run Navisworks trainings, or Revit training or AutoCAD training or whatever training the teams need to upskill themselves around new systems without that we're trying to roll out, so we don't roll out a system without trying to provide some sort of level of training for it. It's also not one person's job to actually learn it, it's everyone's job within the company, to actually if they've got some sort of direct impact, we will try to, we will provide training on it so that they have more of an awareness of it."*

Apart from inhouse training sessions the company organise webinars, industry-wide meetings and external training opportunities through vendors like Autodesk. CSB2 explained the initiatives by the company as follows:

> *"Our company is like they will send us if there is a webinar, there was a regular request, so we can sit online and learn stuff. And we do and just, they encouraged us to join in the industry wide meetings now. They were where they show one of the new things happening. So, these are the things the companies will organise for us to learn the new systems out there in the market. Yes. So more like webinars, training sessions, if Autodesk is running a training session, they will send us there as well."*

The company also demonstrated a clear practice of regularly engaging in communication with software vendors to stay updated on industry trends and advancements. Given the support and assistance provided by the company, employees are anticipated to possess the motivation and willingness to learn and apply their knowledge. As expected, employees demonstrated high motivation for learning. For instance, CSB2 depicted that learning new things is the most enjoyable and fulfilling part of their job. CSB4, on the other hand repeatedly mentioned: *"I can always learn more"* indicating a strong motivation, while

CSB6, highlighted that: *"we are always learning new things every day"* suggesting that their work environment provide them with constant opportunities for growth and learning. However, CSB2 emphasised that expanding the teams and allocating time for learning are also vital in continuous growth and improvement, by stating that:

> *"It is like giving more time for the site team because they are not sitting idle, not doing anything they are, they have to do the job, and they have to learn few things. So, it's like giving them a bit of time, with a freedom to do approach us or to start thinking out of the box. It is like giving the person his own space to develop. I think it is happening as of now as we speak. Because they are like widening the teams. So, they can give some space to the individual. So, because everybody's busy. And it's like giving them like with a bit of time to learn new things, because a lot of people say that I don't have time for this. So, it's like no, allocating some learning hours on the daily tasks on our weekly does if they have like, two hours of learning of what you learned this week, something new, then it will be useful."*

This can be achieved by setting aside dedicated learning hours within their daily or weekly tasks, ensuring that everyone could allocate time for learning something new. Accordingly, instead of having idle periods, employees are encouraged to actively learn and acquire new skills while performing their job responsibilities.

At CSB, continuous learning extends beyond traditional training sessions, LinkedIn learning, and webinars. They actively utilise case studies to share valuable insights and lessons learned from their BIM projects. As explained by CSB1:

> *"We've got a number of case studies, we've done projects to be able to highlight where we've seen value, whether it's and trying to get, like the planners or the commercial team to actually say, where they saw value, as opposed to just the digital team saying this value, so that we can actually start having more fundamental conversations with leads around the value there. So, we do that. But also, a lot of times, it's more so having skilled individuals on our project so that they can actually drive those changes on the project from experience."*

CSB2 added that the team gathers valuable learnings from each project and carries them forward to the next one and strive to incorporate these learnings to improve and enhance their approach in subsequent projects. They believe that by combining structured training, clear communication, and ongoing support, the company can create an environment where employees feel empowered and motivated to learn and use BIM effectively. According to CSB2:

> *"Because when, if the company is forcing them to use BIM, that there may be frustration, that is optional to use, then we cannot guarantee, and we don't know whether they will be using it. But thing is, if we give them that approach for the next project, they start saying again, we're going to do this in different way for the next project, start learning this one, start learning and start using these things now. So, you can use it, they have to have a structured way of teaching people as well, not just*

like, forcing them to do it. You should have a structured way of approach of developing BIM environment in a company, we can't just push it up to people."

7.4.4 The nature of reality and truth

Every organisation has beliefs about the nature of reality and methods to identify that reality. These underlying beliefs guide individuals on how to identify relevant information, how to interpret it, and how to determine when they have enough information to decide whether or not to act, and how to act. It was evident during the interviews that CSB determines whether something is true or not, mainly through a pragmatic approach. They do not hold the belief that truth and wisdom reside only in one method or source, to them truth can be discovered by different sources. They believe that **truth is determined by trial and error,** and **objective testing is a source of truth.** Additionally, CSB based their way of determining truth on 'revealed dogma', which was apparent in their pattern of underlying belief **experience, and expertise are critical in decision making.**

CSB believed in objective tests to determine the truth within the organisational context. This was highlighted in their approach to train the employees. Before conducting the training, the digital engineering team evaluates the project deliverables and identifies the essential aspects of the BIM model that the professionals need to learn. Then they use questionnaires to evaluate the current level of skill of the employees. CSB2 described the process *viz.*:

"What we do, we just give the basic training first, and then we'll send them a task. So, they have to do a task like a questionnaire and then they will reply and what whoever replied back by doing the task like asking them to find number of walls in the sitting area or count the square meters of the plan in sitting area or count the structural steel members. So, we give a few tasks, and then depending upon their response, we can we know Okay, which person is at what level after the basic training and then we take them to the next level."

Then the employees are categorised in to three levels as basic, intermediate and proficient based on their responses to the questionnaires. These skill levels are designed to build upon each other, so that trainees can gradually progress from a basic understanding to a more advanced level of proficiency. For example, in this BIM training program, the basic level covers basic navigation, model structure and component selection. The intermediate level covers more advanced topics like model coordination, clash detection, and construction sequencing. The proficient level focuses on more complex tasks like model management, advanced data analysis and collaboration with other disciplines. CSB2 further explained:

"We run training sessions in batches, we as BIM experts, me, as a Digital Engineer, we are the BIM experts. Like we know how to use this model, we know how the model is done. So, we take that, and we see what the deliverables in the project and we are organise a meeting with the leaders saying, we have to train the engineering

> *coordination team or the Site Engineers or Project Engineers, so they can use this BIM model. So, and then we start evaluating, like how to help easily, how they can easily get into it, instead of learning it from scratch, just showing the few buttons on what they want to click. So, they can see the model itself. So, the training sessions are breaking down into basic level, intermediate and the proficient level so we just make sure they understand the basics first, and then they will go to the next level after a couple of months."*

The training program is designed to meet the specific requirements and responsibilities of each employee based on the results of the evaluation. This approach ensures that they acquire skills that are directly applicable and beneficial to their job functions. Consequently, the tailored training methodology provides employees with the most practical and appropriate training available. CSB6 added:

> *"For example, a Site Engineer, if he's on the 3D model, he knows what exactly is happening, how exactly he has to plan. And if you talk to a Quantity Surveyor, he wants to take up the material quantities for sure, for example, and procure with them, if he's on the BIM he can easily understand what he is looking at, what he is after and what he is doing. And how he can quantify the materials with a bit more. An engineering coordinator, he will understand how to go and find the clashes, how to go and find the constructability issues. So, we take those examples, each example and then put them when we're training them, we show them these are the benefits if you use this one, and then they will start asking questions back to us like that, because it will reduce the pressure as well, it will reduce the time of doing a task. So, they will, a lot of people come back and say, okay, we want to do this and that to the task, and then they come back and then we train them again."*

The pragmatic approach to determining truth and reality was also demonstrated by their use of trial and error as a mechanism to determine truth. This underlying belief evolved when CSB employees discussed how they always test the systems before applying them to significant projects. This was done because there could be system failures, and if any of the systems failed, they would lose information, and information is an asset to them. Thus, they were careful not to rush into untested systems and ensured that workflows and systems are thoroughly tested before being implemented in projects. They use small case project as opportunities to try out new methods before integrating them into larger projects.

Being purely pragmatic, the digital engineering team conduct case studies to obtain feedback from different stakeholders to determine the real value of BIM for different departments of the company. The case studies are conducted not just from the perspective of the digital team but also from other teams such as planners and the commercial team. By having other teams attest to the value they have seen, the company can engage in more in-depth discussions with team leads about the benefits of digital technology. Thus, these case studies are used as concrete evidence of benefits of BIM.

> *"We've got a number of case studies, we've done projects to be able to highlight where we've seen value, whether it's and trying to get, like the planners or the commercial team to actually say, where they saw value, as opposed to just the digital team saying this value, so that we can actually start having more fundamental conversations with leads around the value there. So, we do that."*

Apart from the pragmatic approach, the company also placed a strong emphasis on the experience and expertise of its employees when making informed decisions. Relying on the wisdom of wise men is known as the revealed dogma. The company believed in experienced employees to identify potential failure points of the systems they use. According to CSB1:

> *"We would typically, like our team itself, are quite experienced. So, we know where those failure points are, we also make sure that we're constantly speaking to software vendors, to make sure we know sort of where the industry is going. There's no point in sitting on the bleeding edge with some of these systems, because there's potential for it to fail. So, we don't like we make sure that our jobs and the system that is the workflows we're setting up, have been tried and tested before actually rolling them out on our projects. And then look at these other opportunities, as small case opportunities, like work, use, like, try to find a project on the side where we can test something out before we roll it out. So, it would never actually roll out something that sort of has been untried and tested for the risk that we potentially lose information or lose something because that itself opens ourselves up to more risk."*

The company is open to working with software and hardware vendors to explore new possibilities and determine whether there is potential value in implementing them in their projects. Thus, the company has a dedicated systems lead who is responsible for keeping up with the latest developments in the industry and identifying opportunities to add value. CSB6 added that:

> *"We've got a team of like, like within our digital team, we've got systems lead, who's responsible for like, looking at what's coming out from the industry and trying to sort of where we can add value. So, we're constantly testing new things out and seeing whether it was ready for market, whether it's ready for our projects or not. Or whether it's, we can just use it in a small test piece. So, we're constantly looking for new ways of working, it's not something that we really sort of wake up tomorrow and go, we're going to test something out. It's something that's more we are approached by software vendors or hardware vendors to try something out and see whether there's value in it."*

The experience and expertise were critical at CSB when making decisions. As a result, they made a deliberate effort to recruit individuals who possess BIM skills and experience. This was done with the pattern of underlying belief that having a skilled and experienced team member is a crucial factor in successfully implementing and utilising BIM.

7.4.5 The nature of relationship to the environment

The underlying beliefs on a BIM-enabled construction organisation's relationship to its environment are determined by whether the organisation's members believe they harmonise, dominate, or are dominated by their external environment. The external environment of CSB is its stakeholders including client, consultants and subcontractors. The company assumes that it must dominate the environment through progress and improvement by developing its own capabilities. This was reflected in their pattern of underlying belief that **survival and growth lie within own control.** This belief was strongly rooted and visible in the formulation of their BIM mission. CSB's BIM mission is to be the recognised leader for innovation and excellence in the construction sector by the year 2025. The importance given by CSB on change and innovation indicates that these aspects are central to their niche and overall business strategy. This mission is accomplished by dividing it into various objectives. For example, one of the objectives is to ensure that every project at CSB has access to a BIM model. The employees are actively working to fulfil this mission, and they adapt the organisation accordingly through ongoing learning, training, and obtaining necessary resources.

The company assumes that their existence and survival in the environment is under their control. Accordingly, the organisation has undergone significant changes in its structure to accommodate and foster change and innovation. This includes the establishment of a separate digital engineering team and a research innovation team. These teams focus on driving technological advancements and fostering innovative practices within the company. According CSB1:

> *"We do have a central digital team within our company, we've also got a separate innovation team within our company as well. Which we are placed on the projects as required, all of our projects have a digital resource allocated to them. So, there is a, a digital resource for all our jobs, and that their role is to drive BIM and digital and an innovation on our projects."*

CSB1 explained that the recruitment strategy at CSB has been revamped to include BIM experts in response to the changing landscape. A decade ago, these roles did not exist and there was a lack of digital roles within projects. However, the organisation has recognised the importance of managing information strategically and fostering innovation at a broader level within the company. CSB1 stated:

> *"10 years ago, this role didn't exist. Number of digital roles on projects didn't exist. It's not only on projects but even more a bit wider, I suppose within our company, we've got a number of roles that sit more sort of strategic level, around the way we manage information. The way innovation sits within our company, like a lot of times*

> *it was down to our engineers and our projects to push it. These days, it's sort of seen as more of an as like a subject matter expert role where they can kind of be parachuted onto a project to actually add value. So, there's a number of these roles that sort of now are coming out that sort of we do advertise for and look for more, these subject matter experts to be able to sort of provide assistance. So as these roles as like a whole."*

The recruitment strategy has been adjusted to attract individuals with expertise in BIM reflecting the organisation's commitment to incorporating new technologies and approaches. CSB2 described why it is crucial for the company to bring in experienced individuals or hire people with knowledge in BIM:

> *"Bringing in the experience people or bringing in the people with that knowledge and hiring, every company should start hiring at least one of the BIM experienced people so they can start showing the benefits of using the BIM model. These are the things they have to do instead of just telling them to okay, this is what you do it instead of saying in a harsh way, they have to show them the value of it and then at that time, they will understand okay, maybe I have to start to change my way of approach. Because this is saving a lot of time for me this reduce lot of headaches. So, we have to show the value for a person to learn what exactly is there in the market. Yeah."*

It acknowledges that the company does not simply react passively to external factors but takes an active and proactive role in shaping its own destiny.

They also operate from the pattern of underlying belief that **collaboration with other stakeholders is a vital part**, which takes a harmonising orientation with the environment. This resulted the company to work with clients and consultants collaboratively. This was demonstrated in by CSB5, stating that contractors should not be viewed as competitors by their design partners but rather as collaborators during the design process. At CSB, they recognise the importance of exceptional design and work closely with architects and consulting engineers to foster a collaborative environment from the very beginning. They appreciate the value of innovative design and aim to protect its essence while ensuring its feasibility and efficiency. Without early engagement, contractors are unable to fully utilise their engineering expertise. However, it is essential to avoid imposing a contractor's products and processes on design partners without their input. The key lies in adopting design collaboration within clear protocols that promote improved construction and certainty, resulting in designs that offer enhanced value. A manufacturing-oriented approach requires constructors to guide their clients and project teams through a unique process. For instance, as highlighted by CSB6, considerations such as room layouts and the placement of light switches and plug sockets must be addressed early in the design phase. This allows for off-site manufacturing of walls with pre-installed services, reducing the need for disruptive

rework that often occurs in traditional construction methods. Meeting clients' needs is a major priority at CSB; thus, they give proper attention to understand the clients' requirements and ensure that those deliverables are met during design and construction and for handover. For this purpose, they have specifically appointed the Lead Digital Engineer.

7.4.6 The nature of time

Employees underlying beliefs on time indicate either a past, present or future orientation. With regards to the underlying beliefs on the nature of time unit, future was important at CSB. This was evident in their pattern of underlying belief **BIM success is a matter of long-term planning**. Therefore, the CSB set goals on BIM and digital delivery. Proactive interventions of the company were geared strictly toward its goal to become the leader for innovation and excellence in the construction sector in 2025. CSB2 mentioned that the company has a main BIM strategy for 2020-30, which aimed to ensure that digital build models, including a comprehensive 3D BIM model, are created for every project, serving as a complete and accurate representation of the final design and construction. These digital models will be treated as essential deliverables, equivalent to handover documents, capturing the as-built conditions on site. CSB1 mentioned:

> *"All of our meeting rooms in our offices have screens these days. All of as part of one of our main goals is that the model was made available to all the teams for all meetings, and some will be there available to drive it if they need it. So, every meeting the models are available. Look, it's available for design coordination meetings. It's available for safety meetings, or safety design meetings. It's often available for planning meetings as well. So, it's available for all meetings, but primarily is it'll be available for primarily design planning and safety meetings."*

They are actively engaged to develop clear guidelines, plan, protocols and strategy to be used by the employees in the digital engineering setting. Herein, Digital Engineering Management Plan (DEMP), Digital Engineering Project Protocols and Digital Engineering Strategy were referred during the data analysis viz.:

> *"Digital Engineering Management Plan - the purpose of this document is to clearly define the Digital Engineering (DE) scope of work for the duration of the project. This document outlines the scope and process to be followed throughout the bid and post-win stages of the project. This document is therefore to be reviewed and updated at the relevant stages noted in the agreed DE delivery documents created by both CSB and a response to the Employer Information Requirements (EOI). This document ensures that all DE-related Principal and project team requirements have been allocated to the DE team or appointed consultants, and the extent of responsibility of each party is clearly defined. This document also describes how the project team will develop, monitor and control information and models throughout the project. It is therefore important that this document is completed in agreement with the modelling collaboration team to ensure that all team members understand how the DE services are to be defined prior to commencing DE activities.*

> *Digital engineering project protocols- this document define how the DE team will develop, monitor and control information and models throughout the delivery phases of the project. The protocols serve as a guideline to all relevant consultants and stakeholders who intend/are required to contribute to the development, coordination or management of models during the bid or project and will correlate to the protocols established by the design and/or delivery teams in their respective documents.*
>
> *Digital Engineering Strategy- This document outlines the Digital Engineering Strategy for a particular project. It is intended as a high-level, non-technical document to describe digital engineering objectives and strategy, digital engineering roles and responsibilities, and the scope of digital engineering within pre-contract and delivery phases."*

The future orientation at CSB has resulted to establish standards and workflows to streamline the BIM implementation. These standards facilitate the alignment of these stakeholders by defining roles, responsibilities, and communication channels. Thus, planning ahead concerning the future was crucial at CSB.

Employees held the pattern of underlying belief that **previous experience in BIM was important.** They understand that continuous learning goes beyond traditional training methods and actively utilise case studies to share insights and lessons learned from their BIM projects. These case studies serve as valuable tools to highlight the value they have seen in their projects, not only from the perspective of the digital team but also from other stakeholders such as planners and the commercial team. By involving different teams and gathering their perspectives on the value created, CSB aims to have more meaningful discussions with project leads about the value proposition. CSB1 went onto explain that:

> *"We've got a number of case studies, we've done projects to be able to highlight where we've seen value, whether it's and trying to get, like the planners or the commercial team to actually say, where they saw value, as opposed to just the digital team saying this value, so that we can actually start having more fundamental conversations with leads around the value there. So, we do that."*

CSB2 also added that the team gathers valuable learnings from each project and carries them forward to the next one and strive to incorporate these learnings to improve and enhance their approach in subsequent projects. While the company acknowledges the importance of learning from the past, their primary focus is on utilizing these learnings to gain an advantage in the future. This forward-looking mindset reinforces the company's future orientation rather than being solely focused on the past. Overall, the underlying belief at CSB is that the most relevant time for conducting daily affairs in the BIM environment is the future. They understand the importance of learning from the past but prioritize incorporating these learnings to shape their future endeavours and drive continuous improvement in their projects.

Table 7.2. Patterns of underlying beliefs of Case B

Organisational culture dimension	Questions need to be answered	Patterns of behaviours	Patterns of underlying beliefs	Underlying beliefs of CSB
The nature of human relationships	Would an autocratic or participatory authority system be more effective?	• Top-down approach to decision-making. • Top management has BIM knowledge. • Delegation of decision-making power to the digital team. • Digital team controls BIM direction. • Seek consultation and input from digital engineering team during decision-making. • Career progression from technical roles to leadership positions is common within the organisation. • Innovation is driven by technical expertise (digital team). • Digital engineering team remains updated through constant communication with software vendors and industry trend. • Recruit people with BIM knowledge. • Digital team is best qualified to manage the direction of BIM development.	• Ultimate decision-making power resides with the authority positions. • Skills and expertise serve as sources of power.	Autocracy Skills-centred.
	Would it be more effective to structure society based on individualism or groupism?	• Mission is shared among employees. • Build personal relationships with each other beyond work-related duties. • Take an active interest in each other's lives. • Employees understand how their individual contributions contribute to the company's larger objectives. • Employees show genuine care and concern for each other's well-being. • Engage in informal communication. • Value the diverse skills and contributions of all team members. • Encourage innovation and championship behaviours. • Employees take ownership of their learning process and actively participate in acquiring the knowledge and skills. • Regular formal training.	• Having a sense of belonging is necessary. • BIM success is a collective responsibility.	Groupism.
	What is the ideal way for individuals to interact with one another? Is life characterised by competition or cooperation?	• Offer mutual assistance and support to colleagues without hesitation. • Employees are willing to go the extra mile to help each other and work towards common goals. • Employees do not hesitate to seek help from colleagues, regardless of their age or seniority. • Employees actively share their expertise and knowledge with others. • Encourage continuous learning and a growth mindset. • The digital engineering team is seen as the go-to resource for digital and IT-related issues. • BIM is seen as a tool that enhances connectivity and collaboration among team members. • Engage in open and candid communication. • Work together to navigate the learning curve associated with BIM and other digital tools.	• Mutual interdependence is best suited to problem solving.	Cooperation.
The nature of human nature	In this organisation, how is human nature viewed; perfectible, immutable, good, neutral, or evil?	• Practice of verbal appreciations. • Acknowledge employees who use BIM in their daily tasks. • Celebrate and recognise employees' innovative ideas and contributions through various communication channels. • Trust employees and empower them to identify areas for improvement and suggest solutions. • Encourage continuous learning and improvement. • Maintain open communication channels, such as chat rooms and emails. • Demonstrate responsiveness to employee suggestions. • Tolerance for mistakes.	• Employees get motivated by appreciations. • Employees should be open for learning and continuous growth. • Employees could be perfectible through training.	Good, perfectible.

Organisational culture dimension	Questions need to be answered	Patterns of behaviours	Patterns of underlying beliefs	Underlying beliefs of CSB
		• Emphasis on character traits such as openness to learning, adaptability, and a willingness to try new approaches. • Foster a supportive learning environment where employees feel comfortable asking questions. • Intrinsic motivation to use BIM. • Structured training approach. • Evaluate which team or department needs the training and determine what deliverables they require from the BIM model. • Digital team conducts inhouse training. • Provide access to external resources.		
The nature of human activity	Is the group focused on doing, being, or becoming? How is truth determined?	• Proactive implementation of BIM even without explicit client demands. • Emphasis on continuous learning and development. • Open to new ideas and skills acquisition. • Trust in employees' abilities and input. • Proactive leadership in training employees on new systems. • BIM methodologies are explored actively to optimise time, cost, and delivery possibilities. • Encourage to think innovatively and explore outside-the-box solutions. • Use BIM as a centralised platform that links various pieces of information, streamlining communication and coordination. • See the BIM benefits. • Takes pride in meeting and exceeding clients' requirements and expectations. • Leverage BIM for tracking and monitoring quality on construction sites.	• Being proactive in the BIM environment was the proper way to behave. • BIM is a tool for efficiency. • Quality delivery is the main priority.	Doing – Proactive, efficiency and quality driven.
		• Embrace continuous learning and personal growth. • Adapt to new tools, workflows, and technologies in the BIM field. • Support and provide access to different learning platforms (e.g., LinkedIn Learning). • Engage in regular communication with software vendors for updates on industry trends. • Actively utilise case studies to share valuable insights and lessons learned. • Demonstrate high motivation for learning and staying up to date. • Allocate dedicated learning hours within daily or weekly tasks. • Organise training sessions, webinars, and industry-wide meetings for employees.	• Continuous improvement was deemed essential.	Being-in-becoming.
The nature of reality and truth	How is truth determined? What is the source of truth, and how does it come to light? By tradition, wisdom, conflict and debate, pragmatic criteria, scientific method or social consensus?	• Test the systems before applying them in projects. • Use small case projects to try out new methods before larger project integration. • Conduct case studies to get feedback from different stakeholders. • Seek feedback from various teams, not just the digital team.	• Truth is determined by trial and error.	Pragmatic.
		• Evaluate project deliverables to identify essential aspects of the BIM model for employee training. • Use questionnaires to assess employees' current level of skill in BIM. • Use a tailored training methodology to meet specific requirements and responsibilities of each employee. • Focus on practical and job-relevant training to benefit employees' work tasks. • Continuous feedback and improvement in training based on employee inquiries and feedback.	• Objective testing is a source of truth.	Scientific method.
		• Recruit individuals with BIM skills and experience for the team. • Constant communication with software vendors to stay updated on industry developments.	• Experience, and expertise are critical in decision making.	Wisdom.

Organisational culture dimension	Questions need to be answered	Patterns of behaviours	Patterns of underlying beliefs	Underlying beliefs of CSB
The relationship of a group to its environment	How do the organisation and its members interact with the outside world, particularly the external market of the organisation's services? Is it a domination, submission, harmony?	• Has clear strategic BIM mission and objectives. • Revamp the recruitment strategy to attract individuals with BIM expertise. • Establish dedicated digital engineering and research innovation teams. • Continuous progress and improvement to develop own capabilities and strategies. • Empower innovation.	• Survival and growth lie within own control.	Dominate.
		• Work collaboratively with clients and consultants. • Early engagement with contractors for engineering expertise. • Appointment of Lead Digital Engineer for client deliverables. • Work closely with architects and consulting engineers to foster a collaborative environment. • Ensure deliverables are met during design and construction.	• Collaboration with other stakeholders is a vital part.	Harmony.
The nature of time	Is the organisation's basic orientation toward past, present and future? What does time mean to this organisation?	• Learn from past projects and using that knowledge to inform their current and future endeavours.	• Previous experience in BIM was important.	Past.
		• actively develops and follows clear guidelines, plans, and protocols related to digital engineering and BIM implementation. • Ensure that responsibilities and roles related to digital engineering are well-defined and allocated appropriately. • continuous improvement and adaptability.	• BIM success is a matter of long-term planning.	Future.

7.5 Summary

This chapter presented an in-depth within-case analysis of Organisation B, focusing on the extraction of underlying beliefs across six distinct cultural dimensions. These dimensions encompass the nature of human relationships, the nature of human nature, the nature of human activity, the nature of reality and truth, the relationship of a group to its environment, and the nature of time. Through a meticulous process of open and axial code analysis, behaviours and patterns of underlying beliefs were identified, subsequently leading to the extraction of specific underlying beliefs. CSB believed in autocracy in BIM skills, groupism, cooperation, goodness, perfectibility, doing and being-in becoming orientations, proactivity driven by efficiency and quality, pragmatism, scientific method, wisdom, domination, and harmony with environment, past and future. The next chapter presents the within-case analysis of Organisation C.

CHAPTER 08- WITHIN CASE ANALYSIS OF ORGANISATION C

8.1 Introduction

The chapter 07 presented within case analysis for Case B. This chapter offers a detailed within case analysis of organisation C. Initial sections of the chapter present background information of organisation C and organisational structure, highlighting key departments and roles related to BIM. Subsequently, the chapter presents the details of the interviewees involved in the study. This includes information on their positions within the organisation, their roles and responsibilities, and relevant demographic characteristics. Next, an overview of the responses collected from them regarding the external adaptation and internal integration problems faced by organisation C in the BIM environment is presented. In the following sections of this chapter, the underlying beliefs, and patterns of underlying beliefs supported by behaviours discovered in organisation C within the BIM environment are provided.

8.2 Background information organisation C

Case study organisation C (CSC) is a renowned Australian-owned and operated business that has been at the forefront of the commercial construction industry for over five decades. Since their establishment in 1961 CSC has completed numerous construction projects across a diverse range of sectors, including industrial, residential, retail, office, hospitality, recreation, education, health care, aged care and retirement living. Their expertise rests in the building industry's design, cost management and construction, on which they have developed a reputation for offering exceptional services. Thus, the company has been consistently recognised and honoured within the construction industry for its outstanding contributions. The company has received numerous accolades and industry recognition, ranging from design awards to commendations for safety and project management. The company employs over 700 people and has an annual revenue exceeding $1 billion. The company's mission is on building trust with clients by consistently delivering on promises. By achieving high-quality results and maintaining open lines of communication, CSC establishes solid foundations for long-term relationships. This commitment to quality outcomes and effective dialogue enables the company to cultivate strong partnerships that can endure into the future. The collaboration, approaching challenges with a solution-oriented mindset and upholding the utmost integrity are the key values at CSC. The company actively fosters a collaborative environment, encouraging the exchange of ideas and fostering innovation.

Innovation is seen as an integral to the company's growth, and they consistently engage in research and actively implement new technologies to provide their clients with cost-optimised, efficient, and advanced solutions. Modular construction is a key innovation aspect of CSC's approach, offering the clients unparalleled flexibility and transforming project delivery options. This provides advantages such as reduced time on site, improved program control, high-quality outcomes, and value for money. These modular solutions, include volumetric, nodal and panelised systems, which can be applied to specific building elements or entire projects. To support the modular construction capabilities, they have established a 'Solutions Centre' as a dedicated prefabrication warehouse space. The company is also dedicated to reducing its environmental impact within an industry known for high greenhouse gas emissions. These include the implementation of solar energy pods, minimising construction waste through innovative design approaches, and sourcing sustainable materials as alternatives for clients. Furthermore, the company has a dedicated team that conducts extensive research into global construction materials, techniques and methodologies. With this focus on innovation, BIM was introduced to the company as a requirement to fulfil client demands. Their current main choice of BIM application is Revit, Revizto and Navisworks. There is a designated BIM team in the company lead by the BIM Manager.

Figure 8.1 shows the formal organisational structure of the CSC. This organisational structure was built based on the findings from the interviews when discussing components such as structure, communication, company website and the organisational chart provided by the interviewees.

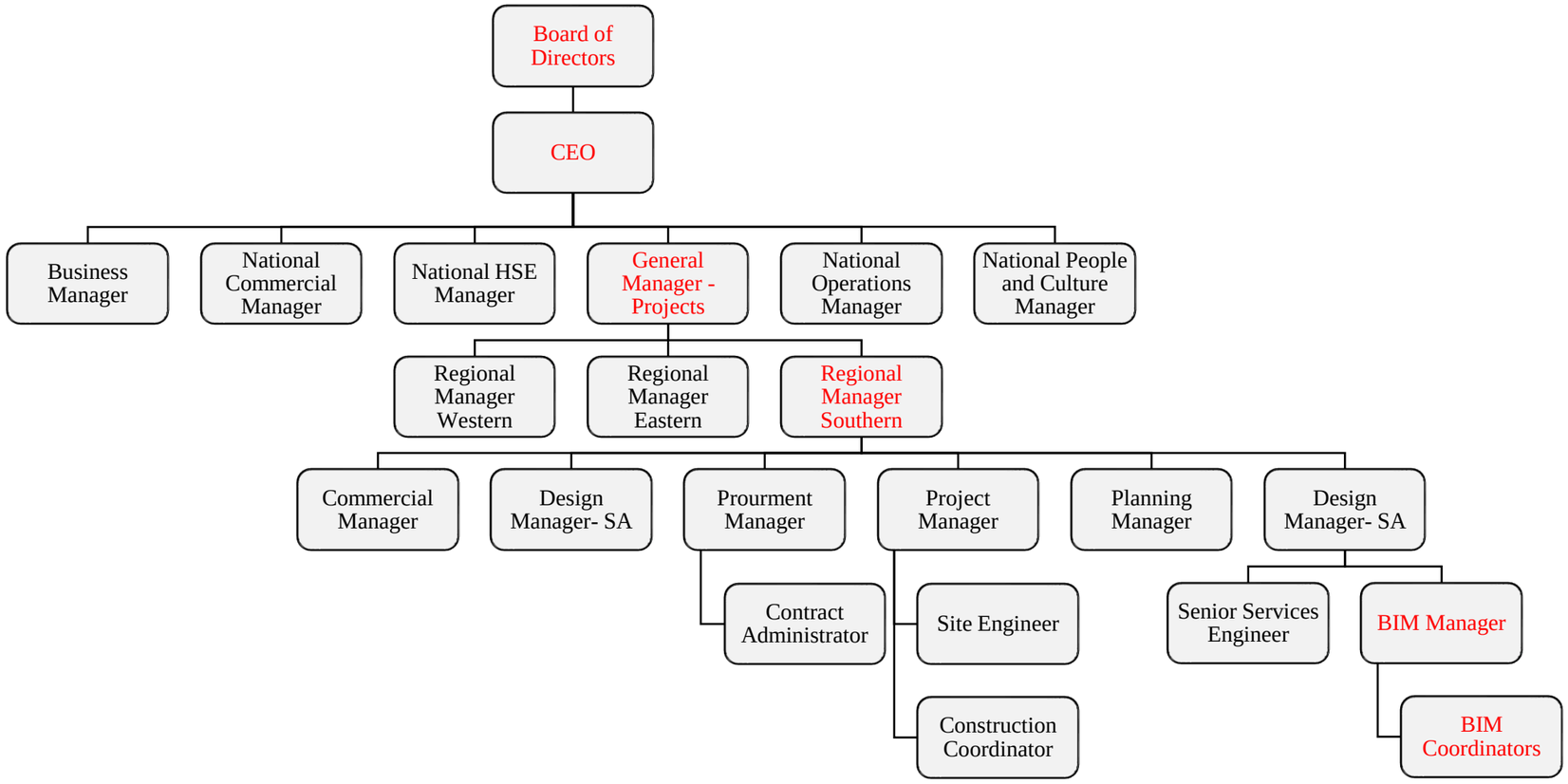

Figure 8.1. Organisational structure of the organisation C

Six interviews were conducted within the company, with organisational roles presentative of the two levels of the organisational structure: senior management level and operational level. Accordingly, six interviews were conducted within the organisation, with three from managerial level and three from operational level. Table 8.1 summarises the details of interviewees of the CSC.

Table 8.1. Details of interviewees in Case C

Interviewee	Job function	Industry experience	Experience with BIM
Interviewee CSC1	BIM Manager	11 years	11 years
Interviewee CSC2	General Manager	24 years	10 years
Interviewee CSC3	Design Manager	16 years	6 years
Interviewee CSC4	Construction Coordinator	5 years	3 years
Interviewee CSC5	Site Engineer	4 years	4 years
Interviewee CSC6	Contract Administrator	4 years	1.5 years

CSC1 holds the position of BIM Manager at CSC and is responsible for leading the delivery of BIM related duties on construction projects. CSC1's role is required to provide efficient coordination with the Construction Managers and the engineering management team, including provision of technical support and advice on various projects using BIM operating systems. CSC1 is also responsible for the ongoing development of BIM processes and standards across the organisation, including training of all staff and specific mentoring of BIM staff.

CSC2 is the General Manager at CSC and is responsible for overseeing and managing construction projects within the company. CSC2's primary responsibility is to ensure the successful completion of construction projects while adhering to budgetary, timeline and quality objectives.

CSC3 works as a Design Manager at CSC and has an architectural background. With 16 years of experience, CSC3's main role is to coordinate the design team at the head office and project teams to provide essential drawings and specifications – they hold a good understanding of BIM and the modelling process.

CSC4 functions as construction coordinator. CSC4 has been working in this role at CSC for 2 years and is responsible for to assisting the team in clash detection and issue resolution during the construction process. CSC4's involvement spans from the early stages of design to the finalisation of construction drawings, with a focus on ensuring quality, cost-effectiveness and compliance with client requirements.

CSC5 is a Site Engineer at CSC who has been involved in projects with a site management role. Primarily CSC5 uses BIM to track RFIs, close out issues and manage subcontractor documentation such as their ITPs and quality assurance records.

CSC6 functions as a Contract Administrator responsible for overseeing the complete cost analysis of projects prior to the commencement of work or contract awarding. Within this role BIM is incorporated into the process of creating project cost plans and estimates.

8.3 Overview of responses to external adaptation and internal integration problems

According to the working definition developed in Sub section 3.2.2, organisational BIM culture is the *"patterns of beliefs and thinking guided by behaviours and artifacts, that was learned by members of BIM using the organisation as it solved its problems of external adaptation and internal integration."* The external adaptation problems in BIM-enabled-construction organisation include BIM mission and strategy; BIM goals and objectives; means to be used in achieving BIM strategy; BIM performance evaluation and remedial actions to ensure that members meet the BIM mission and strategy (Schein 2010). The internal integration problems include language used in a BIM environment; BIM team boundary; power and status allocation criteria in a BIM team; peer relationships in BIM environment; allocation of rewards and punishments and unexplainable and in explicable issues (ideology) (Schein 2010). The underlying beliefs were found by questioning how the group responded to these internal integration and external adaptation problems. The following is a short summary of the key responses to such problems:

BIM strategy and objectives - CSC lacks a comprehensive and well-documented BIM strategy and established objectives. The need for BIM at CSC is primarily driven by client demands and contractual obligations. Their only objective was to establish an in-house BIM team. This was deemed necessary for CSC, being a Tier 1 company, to effectively manage projects of greater magnitude and surpass traditional construction practices.

Means of accomplishing BIM goals - CSC is using Autodesk Revit, Autodesk Navisworks, and Revizto as BIM authored software. They also use SketchUp, twin motion for rendering, AutoCAD to read drawings. They occasionally work with point cloud data, which involves capturing a 3D scan of an existing building. This data is then used to either create a 3D model of the existing structure or incorporate it into the design process.

BIM performance evaluations and remedial actions - the company has no structured process for evaluating BIM performance of the employees, and at present CSC has only established

HR evaluation systems. Consequently, there is a need to establish a specific evaluation framework to assess the BIM performance of employees.

Common language - the adoption of new BIM standards such as ISO1950 has led to a change in the language used at CSC. The implementation of these standards has brought about a shift in the terminology and communication practices related to BIM within the company.

BIM team boundaries - at the start, the BIM department had only one member (i.e., the BIM Manager) without any additional team members. However, they have since expanded the team by hiring three more individuals who directly report to the BIM Manager. The team consisted of individuals with architectural background, civil engineering and structural engineering. They rely on each other's expertise to collaborate and elevate the BIM practices to a higher level.

Power and status allocation criteria in a BIM team – at the organisational level, the General Manager has the power and responsibility to make decisions related to BIM implementation and use. However, the BIM team headed by BIM Manager also has the power to govern the BIM use. BIM team is responsible for supporting the implementation of BIM to achieve best practice deliverables, ensuring completion of monthly project overviews to a high standard, and contributing to the establishment of the BIM Execution Plan, Protocols, CDE and federated model for the project.

Rewards and punishments - there are no specific incentives or penalties in place at CSC for individual BIM usage. The sole incentive revolves around the actual improvement in project outcomes resulting from effective BIM utilisation.

Ideology - a common challenge that arises is when subcontractors fail to provide the required 3D drawings and instead submit 2D drawings. This poses difficulties in the BIM workflow and coordination process. When subcontractors are compelled to submit 3D drawings, there is a risk that they may intentionally make mistakes or not invest adequate effort into the task.

8.4 Underlying beliefs of organisation C

The fundamental underlying beliefs that exist within an organisation create a cultural paradigm which serves as the foundation for all aspects of organisational life. These beliefs shape the behaviours of individuals within the organisation and influence how they interact with one another and approach their work. Interviewees' responses to internal integration and external adaptation issues in the BIM environment reflected different patterns of underlying beliefs. These patterns were analysed against the cultural dimensions *viz.* human

relationships; organisation's interaction with the environment; the nature of reality, time; the nature of human activity; and the nature of human nature to reveal the underlying beliefs of the CSC (Refer to Table 8.2).

8.4.1 The nature of human relationships

The underlying beliefs that dictate how individuals within the group interact and relate to each other are considered under this category. These beliefs pertain to the interactions between employees, power distribution, competitive and cooperative nature of relationships. Thus, the beliefs solve the problems related to best authority system, best way to organise and correct way to relate to each other.

Best authority system

The underlying beliefs within this category are geared towards answering the question of whether an autocratic or participative authority system is the optimal approach for organisational operations. **Expert opinions are valued but ultimate decision-making power resides with the authority positions** was identified as a pattern of underlying belief of the company. This means the company tends to make decisions in an autocratic manner, where the key business decisions are made by the General Manager and the management team at the organisational level. However, the perspectives of BIM experts are duly considered during the decision-making process.

The top management is primarily responsible for making decisions regarding BIM, including tasks such as choosing a BIM vendor or selecting BIM authoring software. CSC5 outlined a hierarchical structure that guides the decision-making process in such cases:

> *"In the organisation structure, I think it's CEO, then Construction Managers, we have a General Manager, and the BIM Manager reports to the General Manager. We report to the BIM Manager."*

There is a little space for general employees to get involved with the decision making, primarily by offering relevant background information. For instance, the construction coordinators, positioned at the lowest level of the hierarchy, are tasked with providing essential background information to facilitate the BIM related decision-making process. While ideas may originate from the employees, it is their responsibility to effectively persuade the top management by presenting a comprehensive justification. CSC4 explained how they convince the top management by making arguments using cost benefit analysis as a compelling tool:

> *"So, the way it works is that you think of it, you come up with an idea, you take it to your manager, he takes it to his manager, who will take it to the, I think directors or the CEO. And then the most important factor to consider is the cost benefit analysis. So, you have to go prepared with I want to do this, this is how I think it will benefit the company. And this is how much it's going to cost us. But this is how much we will save, or this is how much time or money we will save. If we go through with this small, upfront cost. That's how you sell your idea."*

Best way to organise

To understand the underlying beliefs of CSC regarding the nature of human relationships, need to examine their assumptions about the most effective way to structure the society. This involves determining whether CSC leans towards individualism, which prioritises personal freedom and achievement, or groupism, which emphasises group interests and interdependence among individuals. CSC's underlying belief on the best way to organise was centred on 'groupism'. Employees held the pattern of underlying belief that **discussions gave results**. Employees at CSC strongly held the pattern of underlying belief that discussions, both formal and informal, were key to achieving results.

Employees believed that informal interactions allowed for open conversations, brainstorming, and the sharing of ideas. These informal discussions created a more relaxed and comfortable atmosphere where they could freely express their thoughts, challenge assumptions, and explore innovative solutions. For instance, CSC3 described:

> *"Every time, if someone's found something new, we all like, come over, let me show you this. It's very informal. It's not like we planned to sit and discuss. But if you're trying to roll out a new software across the company, then we sort of give everybody a day or two to work on it. And then we'll come together to sort of come up with a game plan of how we're going to roll this out what we think is the best way to teach everybody or to explain the process to everyone. And yeah, it's a lot of collaborative effort. It's not individual."*

Informal discussions at CSC contributed to knowledge sharing, learning from one another's experiences and building relationships among team members. They allowed for the exchange of tacit knowledge and practical insights that might not have been captured through formal communication channels alone. Informal interactions helped to strengthen bonds and create a sense of camaraderie, leading to a more cohesive and collaborative work environment. Even their open office layout encouraged spontaneous conversations and informal interactions, enabling employees to easily approach and engage with one another. CSC6 explained their work environment that fosters the group sense by saying:

> *"Imagine like there's four people working in four different corners of that same room. So, you just turn and say, I've had a terrible experience with this. Be careful*

> *when you're doing that. And then someone like me, I used to get a lot of this from my co-worker. So, then I just started a list of things that they are, they've been constantly talking about. So, one was consultants not giving so and so information. So, like, beware of this person, this consultant, things like, make sure you have your so if you're ordering timber, make sure your take your take off is ready. Make sure your take off is ready this early on, because they're going to have a lead time. So, things like that. It's not formal. It's very informal and organic."*

CSC5 shared an example of collaborative problem-solving within the team, specifically regarding the process of importing a CAD file into Revit and addressing the issue of aligning True North and Project North:

> *"It was about exporting a CAD file into Revit. Actually, importing it to Revit. So, the question was that when you bring that CAD file, what's the best way of fixing the True north and project north, like rotating the CAD file? As we get the Revit itself, rotating and scaling it's totally different from AutoCAD. So yeah, we were discussing and also when you're setting up the project north and the true north, it's very important to make it 100% accurate. So, for example, if you're rotating this if, if there's like 1.001-degree difference, like it's not true, maybe it looks right there, but if you go like 200 meters away, that one's point 001 degree has changed, like two three meters difference. So that's very important to find a way that it will rotate it to the exact location that we want here. So that is what we were discussing."*

With these discussions employees collectively analyse and address challenges related to specific tasks. By sharing insights, experiences, and technical expertise, the team can arrive at the most effective and accurate approach for solving the problem at hand. In addition to informal discussions, CSC also values formal channels of communication. These structured and organised discussions serve the purpose of official procedures and documentation. Formal discussions provide a platform for sharing important information, making decisions, and keeping everyone informed. Team meetings, documented through email chains, allow for task assignments, project planning, and the exchange of opinions, inputs and ideas. However, these formal discussions are flexible and organic, allowing for the integration of lessons learned and the exploration of new perspectives. This was explained by CSC4 saying that:

> *"We discuss together; So, we have like team meetings where we, which is documented, it's like a chain of emails where we made sort of document what tasks everybody is doing at the moment, what future projects we might be getting onto. And anything that anybody wants to add. So that's the space where you can give lessons learned. You can give opinions, inputs, ideas, all of that. So, it's there. But it's not like concrete, we have to do this."*

Correct way to relate to each other

Examining employees' underlying beliefs about the appropriate way for them to relate and interact with each other, and distribute power and affection provide insights into their underlying beliefs about the nature of human relationships. This can be determined by assessing whether the contractor emphasises competition or cooperation as the correct way for team members to relate to each other. Thus, they held the pattern of underlying belief that **mutual interdependence is best suited to problem solving**. At CSC, there is a strong sense of teamwork, resembling a close-knit family, where mutual support is deeply ingrained. This willingness of colleagues to offer guidance and share knowledge reflects the cooperative nature of the organisation. CSC has implemented a dedicated email address specifically for employees to direct their queries. This email address is managed by the BIM team, who take responsibility for providing solutions and assistance. CSC4 shared their experience of helping others through this email system:

> *"It's separate from my own email address. So, when that when something comes for that, like a request to, it can be anything converting files, getting some drafting help, it can be asking us for clash detection, or even just we're planning, we have a 3D model, and we don't know what to do with it. So please guide us, it can be anything, any queries. And now since we've worked together for years, we all have like a skill set. So, we know who's going to do what, or it's a lot of times it's based on what your current workload is. So, if I'm already doing some work for someone else, and I don't have the time I'm flat out busy, a colleague will pick it up and send the conversions or things like that. But if it's something specific, like doing design management, and or if a team has a construction team is unsure of what to do with their 3D models and stuff like that, then the BIM Manager goes and has a chat with them to see what they really need from this. But if it's something like creating a walkthrough, then it directly comes to me, it's not even a question."*

After years of working together, the team has developed a shared skill set and an understanding of each other's strengths and capabilities. This familiarity has allowed them effective task allocation and collaboration based on factors such as workload and expertise. This allocation of tasks based on individual skills exemplifies the cooperative approach within the team. The team members support each other by stepping in when someone is overloaded, while also relying on the expertise of the BIM Manager and specialised individuals for more complex requirements.

The different disciplines within the company collaborate closely with each other. CSC3 provided an example of how they supported the estimating team by handling various file conversions. Specifically, when it comes to inputting files into CostX, they need to be in a specific format. Architects typically send files in Revit or Navisworks formats, and it becomes necessary to convert them into a compatible format. This is important as CostX

categorises items based on Revit families. This means that elements such as roofing, walls, masonry structures and various components within the structure (such as wood timbers, steel and concrete) are organised in the same categories as they appear in Revit. This categorisation enables the estimating team to easily access a breakdown of the project, which they can further link to spreadsheets for analysis and other purposes. At CSC, employees relied on the organisation's internal IT department to oversee the upkeep and upgrading of the hardware and networks necessary for their operations, and they collaborated with the department in a cooperative manner. According to CSC5:

> *"If anything happens with, I don't know, licensing or installation of software or with the network VPN, yeah anything happens here, we can call those guys, and they can access our computers through TeamViewer. And the fix it quick."*

The interdependence within the company extends beyond colleagues and encompasses seeking help from other external companies. For an instance, CSC1 mentioned:

> *"Everyone is a lot more open to helping each other now. If I have an issue with software, I will call one of the guys in another company. I call one of the guys I used to work with, before I go back to our vendor. Just because I know that they would, they would know exactly what I'm talking about. And I can explain it to them easily."*

8.4.2 The nature of human nature

An organisation's underlying beliefs regarding the nature of human nature revolved around their core underlying belief regarding whether humans were inherently good, neutral or evil, and whether human nature was capable of improvement or remained fixed. People at CSC held the pattern of underlying belief that **appreciations are not expected, but mistakes are highlighted**, and **disagreements are normal and acceptable** which reflect that the nature of human nature is 'evil'. At CSC, appreciations, and rewards for doing one's job are not popular or expected. Employees are expected to fulfil their responsibilities without the need for explicit appreciation or rewards. They also believe that some companies may excessively focus on rewards and encouragement, leading employees to engage in activities that may not add value to the projects. The BIM Manager, CSC1 affirms this by saying:

> *"If I notice something, I'll say yeah, good work, but it's not expected. Because you're doing your job. Yeah, that's where do you draw the line. I think some companies go above and beyond with the rewards. Encouragement makes people almost do things that don't have actual value to a project. If you know what I mean, they do things that look on the surface, it looks amazing. But then when you apply it on a project level, it's got no value. So that's the way we sort of draw the line doesn't have value to the project if it does, then that is the reward."*

CSC's focus is more on getting the job done and fulfilling job responsibilities rather than placing a strong emphasis on monetary rewards or incentives for individual team members.

The employees are easily disappointed when their colleagues do not utilise BIM to an appropriate level. This was further clarified by CSC2:

> *"Well, there's deadlines to meet. So, there are consequences if you don't meet your timeframe. So, in design meeting you have to meet a deadline by whatever. But at the same time, if there's a successor task to completing that task, you can't you know, you can't progress your task until someone's giving you the right piece of information. So, you would need to track all the way through, get your information requests ready. So that then you can say, someone's coming to me saying, well, you got to finish we like hang on, I can't finish because you haven't given me this. When? Have you given me that information if you ask for it? So, there's a process of successor tasks or predecessor tasks that need to be considered. So, there's a program that needs to be met. So, you can be penalized by not meeting your timeframes. But if they're I guess the ultimate result is that you get to 100% for construction, 100% IFC endorsed documentation, that's a milestone, that team the design team can then hand over construction team to then go and build. You know, there's a celebration, at that point in time the team yet we've done it, off we go. There's not necessarily bonus payments or anything like that incorporated."*

At CSC disagreements are common and if someone is disagreeing with someone else's statement, it is encouraged to express the disagreement face-to-face with the others. CSC2 pointed out that:

> *"If you have a disagreement in one of the during a meeting, that you're really after the statement of other participants of the meeting, you're encouraged to provide the disagreement face-to-face. So, I If you have a disagreement with some of the disagreement Yeah, I am encouraged to present the unsettlement face-to-face. Oh, absolutely."*

In this environment, if someone's task is dependent on receiving specific information from another person or team, they are expected to track and communicate their information needs. If someone asks them to finish a task but the necessary information has not been provided, they are within their right to point out the missing information and inquire about its status. It appears that communication within CSC can be direct and straightforward, even if it involves saying 'no'. Further, the meetings appear to be very tense and there are arguments. CSC1 suggests that it is important to have people with the right temperament for effective collaboration. However, it is not always possible to have everyone on the same page. Therefore, it is necessary to be blunt and assertive to prevent discussions from going in circles, especially when employees are confident that their perspective is correct.

> *"It is tense, like some projects can be quite quick moving. And once again, it comes down to the temperament. It hinges on employing people with the right temperament. But you can't always have you know, that's my saying they can't always ever fall forward. You know, so every team is different. But you pretty much know everyone and yeah, there's arguments, you know. And quite often, sometimes you need to be blunt. Otherwise, things will go around in circles, especially like and it's anything*

> *you're very confident that you're right. You're well within your right to be very blunt, and just say no, this is what's happening."*

These aligns with the notion of a potentially evil human nature where appreciations are rare, and disagreements are acceptable.

8.4.3 The nature of human activity

The underlying beliefs of nature of human activity are evident in the actions and behaviours of the employees at the workplace, and their responses to the work environment. Three fundamental activity orientations can be identified as 'doing', 'being-in-becoming' and 'being'. It was evident in the interviewees' responses they were in the pattern of underlying belief that **the correct way to behave is being reactive, not proactive**, which aligns with 'being' orientation. At CSC, everyone recognises the importance of BIM in staying competitive within the industry. However, they do not proactively use BIM in all their projects. Instead, they wait for client demands or contracts to drive their adoption of BIM. This reactive approach indicates a tendency to prioritise immediate needs and external pressures rather than taking the initiative to implement BIM across all projects. The general manager, CSC2 outlined:

> *"So pretty much in every instance, it's instigated by our clients, so it's pretty rare that we will just go into that off our own back because we do actually know how to build in 3D or from paper, traditional means. So, the key is, the higher the complexity of the project, it's becoming more and more demanding from driven by clients."*

Instead of investing their own money in BIM initiatives, CSC views it as a cost that is passed on to the client. CSC6 explained when the project tender includes a requirement stating that a model must be produced the BIM cost will be embedded within the overall building cost as part of the procurement process. When clients are unwilling to invest in or allocate sufficient funds for BIM, even the BIM team is compelled to shift their focus to other responsibilities. Then they get engaged in design management tasks that are typically associated with construction managers. This was highlighted by CSC4 *viz.*:

> *"We report to the BIM Manager, but our tasks are more aligned with design management, because there's not as much BIM requirements and projects here like we want to, but if your client is not willing, or your client is saying there's not enough money, then you just you have to do something else. So, we end up doing design management related work, which goes under Construction Managers."*

Even if the client demanded to use BIM in their projects, this reactive approach resulted in a hybrid setup where both 2D and 3D drawings were used in their projects. This is because 3D model's usage tends to diminish as the project progresses. While visually appealing and informative 3D representations are created during the design phase, the utilisation of 3D

models often drops off when it comes to the construction phase. The focus tends to shift towards producing traditional 2D drawings for construction purposes, and the use of 3D modelling becomes limited mainly to structural elements. Affirming this, CSC3 opined that:

> *"It's typically a bit of a hybrid as to what we see on the market on the lower cost sort of projects. Yeah, so not all yeah, so not all services typically drawn in 3D. A lot of imagery is produced out of architectural firms in three dimensions, but then what they ultimately do is, they'll snip that through to their details to then produce two dimensional drawings, and then it doesn't follow through. So, if you think of the lifecycle, there's a sales pitch piece for an architect or client as they are completed this fancy building. And then they have all the images, and it looks fancy, but then when it gets to building, then it drops off. So, 3D, sort of 2D, but we don't have to continue a little bit element of 3D in terms of the structural, mainly structural model. And then beyond that, it just sorts of falls away. There's no requirement at the end of the job for a virtual model on a lot of low-cost jobs."*

The 'being' mindset within CSC is impacting the proactive initiatives of the BIM team. The BIM Manager and their team are actively making efforts to train employees on BIM implementation. However, the employees seem to show a lack of interest or disregard for these efforts, as reflected in their low attendance at training sessions. CSC4 mentioned that:

> *"The responses to training sessions were quite low. Initially, we had a good response when we started it, because it was a lot of graduates and site assistants who are being called for this. But then as soon as we started moving to the upper management and site supervisors who are older people, not as much attendance. A lot of them feel like what is the point of learning all this, or I only have few more years left in the industry, I don't need to know this, then a lot of them also say this has worked for me so far. It will keep working, I don't need to know."*

This disengagement extends to lessons learned meetings as well, where experienced individuals who could contribute valuable insights choose not to participate. During the lessons learned meetings, the entire team gathers to reflect on the project, identify areas for improvement, and provide feedback on what could have been done better. The discussions and feedback are documented, and minutes are taken for reference. These meetings often result in actionable outcomes. They can lead to the creation of an action plan, or the development of a checklist based on the insights gained from previous projects. This ensures that the team considers these lessons and incorporates them into future projects from the outset. CSC5, expounded that there is a lack of seriousness and commitment from employees towards lessons learned meetings. It is not uncommon for key individuals who possess valuable knowledge about mistakes or failures to be absent from these meetings.

8.4.4 The nature of reality and truth

Every organisation has beliefs about the nature of reality and methods to identify that reality. These beliefs guide individuals on how to identify relevant information, how to interpret it,

and how to determine when they have enough information to decide whether to act, and how to act. This determination could be reached through various means, including pragmatic testing, drawing on wisdom or expertise, or by considering social consensus. It was evident that CSC prioritises objective means of determining reality and truth and does not rely on subjective means or others wisdom. This was found in their pattern of underlying belief **decisions ought to be cost-based**. When presenting an idea, employees must be prepared with a proposal that clearly outlines the benefits the company can gain, and the costs involved. This encompasses factors like cost savings or the potential for saving time and money through the implementation of the idea. By presenting a well-structured argument that convincingly demonstrates that the advantages outweigh the initial costs, employees can successfully pitch their ideas within the organisation. CSC4 explained their strategy for effectively convincing upper management of their ideas by employing a cost benefit analysis *viz.*:

> *"I think the way it works is that you think of it, you come up with an idea, you take it to your manager, he takes it to his manager, who will take it to the, I think directors or the CEO. And then the most important factor to consider is the cost benefit analysis. So, you have to go prepared with I want to do this, this is how I think it will benefit the company. And this is how much it's going to cost us. But this is how much we will save, or this is how much time or money we will save. If we go through with this small, upfront cost. That's how you sell your idea."*

CSC5 shared an example where they opted for an expensive software license because it would provide them with the benefit of acquiring new projects that were previously inaccessible to them. While the price of the license remains an important factor, the decision to invest in new software is justified when it offers the potential to explore new project opportunities. Therefore, even though the license is expensive, the anticipated benefits and opportunities associated with the software justify the investment. This was further elaborated by CSC4:

> *"So having all these licenses can be expensive. And not everybody in the company has it. Everyone in our company is given this AutoCAD TrueView and Navisworks 3D viewer. Those are the free ones. And I think only the BIM team has access to all the Autodesk products, all of Yeah. Anything we want actually; we can even ask them to give us new licenses as long as we can justify the cost."*

Alternatively, when they could not provide a financial justification for their decisions, they had to cease using certain technologies, even if they offered benefits. In these cases, the inability to justify the expenses led to the discontinuation of the technology's usage. For instance, CSC4 highlighted that when a financial justification for their decisions, they had to stop using software like Gamma AR, OpenSpace, and Deep Space and stated that:

> *"We've been trying to experiment with drones or try to track the progress of a project. So, you take constant site photos, and yeah, and for that we were trying to do an automated thing. So, we tried using this software called Gamma AR, open space, deep space. And yeah, so we had to like buy licenses for those but towards the end, we weren't able to justify that it was actually helping because there were still glitches in the software's. So, then we dropped off from those."*

Cost-based decision making was also evident in how they select the BIM vendor. CSC1 mentioned that in the past their main concern when selecting a vendor for BIM software was gaining access to training and implementation assistance. However, their perspective has now shifted, and their primary focus is on the cost of the software license. They no longer prioritise choosing a vendor based on their ability to provide support or assistance. Instead, they believe that the software itself is stable and that there is ample online help available for addressing any issues. As a result, the decision-making process revolves around selecting the vendor with the lowest price for the software license subscription. CSC1 said:

> *"So, in our BIM plan we have a hierarchy of clashes, or elements. So, for example, if this chair and table are clashing, which one are you going to move? Move the chair. So, if the light and the grill were clashing, you'd have to move the grill because the architect would like the lights or the enormity of the spot. And if you move a light, and that affects lighting levels, but that's all in the hierarchy. So, the hierarchy sort of sets how we make decisions. most of the time people, we work together we try and be realistic, you know. So, at the end of the day, most of the time it comes down to what's going to cost more to compromise. So, if the price of copper is very high, we try and avoid moving copper elements like pipe work. Yeah."*

8.4.5 The nature of relationship to environment

The underlying beliefs on a BIM-enabled construction organisation's relationship to its environment are determined by whether the organisation's members believe they harmonise, dominate, or are dominated by their external environment. The external environment of CSC is its stakeholders including client, consultants and subcontractors. It was found that the company is in the pattern of underlying belief of **the best way to survive is to maintain the status quo unless forced otherwise**. This aligns with the submissive orientation towards the external environment. The BIM use was encouraged in this company only when called upon to do so by a third party. They expect that an external party should provide the impetus to use BIM. It came up repeatedly during the interviews that BIM is only used in a project setting if the client, consultants or the contract dictate its use. This was confirmed by CSC1 who stated that:

> *"BIM is driven by the client, mostly. It was mostly client driven, and part of the contract. If it's a requirement on the project, and if it's a part of our contract, say, hey, you know, it's part of our contract. To be on this project, we have to meet the contract requirements, which means we have to meet requirements. So, if you don't think you can, and we'll find another project for but in most cases, the level that we*

> *do BIM here typically will meet the criteria for most projects will exceed the expectations."*

Similarly, CSC2 reinforced that it is very rare they would use BIM in their projects by their own will. Their default approach is to rely on traditional methods of construction, and they have the necessary expertise and experience to execute projects effectively without the use of BIM. Therefore, they expect clients to insist on its implementation. According to CSC2:

> *"So pretty much in every instance, it's instigated by our clients, so it's pretty rare that we will just go into that off our own back because we do actually know how to build in 3D or from paper, traditional means. So, the key is, the higher the complexity of the project, it's becoming more and more demanding from driven by clients."*

The LOD provided in BIM model is primarily driven by the client's expectations and the contractual agreements in place. If the contract explicitly states a LOD 400 requirement, then the consultants are obligated to fulfil it. However, if the contract does not specify a particular LOD, then they may be able to submit simpler deliverables such as AutoCAD drawings. Therefore, the contract plays major role in BIM use. As emphasised by CSC4:

> *"It all comes from the client; it depends on what your contract is like with your consultants. So, if your contract stated LOD 400, then they better drafted, they have to do it. But if there was no mention of anything, and they just said BIM, they can even submit an AutoCAD drawing and get away with it. So, it's based on what you put in your contract. Plus, like, if you demand a 3D model, the charge is usually higher, even though they do make a 3D model to get 2d drawings. So, but they still up charge you for it. So, you have to ask your client what they want? And do they really care about it? Its client driven. It's not builder driven."*

The CSC does not have a specific mechanism in place to measure the performance of BIM implementation. Instead, they rely on meeting client requirements as their primary performance measurement. The BIM Manager, CSC1, has taken the initiative to send surveys to clients in order to gather feedback on their performance and stated that:

> *"BIM is important only mainly, I guess, if the clients if we meet their expectations, if we meet the expectations of the clients on the project, I guess that's our measure of how we measure ourselves. Yeah. And I have sent out a survey, I sent out a survey to several clients, who we have worked for to get their feedback on how we performed, what their expectations are, what their expectations would be on the next project. So, I've sent out a survey."*

8.4.6 The nature of time

Employees underlying beliefs on time indicate either a past, present or future orientation. With regards to the underlying beliefs on the nature of time unit, past was important at CSC. They held the pattern of underlying belief that **learning from past experiences is important**. Several aspects of their beliefs reflect a past orientation: the employees at CSC

believe in learning from the past, analysing past experiences, documenting lessons learned and applying this knowledge in their future endeavours. CSC1 stated that,

> *"I think it's the transition. Because at the same time, you know, you might have the guys that are more interested in the 2D side, but they still have the technical knowledge of what you're doing. So, if whether they want to go on a BIM side or not, still have massive value. Technically. Yeah. It's not just, we cut you off if you're not interested, done. They've got years of experience."*

This indicates that the company places significance on reflecting on past projects and experiences. Instead of just moving on to the next project, they take the time to analyse what happened in the past. By focusing on what went wrong in previous projects and seeking feedback, the company is trying to learn from past mistakes to avoid repeating them in the future. The fact that they document the lessons learned (and sometimes turn them into actionable plans or checklists) implies that they want to apply this knowledge in future projects, drawing on past experiences to guide their actions. This statement suggests that the company adapts its practices based on past experiences with new types of projects. They are using past knowledge to inform how they approach similar projects in the future. CSC4 stated that,

> *"Ah, it's our company policy that after every, after every project, actually, the whole team sits together for a lesson learned. And you have a lesson learned meeting, you invite people who will be working on similar projects in the future as well. So, they get to listen to what went wrong in this one and sort of give feedback, we give feedback on what we could have done better, what went wrong, how things could have been handled better. And all of this is documented, you will have a minute for it. Sometimes it even changes into an action plan. Or you will make a checklist of things that from those lessons learned you make a checklist thing, next time when we're starting a project, we will look for this, beforehand."*

Table 8.2. Patterns of underlying beliefs of Case C

Organisational culture dimension	Questions need to be answered	Patterns of behaviours	Patterns of underlying beliefs	Underlying beliefs of CSC
The nature of human relationships	Would an autocratic or participatory authority system be more effective?	• There is a decision-making hierarchy. • BIM is controlled by the top management. • Top management selects BIM vendors and software. • Top management controls the resources and decision-making power to innovate. • Top management buy-in is necessary. • BIM needs should be justified for top management to take actions. • BIM team possesses the skills yet lacks the power. • BIM team provide background information needed for decision making. • BIM is not integrated in organisational strategy. • BIM team remains in the role of supporters. • BIM team clarify technical issues. • Top management lacks BIM knowledge.	• Expert opinions are valued but ultimate decision-making power resides with the authority positions.	Autocracy- top management.
	Would it be more effective to structure society based on individualism or groupism?	• Employees collaborate to analyse and address challenges related to specific tasks. • Learn from each other's experiences and practical insights. • Tacit knowledge is exchanged that might not be captured through formal channels. • Lessons from past experiences are shared to improve future approaches. • Employees engage in spontaneous conversations and informal interactions. • Encourage brainstorming and idea-sharing through informal discussions. • Technical expertise is shared and leveraged to solve complex challenges. • Formal discussions are structured and organised. • Formal discussions are documented through email chains and records.	• Discussions gave results.	Groupism
	What is the ideal way for individuals to interact with one another? Is life characterised by competition or cooperation?	• The workload is managed cooperatively to prevent overburdening any individual • A dedicated email address is used for colleagues to direct queries and seek assistance. • BIM Team provides solutions and assistance. • BIM Specialised individuals take on more complex tasks. • Collaboration extends beyond immediate teams, promoting cross-functional cooperation. • Reach out to external contacts for assistance and guidance. • Ensure that the right expertise is applied to the right tasks. • Offer mutual assistance and support to colleagues without hesitation. • Rely on each other's strengths and skills for effective problem-solving. • Share the lessons learnt. • Encourage continuous learning and a growth mindset. • Communicate openly and clearly.	• Mutual interdependence is best suited to problem solving.	Cooperation.
The nature of human nature	In this organisation, how is human nature viewed; perfectible, immutable, good, neutral, or evil?	• Lack of emphasis on appreciations and rewards. • Cautious of excessive rewards or encouragement that might lead to non-value-added activities. • Meeting deadlines and milestones is emphasised, and there may be consequences for not doing so. • Celebrations focus on team achievements rather than individual bonuses. • Direct and assertive communication. • Communication is direct and straightforward, even if it involves expressing disagreement or saying "no". • Employees address disagreements directly and face-to-face. • Individuals are responsible for tracking and communicating their information needs.	• Appreciations are not expected, but mistakes are highlighted. • Disagreements are normal and acceptable.	Evil, perfectible.
The nature of human activity	Is the group focused on doing, being, or becoming?	• Decisions and initiatives are often driven by client requirements rather than internal strategic planning.	• The correct way to behave is being reactive, not proactive.	Being.

Organisational culture dimension	Questions need to be answered	Patterns of behaviours	Patterns of underlying beliefs	Underlying beliefs of CSC
		• Cost of is BIM is transferred to the client. • Prioritise short-term needs and immediate client demands over long-term strategic investments. • Limited investment in innovation. • Show a lack of interest or engagement in proactive training sessions. • Do not risk the staff time needed for training. • Lack of ownership in learning. • Diminished use of technology. • Exhibit disinterest in participating in lessons learned meetings. • Hybrid use of 2D and 3D drawings. • Avoid BIM if it all possible.		
The nature of reality and truth	How is truth determined? What is the source of truth, and how does it come to light? By tradition, wisdom, conflict and debate, pragmatic criteria, scientific method or social consensus?	• Emphasis on cost justification. • Pitch ideas based on cost-benefit analysis. • Discontinue technologies without financial justification. • Select most cost-effective BIM vendors . • Use other cost-effective alternatives as much as possible. • Inability to see the benefits, basic distrust for BIM.	• Decisions ought to be cost-based.	Scientific method-Cost driven.
The relationship of a group to its environment	How do the organisation and its members interact with the outside world, particularly the external market of the organisation's services? Is it a domination, submission, harmony?	• BIM use is driven by client demands and contractual obligations. • Collects feedback from clients through surveys to gauge their performance. • Emphasise client satisfaction. • Prioritise maintaining positive relationships with clients. • Rewards come through meeting the needs expressed by the clients. • Avoid BIM if it all possible. • Rely on traditional construction methods and practices. • No BIM strategy or objectives available	• The best way to survive is to maintain the status quo unless forced otherwise.	Submission.
The nature of time	Is the organisation’s basic orientation toward past, present and future? What does time mean to this organisation?	• Hold lessons learned meeting after each project. • Apply past knowledge in future projects. • document insights from lesson learned meetings serve as a reference for future projects.	• Learning from past experiences is important.	Past.

8.5 Summary

This chapter presented an in-depth within-case analysis of Organisation C, focusing on the extraction of underlying beliefs across six distinct cultural dimensions. These dimensions encompass the nature of human relationships, the nature of human nature, the nature of human activity, the nature of reality and truth, the relationship of a group to its environment, and the nature of time. Through a meticulous process of open and axial code analysis, behaviours and patterns of underlying beliefs were identified, subsequently leading to the extraction of specific underlying beliefs. CSC believed in autocracy of top management, groupism, cooperation, evilness, perfectibility, being, scientific methods, submission, client-dominance, contract dominance, and past. The next chapter presents the within-case analysis of Organisation D.

CHAPTER 09- WITHIN CASE ANALYSIS OF ORGANISATION D

9.1 Introduction

The chapter 07 presented within case analysis for Case C. This chapter offers a detailed within case analysis of organisation D. Initial sections of the chapter present background information of organisation D and organisational structure, highlighting key departments and roles related to BIM. Subsequently, the chapter presents the details of the interviewees involved in the study. This includes information on their positions within the organisation, their roles and responsibilities and relevant demographic characteristics. Next, an overview of the responses collected from them regarding the external adaptation and internal integration problems faced by organisation D in the BIM environment is presented. In the following sections of this chapter, the underlying beliefs, and patterns of underlying beliefs supported by behaviours discovered in organisation D within the BIM environment are provided.

9.2 Background information organisation D

Case study organisation D (CSD) is one of the leading construction companies in Australia. Founded in 1949, the company has a long history of successfully delivering major projects across various industries. CSD has extensive experience in constructing complex buildings within various sectors, including healthcare, stadiums, offices and mixed-use developments. Thus, their expertise covers a broad range of projects, from new developments to refurbishments, redevelopments, and expansions. They also specialise in designing and building crucial infrastructure that includes bridges, roads, tunnels, airports, water and wastewater systems. The company has a workforce of more than 5,00 people and has completed projects worth over $ 4 billion. The values of the CSD are integral to their organisational culture and demonstrate their dedication to being a modern, innovative company with the necessary skills and mindset to create a positive impact. Those include care, empowerment, imagination and future-focus. They demonstrate care by considering the impact of their actions on communities and the environment and empower their teams to take responsibility and accountability, which helps to build trust. They are future-focused, with a commitment to creating sustainable outcomes and anticipating future needs to remain at the forefront of the industry.

CSD has a strong commitment to sustainability and has been recognised for its efforts in reducing its environmental impact. The company has a reputation for excellence and prides itself on delivering projects on time and budget. In terms of its strategy for innovation, CSD

has been at the forefront of using technology to enhance its construction processes. CSD has a team dedicated to a department entitled: ‘Technology, Engineering and Knowledge’, which prioritises technical excellence, innovative technology, and a framework for knowledge and innovation throughout the company. Their digital delivery has a primary focus on integrating BIM, GIS, geospatial, surveying, and emerging technology functions. They use BIM as a digital 3D model of a building used to plan and manage construction projects. This enables CSD to collaborate more effectively with architects, engineers and other stakeholders, resulting in greater efficiency and accuracy throughout the construction process. The company use BIM software applications depending on the requirements of the clients. They aim to offer clients a virtual tour of upcoming facilities, leveraging BIM as a platform for collaborative efforts between teams, consultants, and clients. These off-shelve software include Autodesk Navisworks, Revit and 12D.

Figure 9.1 shows the formal organisational structure of the CSD. This organisational structure was built based on the findings from the interviews when discussing components such as structure, communication, company website and the organisational chart provided by the interviewees.

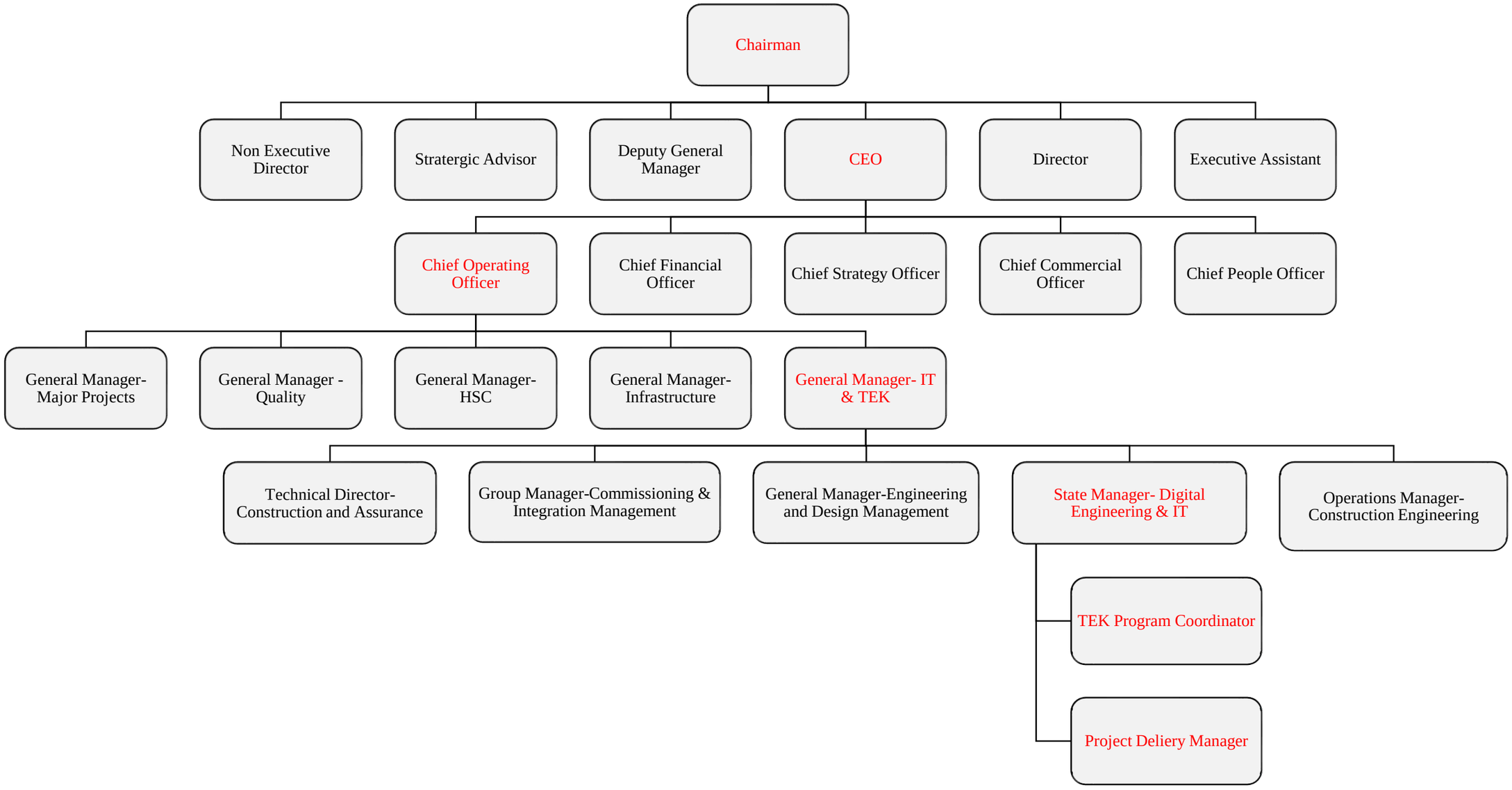

Figure 9.1. Organisational structure of organisation D

Six interviews were conducted within the company, with organisational roles presentative of the two levels of the organisational structure: senior management level and operational level. Accordingly, six interviews were conducted within the organisation, with three from managerial level and three from operational level. Table 9.1 summarises the details of interviewees of the CSD.

Table 9.1. Details of interviewees in Case D

Interviewee	Job function	Industry experience	Experience with BIM
Interviewee CSD1	State Manager	36 years	10 years
Interviewee CSD2	IT Manager	10 years	6 years
Interviewee CSD3	Project Delivery Manager	9 years	6 years
Interviewee CSD4	Planning Engineer	16 years	5 years
Interviewee CSD5	Senior Project Engineer	12 years	6 years
Interviewee CSD6	Project Engineer	7 years	2 years

CSD1, as the State Manager at CSD, is responsible for overseeing and managing construction projects within South Australia and has primary responsibility for ensuring the successful completion of construction projects while adhering to budgetary, timeline, and quality objectives. CSD1 possesses a comprehensive range of construction expertise that encompasses various areas, including trade work, construction management and business management.

CSD2 holds the position of IT Manager at CSD and is responsible for managing the organisation's IT infrastructure, systems and processes and plays a crucial role in ensuring that the company's technology resources support the efficient and effective operation of the business. CSD2 has completed an AutoCAD training course and a BIM course with TAFE, while having a hands-on training and mentorship.

CSD3 is the Project Delivery Manager at CSD who oversees and manages the successful execution of projects from initiation to completion. CSD3 is also responsible for ensuring that projects are delivered on time, within budget and according to quality standards. In the early stages of their career as an architect, CSD3 primarily used AutoCAD as the main software tool. However, when CSD3 transitioned to the construction side of the industry, they started utilising BIM technology.

CSD4 as the Planning Engineer at CSD, involves developing, refining and overseeing the planning process, detailed scheduling and performance monitoring to achieve high-quality project outcomes within the specified timeframe and budgetary constraints. CSD4 utilises both Primavera and the 3D BIM model in conjunction to incorporate the time dimension into the model, resulting in a 4D representation.

CSD5 functions as the Senior Project Engineer at CSD and has been with the company for five years. CSD5 first gained experience with BIM when working in Qatar to identify and resolve service clashes during the construction of infrastructure.

CSD6 has been working as a Project Engineer at CSD for 7 years and is responsible for identifying and resolving various issues. These issues include clashes, logistical constraints and understanding the installation requirements. BIM usage includes visualising the design in a digital format to analyse the model and identify any clashes or conflicts between different building systems or components.

9.3 Overview of responses to external adaptation and internal integration problems

According to the working definition developed in Sub section 3.2.2, organisational BIM culture is the *"patterns of beliefs and thinking guided by behaviours and artifacts, that was learned by members of BIM using the organisation as it solved its problems of external adaptation and internal integration."* The external adaptation problems in BIM-enabled-construction organisation include BIM mission and strategy; BIM goals and objectives; means to be used in achieving BIM strategy; BIM performance evaluation and remedial actions to ensure that members meet the BIM mission and strategy (Schein 2010). The internal integration problems include language used in a BIM environment; BIM team boundary; power and status allocation criteria in a BIM team; peer relationships in BIM environment; allocation of rewards and punishments and unexplainable and in explicable issues (ideology) (Schein 2010). The underlying beliefs were found by questioning how the group responded to these internal integration and external adaptation problems. The following is a short summary of the key responses to such problems:

BIM strategy and objectives - CSD's current approach to BIM implementation is reactive, where they only use BIM when requested by clients or consultants. Unfortunately, the organisation lacks a well-defined BIM strategy or specific objectives despite having a mission to transform lives of their clients. The implementation of BIM within the company appears rushed and lacking strategic planning.

Means of accomplishing BIM goals - at CSD, BIM implementation has been primarily driven by external parties, resulting in a lack of a dedicated role or team responsible for managing BIM. Instead, Design Managers who are assigned to specific projects take on the responsibility of overseeing the BIM models within those projects. In cases where additional BIM interventions are required, the Design Managers rely on external consultants to perform

the necessary tasks on their behalf. However, there is an IT department established called TEK (Technical Engineering Knowledge) to support IT related functions in the company.

BIM performance evaluations and remedial actions - the company has no structured process for evaluating BIM performance of the employees, and at present CSD has only established HR evaluation systems. Consequently, there is a need to establish a specific evaluation framework to assess the BIM performance of employees.

Common language - at CSD, the *ad-hoc* use of BIM has resulted in changes to the language and terminology used within the organisation. Specifically, the term 'BIM' is now commonly used to refer to the building information model itself, rather than the broader process or methodology.

BIM team boundaries - at CSD, it appears that there is currently no dedicated BIM leader or team in place. Instead, the responsibility for overseeing BIM projects falls on existing roles within the organisation. In particular, the IT department provides support related to hardware and software requirements for BIM implementation. In the absence of a designated BIM leader, the existing roles, such as the IT Manager, may take on additional responsibilities to serve as the *de facto* BIM leader. It appears that there have been no significant changes to the organisational structure at CSD specifically related to the adoption of BIM.

Power and status allocation criteria in a BIM team – at the organisational level, the State Manager holds the authority and responsibility for making decisions. However, when the decisions involve BIM-related matters, the IT Manager is also consulted for their expertise and input. Ultimately, the power to make decisions resides with the top management of the organisation.

Rewards and punishments - there is no rewards or punishments placed at CSD about BIM use at individual level. The only reward was that the effective BIM use should actually provide a better outcome for the project.

Ideology - in situations where there is a high demand from clients to use BIM, CSD may find it challenging to refuse and assume additional responsibilities and incur extra expenses. This is due to the need to meet client expectations and fulfil the requirements associated with BIM implementation.

9.4 Underlying beliefs of organisation D

The fundamental underlying beliefs that exist within an organisation create a cultural paradigm which serves as the foundation for all aspects of organisational life. These beliefs

shape the behaviours of individuals within the organisation and influence how they interact with one another and approach their work. Interviewees' responses to internal integration and external adaptation issues in the BIM environment reflected different patterns of underlying beliefs. These patterns were analysed against the cultural dimensions *viz.* human relationships; organisation's interaction with the environment; the nature of reality, time; the nature of human activity; and the nature of human nature to reveal the underlying beliefs of the CSD (Refer to Table 9.2).

9.4.1 The nature of human relationships

The underlying beliefs that dictate how individuals within the group interact and relate to each other are considered under this category. These beliefs pertain to the interactions between employees, power distribution, competitive and cooperative nature of relationships. Thus, the beliefs solve the problems related to best authority system, best way to organise and correct way to relate to each other.

Best authority system

The underlying beliefs within this category are geared towards answering the question of whether an autocratic or participative authority system is the optimal approach for organisational operations. **Expert opinions are valued but ultimate decision-making power resides with the authority positions** was identified as a pattern of underlying belief of the company. This company tends to make decisions in an autocratic manner, where the key business decisions are made by the state manager, and the general managers at the organisational level. When questioned on who makes the decisions on BIM implementation in the company, CSD1 answered:

> *"It's the generally management, always involved in decision making. And if your key employees are involved, particularly those that have more of an IT computer background, they'll get involved in the evaluation and the presentations. And then group decisions made based upon the capabilities of the software the cost, how easy it is going to be to use. No point of getting software, if it's just all too hard, no one will use it."*

CSD1, being the State Manager at CSD, agrees that top management understands the value of involving others in decision-making. They recognise that their perspective alone may be limited and that seeking input from others can lead to better decisions. By consulting the IT department during decision-making, top management taps into the diverse expertise, knowledge, and insights of their team members, enabling them to make more informed and well-rounded decisions. These discussions promote an element of participatory authority within the company, although it is ultimately dominated by the autocratic system.

CSD2 described that the decision to use the tool Aconex was made by group of people in top management level. Prior to go ahead with the communication tool, five members of the senior management team discussed and evaluated the available options. According to the IT Manager CSD2:

> *"As a collective senior management team, there was about five of us, who tried a lot of different programmes and things like that. And we just came to a conclusion that yep, that's what we're going to use. And so, we decided on that."*

Even though most of the decisions were made by the upper hand, still there was a little room for feedback. Thus, roundtable discussions were evident in decision making where they promote discussing issues in a group and incorporate consultative style in decision making by involving subordinates in the decision-making process. The decision for training employees to cater new requirements in BIM use is made by the top management with consultation of the employees. CSD6 explained how they make decisions related to training:

> *"It's a roundtable discussion, so senior management, and then consultation with a staff member. So, it may also be the staff member says, I'm really interested in Revit, or I'm really interested in BIM, can I do this BIM course? And, you know, your senior management will say, yes, yes, you can do it."*

Accordingly, there is a consensus among the employees that the autocracy is the best authority system within the organisation, where the top management makes the majority, if not all, of the decisions, with little room for feedback. Although the IT Manager is asked for input in decision-making, the top management group usually makes the final call. This is supported by the pattern of underlying belief, expert opinion-based decision-making is helpful but the ultimate power to make decisions is with the top management.

Best way to organise

To understand the underlying beliefs of CSD regarding the nature of human relationships, need to examine their assumptions about the most effective way to structure the society. This involves determining whether CSD leans towards individualism, which prioritises personal freedom and achievement, or groupism, which emphasises group interests and interdependence among individuals. CSD's underlying belief regarding the best way to organise does not strongly align with either individualism or groupism but rather exhibits features of both orientations. The organisation's approach appears to value both individual autonomy and collaboration within a group context. In a collectivist perspective (groupism) employees held the pattern of underlying belief that **discussions gave results**. The company also holds meetings specifically for addressing requests for information (RFIs). In these meetings, they aim to quickly resolve RFIs using BIM instead of waiting for a response that

could take several days. By utilising software like Revit, they can examine elements from different angles, cut sections and find solutions without going through the lengthy RFI process. This approach saves time, as they can discuss and resolve issues in a dedicated meeting instead of waiting for days. Further, the value placed on groupism has enabled CSD to use varying skills sets and knowledge when solving problems. By working together as a team, leveraging each person's expertise, CSD can effectively address complex challenges and make well-informed decisions. CSD2 explained this by stating:

> *"It's different people for different skill sets, you know, yeah, your site managers are quite often got the technical knowledge, whereas the Project Managers have got, you know, they know what the Architects want in a design criterion. So, you know, if you're particularly looking for, like, something like that, trying to work out where a casting plate is going, that would probably be the Site Manager goes, yep, that's where we need it sort of thing. Whereas, you know, if you're trying to work out whether what would be intersection between carpet tiles and vinyl or something like that. The Project Manager might handle that."*

However, there were instances the company encouraged an individualistic way of organising. Thus, they held the pattern of underlying belief that **training should cater the individual interests**. For example, CSD's approach to employee training appears to be individualistic, focusing on the specific needs and interests of each employee. Training is provided based on the employee's request or when it is deemed necessary by the organisation. For example, if an employee expresses a particular interest in Revit or BIM, they may be given the opportunity to enrol in a relevant course. The decision to approve such training requests is typically made by senior management. According CSD2 clarified this by saying:

> *"So, it may also be the staff member says, I'm really interested in Revit, or I'm really interested in BIM, can I do this BIM course? and, you know, your senior management will say, yes, yes, you can do it. There is only an ad-hoc education. And training programme run by vendors only for necessary personnel."*

CSD6, also agreed that the training approach at the company is *ad-hoc* and tailored to individual employees. This indicates an individualistic orientation within the company, as training decisions are made on a case-by-case basis, considering the specific needs and interests of each employee. BIM skills are seen valuable at CSD and therefore, everyone is expected to develop themselves.

> *"It's definitely mine has been ad hoc, sort of, sort of learns on the job as I went. So that's what I'm a more exposure, you get to sort of the more. But in my role, my role as an Engineer, is not so much to scrutinise a model every day, and I use it more in probably passing. I know so data modellers, they, would have training in various software packages that are related to using it. That's the, you know, previously before*

the organisation or the once they've joined the organisation, they've undergone that training. So yes, it depends on your role, I guess."

Correct way to relate to each other

Examining employees' beliefs about the appropriate way for them to relate and interact with each other, and distribute power and affection provide insights into their underlying beliefs about the nature of human relationships. This can be determined by assessing whether the contractor emphasises competition or cooperation as the correct way for team members to relate to each other. CSD emphasised on cooperative relationships between members rather than competitive ones as the best way to relate to one another. Thus, they held the pattern of underlying belief that **mutual interdependence is best suited to problem solving**. The company's employees believed that they were all part of a team working towards a common goal. According to CSD3, when there is a problem, the team debates how to proceed, but they all have the same goal of completing the project as quickly and efficiently as possible while still meeting codes and standards. All the interviewees believe that in the event of a problem, it is best to seek assistance from colleagues first. When they have a technical problem, they go through a group process before going to the help desk support. This was explained by CSD1 as:

"There are all sorts of resources to get answers. We have a very open office here for information sharing. So, we all work together. We know that one particular person in the office is really good at Revit. So, if you've got a Revit problem, you can ask them quicker than using Google or using their help on Revit."

Even the State Manager agreed to go anywhere and ask for help from anyone. The State Manager mentioned that:

"There are different people in the organisation that know the software better than others. So, it's a sharing of information, go and see, what do you do here, or you get to know who's good at what, and it tends to be the ones that are using it the most. So, I'll even go and ask someone that is probably got the answer."

CSD4 explained this with an example stating that:

"Yeah, I'll give you an example. So, for example, when we were working on the hospital project, I was looking at the plantrooms and the sequence of installation. Obviously, I was looking at the bottom of the model. And then where I wasn't sure how to use the model, or how to look at different layers of mechanical and electrical services, I used to go to add, you know, Services Manager or Services Senior Coordinator, who are sitting like a few decks away from me and, you know, they were showing me how to use it or they could give me advice like that. Yeah. Easy approach."

Thus, there are no power struggles among superiors and subordinates. The group is well aware of its members' capabilities, which makes them extremely reliant on one another. This

kind of environment promotes information sharing among the group members. The technological knowledge and experience on BIM were the main criteria to define the group boundary. When discussing existing rewards system in terms of BIM use, it was evident that the company has no established reward system for individual members. CSD3, on the other hand, with a strong sense of team spirit, stated that the pride of working as part of a team is the best possible reward. This was reiterated by CSD5, who said: "*everyone is in this together and we're all a team working together. It's not for self-reward. It's about the company*." These behaviours and pattern of underlying beliefs on a collaborative work environment to solve problems have been led by the underlying belief that the best way to relate each other is being cooperative. This is because the work atmosphere in the company is friendly and informal; where individuals are dependent upon each other and everyone is willing to ask for help whenever necessary.

9.4.2 The nature of human nature

An organisation's fundamental underlying beliefs regarding the nature of human nature revolved around their core underlying belief regarding whether humans were inherently good, neutral or evil, and whether human nature was capable of improvement or remained fixed. People at CSD held the solid underlying belief that the nature of human nature is 'evil'. This was reflected in their pattern of underlying belief that **employees are only driven by tangible benefits**. The motivation to use BIM is tied to personal benefits that employees can derive from it. This has resulted the selective use of BIM within the organisation, which also reflects the pattern of underlying belief that not everyone needs to use it. Only a selected number of people, such as design managers, are using BIM as it is seen as part of the design process. As explained by CSD4:

> *"Well, that's the problem, because in our company, in our organisation, not everybody is using BIM. And it's not a requirement for everybody to use BIM. So that it's a selected number of people who are using BIM. So, for example, design managers, they're using BIM, and now it's part of the design. So, in design management plan, it's written that you know, the design will be developed in a BIM environment."*

At CSD, interviewees expressed scepticism about the value of BIM and emphasised the need for clear benefits to be demonstrated. They prompt uncertainty about the purpose and usefulness of BIM, repeatedly asking what the point and benefits of using it are. They used the phrases below throughout interviews *viz.*:

> *"What are we trying to achieve with BIM? You know, no one's really told me, or can come up with why are we using it?"*

"What's the point of it? What is the point of BIM? What's the benefit of it?"

Why do you think BIM is going to be used?

"You know, it's something that everyone's talked about, but what why use it? Until someone shows us some benefits!"

This suggests that the interviewees are looking for tangible reasons and evidence of the benefits before fully embracing BIM. The scepticism and limited adoption of BIM has stem from the belief that it is not relevant or beneficial for everyone in the company.

The employees also contend that using BIM is intricate and opting for simple and familiar methods is more advantageous. They argue that there is no need to complicate matters with complex software like BIM if the current methods suffice for communication and planning. For example, CSD3 noted that Site Managers and tradespeople do not perceive immediate personal advantages or grasp the purpose and benefits of using BIM. Instead, they view the use of drawings and plans along with whiteboard markers for site planning as a straightforward and familiar approach that site workers can easily comprehend and visualise. This viewpoint aligns with the pattern of underlying belief that employees are motivated by solid benefits.

"A lot of the times with site planning, we've got our Site Managers and our trades on site, they don't tend to use these applications, because, you know, it's just, they're there. A lot of the guys don't, the site guys wouldn't know how to use these applications. So, to keep it simple, a lot of the times if we're talking about, you know, planning, the day ahead, or the week ahead, we just use drawings, you know, like plans, for example. We would have, you know, either a big A0 or A1 plans, and it's just old school whiteboard marker, just indicating to all the trades, "Hey, guys, you know, we're going to be here on this date, we're going to be doing X, Y, and Z", you're just keeping it simple. It doesn't need to be complicated. For the site, guys, it's a lot. They'll understand your visualization. And the easiest and the quickest way is, you know, just a markup on a site plan. And I don't think Yeah, we don't really need to get too complicated with the programs here."

CSD1, the General Manager mentioned being initially reluctant to provide smartphones to on-site personnel due to concerns about potential distractions and misuse, which indicates that the upper management lacks trust in the employees. However, as the importance of being able to take photos and receive emails on the go became apparent, they eventually embraced smartphone technology. CSD1 explained:

"If we can see a benefit to it, which we could see. We're going back some time, we were reluctant to provide smartphones, to people on site. Because in the early days of smartphones, people just spent more time playing on and using them as a as a as a tool. So, we delayed the implementation for some time. But then it became more important to be able to take photos and receive emails on the go. So, you know, we're

happy to adapt to technology. And yes, it's, it's driven by management in response to making sure we're being as efficient as possible."

This change in mindset indicates that the management acknowledged the potential advantages and increased efficiency that smartphones could bring in terms of enhancing communication, documentation and information access. This demonstrates that motivating employees through tangible benefits aligns with the notion of a potentially evil human nature but it also implies that this nature can be improved by highlighting the benefits at the organisational level.

9.4.3 The nature of human activity

The underlying beliefs of nature of human activity are evident in the actions and behaviours of the employees at the workplace, and their responses to the work environment. Three fundamental activity orientations can be identified as 'doing', 'being-in-becoming' and 'being'. It was evident in the interviewees' responses they were in the pattern of underlying belief that **the correct way to behave is being reactive, not proactive**, which aligns with 'being' orientation. They all agreed that training and education are vital to use BIM to its full extent. However, CSD does not act proactively to provide training to the employees. The top management do not initiate mechanisms to train employees in long run to gain necessary skills and capabilities. The training for the staff to smoothly transit from traditional methods to BIM-enabled methods is given only needed basis. According to CSD2, the emphasis of training is not on enhancing employees' skills, but on maintaining their existing skills. The company's organisational structure remains unchanged and does not support a comprehensive transformation for adopting BIM throughout the organisation. When faced with a BIM project, employees take on additional roles and responsibilities without a proactive setup to facilitate BIM implementation. CSD6 highlights that Project Managers and Contract Administrators also double as BIM Managers in such situations. Their main focus is on achieving project goals without a dedicated BIM vision or objectives. Their priority is simply 'getting the job done anyway'. This approach reflects their belief that the key to appropriate behaviour and human activity is centred on 'being' orientation.

9.4.4 The nature of reality and truth

Every organisation has underlying beliefs about the nature of reality and methods to identify that reality. These underlying beliefs guide individuals on how to identify relevant information, how to interpret it, and how to determine when they have enough information to decide whether to act, and how to act. This determination could be reached through

various means, including pragmatic testing, drawing on wisdom or expertise, or by considering social consensus.

The pattern of underlying belief that **decisions ought to be cost-based.**, demonstrated that the CSD prioritises objective means of determining reality and truth, particularly through the use of return on investment (ROI) ratios and does not rely on subjective means or others wisdom. CSD4 expressed that they focus on cost-effectiveness and justifying expenses based on the potential return on investment. If someone within the organisation sees the potential benefits of using BIM on a project, they would need to justify it to the top management in terms of cost. According to CSD6:

> *"So, if I go to CSD and say, I want to use BIM on this project, they will not just simply say "Yeah, go for it, we give you $1,000 license". You know, it's just not like that. So there has to be some justification for it. Usually, you have to justify the return on investment."*

Employees all agree that cost is a major barrier at BIM use at the company. CSD3 explained that the tools, trades, or consultants chosen for a project depend on the available budget and how much the company is willing to spend *viz.*:

> *"It's all driven by the money, you know, when a company goes for a project, and chooses which kind of tools or trades or whatever they use, or, you know, consultants they use, it's all relative to how much money is present and how much money they're willing to spend. You know, so a company like what I said to you about Revit, you know, Project Coordinators or Site Engineers to use Revit, because they don't need to use BIM to that extent. Okay. And the reason for that is, you look at the cost of the license for Revit. Yeah, do you know what the costs are for Revit? You got to have a look. It's not cheap. I'll tell you, what charges the company for Revit, as in Autodesk, how much they charge the company. I'll tell you that now."*

CSD3 further added that:

> *"AutoCAD, just CAD, how much it costs the company per year? So that's $2,260.00, per year per person. Okay, I've got AutoCAD Mechanical $2,200. I've got Navisworks $2,850, Revit $3,166. Yeah. So, this is the license to have the program Project Planning. So, we're talking about Microsoft projects. I'm not talking about BIM now. That's $257 annually per person per license. Yeah. So, it all comes down to cost, and whether it's required, it's not like, Okay, this guy can, maybe \ different companies have different arrangements with Autodesk. And, yeah, it for something like Revit, it's couple of grand."*

This was confirmed by CSD 6 who mentioned that:

> *"There is an element of there's an upfront cost, So, you know, some of the software is quite expensive. But yes, so that's probably the main difficulties."*

According CSD2, when the project is nearly around AUD50 million, they do not think of using BIM in those projects. They stated that:

> *"It could be, it could be obviously BIM or something. I get has a fair bit of costs associated with everything, you need some subject matter expert, as well, which was my understanding, and the convenience. And depending on the magnitude of the project itself, I think that's what goes on in the decision of organisation whether they should be implementing BIM. On that particular job. As I said, it might have been implemented on our mega projects, like a tunnel, which is multibillion dollar projects, but on a smaller, like I worked with a $50 million project."*

The employees agree that there cheaper alternative available instead of using expensive BIM software tools. Therefore, they tend to go for the cheapest option available, AutoCAD for drawings, Aconex for connect teams and processes across the entire project lifecycle and capture a complete project record all on one platform. CSD2 expressed that:

> *"If our purpose is just for the sake of clash analysis, or just to use a part of it, there are other software's or programs in the market, which can be which are cheaper and can be more conveniently used. we have access to all 2d software's like AutoCAD, and perhaps, PDF or whatever. Yeah, that's what we have been using, rather than BIM."*

9.4.5 The nature of relationship to environment

The underlying beliefs on a BIM-enabled construction organisation's relationship to its environment are determined by whether the organisation's members believe they harmonise, dominate, or are dominated by their external environment. The external environment of CSD is its stakeholders including client, consultants, and subcontractors. It was found that the company is in the pattern of underlying belief that **the best way to survive is to maintain the status quo unless forced otherwise**. This aligns with the submissive orientation towards the external environment. The use of BIM in their projects appears to be driven primarily by external demands rather than recognising its potential benefits for their own operations. They follow a cautious and somewhat sceptical approach, where they are not actively seeking out the benefits of BIM themselves but rather expecting someone else to demonstrate those benefits. CSD1 expressed uncertainty about BIM benefits, stating they would need to see concrete advantages before embracing it. CSD1 said:

> *"Why do you think BIM is going to be used? You know, it's something that everyone's talked about, but what why use it? Until someone shows us some benefits? you know, someone's got to provide it to us. And that's not happening."*

Due to this risk-averse stance, CSD relies on external parties like clients, consultants or industry peers to drive BIM adoption. For instance, CSD6 highlights that the driving force

behind the adoption of BIM is primarily originating from either the Design Consultants during the design development phase or the clients themselves. According to CSD6:

> *"It's definitely pushed by the consultant, and by the client through the design development. And then the company sort of had to upskill itself to use it as a tool. Because a lot of clients now ask for it. Yeah, so generally been driven by the design consultants and the client as an end user."*

If a client requests BIM as part of the project or contract, the company is more likely to incorporate it. Similarly, Design Consultants may also push for the use of BIM during the design development phase. CSD3 further explained:

> *"Sometimes it is the client thing. Sometimes it is a consultant thing. I'm on a project, I'm tendering, I have put a tender out for a project and the designer, I've had different submissions come back, one designer says okay, because of the simple nature of the project, we're not going to incorporate BIM because BIM you know, there's going to be significant hours needed of spent to produce a BIM model so on so forth, when you can have a guy instead, on the other hand, doing CAD work, and just cut out okay, plan elevation done. It's nice and simple, so they've opted to not go with a BIM direction."*

The company perceives BIM models as non-contractual documents, which limits their reliance on the model for making decisions or building from it. If information is missing or not included in the model, they revert to using traditional 2D drawings. CSD1 highlighted they do not tend to use BIM model as it is not contractual *viz.*:

> *"Because the model was not contractual to us. It's, it's not a contractual document, we can't rely on it. If it's, you know, we can look at it. And we can pick a section where we want to pick a section rather than where the architects chosen to do it in in 2d. But we can't build or do anything off of that model. So, it's just really for information purposes only. And a lot of Architects Engineers or whoever's, you know, providing the model it's very rare that give us access to the model."*

CSD2 clarified that the BIM model does not hold contractual status, even if certain information is absent or additional elements are present in the model. In such cases, they cannot consider it as a formal variation since the model's content is not legally binding. As a result, they revert to relying on the 2D drawings to address any discrepancies or changes. The absence of a specific company policy regarding the extent of BIM usage indicates a reactive approach, where decisions are driven by external demands rather than being part of a proactive internal strategy.

9.4.6 Underlying beliefs of nature of time

Employees underlying beliefs on time indicate either a past, present, or future orientation. With regards to the underlying beliefs on the nature of time unit, past was important at CSD having a pattern of underlying belief that **the most effective solutions lie within proven**

traditional methods. This is evident in their emphasis on existing conventional construction practices and their preference for relying on established methods rather than embracing new technologies like BIM. Employees made many references to highlight their inclination towards traditional approaches and their tendency to prioritise past experiences and familiarity with proven techniques. They place significance on the use of 2D drawings, physical plans, and manual processes for tasks such as site planning, estimating and cost planning. They also view these methods as simpler and more easily understood by Site Managers and tradespeople who may not be familiar with software applications. For instance, CSD1 pointed that:

> *"I guess having the BIM model Yeah, does help. And yes, we have used it and look to see but pick up information that wasn't on the drawings at that point in time. And yes, we did use it for some planning on where to put cranes and things like that. But You know, it's just as easy to do it off of a 2D drawing with sections and elevations. Yeah. So, yeah, we don't really use it. Mostly twos wouldn't use it, either is a push from certain areas to use it. But it really hasn't filtered into our industry, despite everyone telling us eight years ago, or whenever it was that every job is going to use BIM to do something not sure what it's supposed to do. But it hasn't happened."*

CSD3 provided additional insight into their preference for traditional methods and practices that have been relied upon over time by stating that:

> *"We would have, you know, either a big A0 or A1 plan. And it's just old school whiteboard marker, just indicating to all the trades, "Hey, guys, you know, we're going to be here on this date, we're going to be doing X, Y, and Z", you're just keeping it simple. It doesn't need to be complicated. For the site guys, it's a lot. They'll understand your visualisation. And the easiest and the quickest way is, you know, just a markup on a site plan. And I don't think Yeah, we don't really need to get too complicated with the programs here."*

CSD6 further elaborated on their reliance on traditional methods and practices that have been consistently used in the past, using 'estimating' as an example:

> *"Estimating commercial construction is really about bundling up documents into the relevant packages, sending them out to the subcontractors and getting the prices back. It's not really estimating its price collecting and making sure that they've got a refund included. And in things like that. We do a little bit of cost planning. We did purchase cost x. And we used it for a short time and didn't find it that beneficial. Because at the stage that we were using it, the documents were always in a very early stage, and certainly there wasn't a model or anything like that. So, it really didn't help us. So, believe it or not, if we're doing an estimate at the moment, we either do it manually and or use Excel. But quite often, the estimates that we'll do our cost planning, we'll do manually. Piece of paper and a pencil and a scale is quicker."*

Their negative past experience with BIM significantly influences their current approach and decision-making regarding its use. Their initial BIM project, which experienced delays, has made them sceptical about the potential benefits of BIM. CSD2 expressed uncertainty about

the effectiveness of BIM in saving time, as they believed it did not contribute to mitigating the existing one-year delay on that particular project. Consequently, they are now hesitant and less convinced about the advantages of implementing BIM. CSD2 explained,

> *"BIM was used on one particular project, our first BIM project. I don't think it helped us to save time because the project was already a year late. Not sure of the benefits of BIM were that good."*

Table 9.2. Patterns of underlying beliefs of Case D

Organisational culture dimension	Questions need to be answered	Patterns of behaviours	Patterns of underlying beliefs	Underlying beliefs of CSD
The nature of human relationships	Would an autocratic or participatory authority system be more effective?	• Top management makes key business decisions. • Top management buy-in is necessary. • Seek input from relevant experts and employees to improve decision-making outcomes. • Employees have some say in decisions related to their training and development. • No BIM specialised team. • IT department possesses the skills yet lacks the power. • Decision-making focuses on evaluating software capabilities, cost, and ease of use.	• Expert opinions are valued but ultimate decision-making power resides with the authority positions.	Autocracy- top management.
	Would it be more effective to structure society based on individualism or groupism?	• Maintain regular communication through meetings. • Dedicated RFI Meetings. • Acknowledge the strengths of different roles within the organisation and delegates tasks accordingly. • Consider multiple perspectives to make informed decisions.	• Discussions gave results.	Groupism.
		• Training is provided based on individual interests, role and as-need basis. • Tailor the training to individual employees' specific needs and interests. • Training intensity and depth may vary based on individual job roles. • Ad-hoc learning. • Employees are encouraged to take initiative in identifying their training needs and seeking opportunities for self-improvement and skill enhancement.	• Training should cater the individual interests.	Individualism.
	Would an autocratic or participatory authority system be more effective?	• Seek assistance from colleagues when facing technical problems before resorting to external sources. • Employees freely share their knowledge and expertise with one another. • Lack of power struggles. • Lack of individual rewards. • Find intrinsic satisfaction and pride in being part of a collaborative team. • Success and achievements are viewed as collective accomplishments.	• Mutual interdependence is best suited to problem solving.	Cooperation.
The nature of human nature	In this organisation, how is human nature viewed; perfectible, immutable, good, neutral, or evil?	• Adopts a selective approach to BIM usage, where only specific individuals, such as Design Managers, are actively using BIM as part of the design process. • Express scepticism about the value of BIM and repeatedly question its purpose and benefits. • The motivation to use BIM is tied to personal advantages. • Prefer familiar methods for communication and planning, like using drawings and whiteboard markers over BIM.	• Employees are only driven by tangible benefits.	Evil, perfectible.
The nature of human activity	Is the group focused on doing, being, or becoming?	• Respond to immediate needs and challenges rather than taking proactive measures to address potential future requirements. • Maintain existing skills and capabilities rather than actively seek to upskill. • Training is done as needed basis. • Double the roles and responsibilities of existing personnel to support BIM projects. • Employees have the right to keep BIM out, if that was preference.	• The correct way to behave is being reactive, not proactive.	Being.

Organisational culture dimension	Questions need to be answered	Patterns of behaviours	Patterns of underlying beliefs	Underlying beliefs of CSD
The nature of reality and truth	How is truth determined? What is the source of truth, and how does it come to light? By tradition, wisdom, conflict and debate, pragmatic criteria, scientific method or social consensus?	• BIM on a particular project depend on the magnitude of the project • Assess the value of using BIM based on the cost-benefit analysis and the specific needs of each project. • Use other cost-effective alternatives.	• Decisions ought to be cost-based.	Scientific method.
The relationship of a group to its environment	How do the organisation and its members interact with the outside world, particularly the external market of the organisation's services? Is it a domination, submission, harmony?	• Exhibit hesitancy and scepticism towards the potential benefits of BIM. • Demand concrete evidence of advantages before using BIM. • Implement BIM primarily due to external demands from clients and Design Consultants. • Lack of internal initiative and strategy. • Consider BIM models as non-contractual documents, limiting their use for decision-making and construction purposes. • Reverts to traditional 2D drawings when BIM models lack information or completeness. • Upskills the employees only when external parties demand BIM usage.	• The best way to survive is to maintain the status quo unless forced otherwise.	Submission Client-dominance contract dominance.
The nature of time	Is the organisation’s basic orientation toward past, present and future? What does time mean to this organisation?	• Rely on existing conventional methods and prefer established approaches. • Reluctance to embrace new technologies. • Negative past experience with BIM. • Less convinced about BIM benefits. • Reliance on construction knowledge than BIM knowledge.	• The most effective solutions lie within proven traditional methods.	Past.

9.5 Summary

This chapter presented an in-depth within-case analysis of Organisation D, focusing on the extraction of underlying beliefs across six distinct cultural dimensions. These dimensions encompass the nature of human relationships, the nature of human nature, the nature of human activity, the nature of reality and truth, the relationship of a group to its environment, and the nature of time. Through a meticulous process of open and axial code analysis, behaviours and patterns of underlying beliefs were identified, subsequently leading to the extraction of specific underlying beliefs. CSD believed in autocracy of top management, groupism, individualism, cooperation, evilness, perfectibility, being, scientific methods, submission, client-dominance, contract dominance, and past.

CHAPTER 10- CROSS CASE ANALYSIS

10.1 Introduction

In the current chapter, the exploration initiated as within case analysis in Chapters 6-9 is broadened through the presentation of a cross-case analysis utilising evidence from all the cases. Initially, the focus is on scrutinising the underlying beliefs, patterns of underlying beliefs, and patterns of behaviours in each case together. This scrutiny aims to delineate the conditions that give rise to weak, moderate and strong innovative BIM cultures. Subsequently, a diagnostic tool is introduced, designed to dissect the innovative BIM culture in a spectrum of weak to strong. This tool was developed based on the underlying beliefs and patterns of underlying beliefs identified in the analysis. The subsequent sections of this chapter deduce strategies aimed at cultivating a strong innovative BIM culture. These strategies are formulated by considering the patterns of behaviours that were pinpointed through the cross-case analysis.

10.2 Diagnosing an innovative BIM culture

The similarities and differences of underlying beliefs evidenced through the patterns of underlying beliefs across the Cases A, B, C and D are summarised in Table 10.1. Upon reviewing the innovative culture theory, the underlying beliefs were analysed through the lens of the theory. Accordingly, the conditions for weak innovative BIM culture, moderate innovative BIM culture and strong innovative BIM culture found against each cultural dimension. Within each cultural dimension, the analysis answers the below cultural questions pertaining to innovative BIM culture:

- Would an autocratic or participatory authority system be more effective?
- Would it be more effective to structure society based on individualism or groupism?
- What is the ideal way for individuals to interact with one another?
- In this organisation, how is human nature viewed; perfectible, immutable, good, neutral, or evil?
- Is the group focused on doing, being, or becoming?
- What is the source of truth, and how does it come to light? By tradition, wisdom, conflict and debate, pragmatic criteria, scientific method or social consensus?
- How do the organisation and its members interact with the outside world, particularly the external market of the organisation's services?
- Is the organisation’s basic orientation toward past, present and future?

Table 10.1. Cross case analysis of underlying beliefs and patterns of underlying beliefs in innovative BIM culture

Cultural dimension	Questions need to be answered	Case	Conditions for weak innovative BIM culture	Conditions for moderate innovative BIM culture	Conditions for strong innovative BIM culture
The nature of human relationships. Best authority system.	Would an autocratic or participatory authority system be more effective?	A		**Autocracy** • Presence of a powerful leader is critical in a BIM setting. • Ultimate decision-making power resides with the authority positions.	
		B			**Participative** • Skills and expertise serve as sources of power. • Ultimate decision-making power resides with the authority positions.
		C	**Autocracy** • Ultimate decision-making power resides with the authority positions.		
		D	**Autocracy** • Ultimate decision-making power resides with the authority positions.		
The nature of human relationships. Best way to organise.	Would it be more effective to structure society based on individualism or groupism?	A			**Groupism** • Discussions gave results. • Organisation's interest prevails above any personal interests.
		B			**Groupism** • Having a sense of belonging is necessary. • BIM success is a collective responsibility.
		C			**Groupism** • Discussions gave results.
		D	**Individualism** • Training should cater the individual interests.		
The nature of human relationships. Best way to relate to each other.	What is the ideal way for individuals to interact with one another? Is life characterised by competition or cooperation?	A			**Cooperation** • Mutual interdependence is best suited to problem solving.
		B			**Cooperation** • Mutual interdependence is best suited to problem solving.
		C			**Cooperation** • Mutual interdependence is best suited to problem solving.
		D			**Cooperation** • Mutual interdependence is best suited to problem solving.
The nature of human nature.	In this organisation, how is human nature viewed; perfectible, immutable, good, neutral, or evil?	A			**Good, perfectible** • Employees are viewed as being inherently good. • Employees are viewed as being capable of governing themselves.
		B			**Good, perfectible** • Employees get motivated by appreciations. • Employees should be open for learning and continuous growth. • Employees could be perfectible through training.
		C	**Evil, perfectible** • Appreciations are not expected, but mistakes are highlighted. • Disagreements are normal and acceptable.		

		D	**Evil, perfectible** • Employees are only driven by tangible benefits.		
The nature of human activity. Best way to behave.	Is the group focused on doing, being, or becoming?	A			**Doing** • Being proactive in the BIM environment was the proper way to behave. • Quality delivery is the main priority.
		B		**Being-in-becoming** • Continuous improvement was deemed essential.	**Doing** • Being proactive in the BIM environment was the proper way to behave. • BIM is a tool for efficiency. • Quality delivery is the main priority.
		C	**Being** • The correct way to behave is being reactive, not proactive.		
		D	**Being** • The correct way to behave is being reactive, not proactive.		
The nature of reality and truth. Best way to determine truth.	How is truth determined? What is the source of truth, and how does it come to light? By tradition, wisdom, conflict and debate, pragmatic criteria, scientific method or social consensus?	A			**Pragmatic, Scientific method** • Problems should be approached and resolved pragmatically. • Objective testing is a source of truth.
		B		**Wisdom** • Experience, and expertise are critical in decision making.	**Pragmatic, Scientific method** • Truth is determined by trial and error. • Objective testing is a source of truth.
		C	**Moralistic** • Decisions ought to be cost-based.		
		D	**Moralistic** • Decisions ought to be cost-based.		
The relationship of a group to its environment. Best way to relate to the environment.	How do the organisation and its members interact with the outside world, particularly the external market of the organisation's services? Is it a domination, submission, harmony?	A			**Domination** • BIM use provides a competitive advantage. • Using BIM for visualisation is an effective way to persuade clients.
		B		**Harmony** • Collaboration with other stakeholders is a vital part.	**Domination** • Survival and growth lie within own control.
		C	**Submission** • The best way to survive is to maintain the status quo unless forced otherwise.		
		D	**Submission** • The best way to survive is to maintain the status quo unless forced otherwise.		
The nature of time. Best time orientation.	Is the organisation's basic orientation toward past, present and future? What does time mean to this organisation?	A		**Present** • People are motivated by the desire for instant gratification and immediate results.	
		B			**Future** • BIM success is a matter of long-term planning. • Learn from past projects and using that knowledge to inform their current and future endeavours.
		C	**Past** • Learning from past experiences is important.		
		D	**Past** • The most effective solutions lie within proven traditional methods.		

10.3 Underlying beliefs on nature of human relationships of an innovative BIM culture

Best authority system

Depending on who controls the BIM direction within the organisations, the cases showed variations on underlying belief about what is the best authority system suits to each case. From the cross-case analysis Case B provided evidence to support the best authority system for the strongest innovative BIM culture, which is the participative skill-centred authority system. The supporting beliefs contain skills and expertise serve as sources of power, and ultimate decision-making power resides with the authority positions. They believed that the digital team is best qualified to control the direction of BIM. Case A carried evidence for a moderate innovative BIM culture demonstrating a BIM leader-centred autocracy as the authority system. Here, the BIM manager possessed the authority to participate in decision-making alongside top management, and the rest of the BIM team lacked the ability to contribute to decision-making processes. Carrying evidence for a weak innovative BIM culture, Case C and D showed top management-centred autocracy. They upheld the notion that the top management should control the BIM direction of the organisation. The employees with BIM or IT skills in these cases were not given significant authority in decision-making. Instead, their role was limited to providing technical expertise when required for decision-making.

The skill-centred participative authority system is believed to be effective at identifying areas in need of BIM, as multiple perspectives are considered, and expertise is used. The emphasis on involving individuals who possess the necessary skills and experience allows to use tacit knowledge of experts to make informed decisions. In contrast, a top management-centred autocratic system carries the risks of overlooking problems and lacking effective communication. This is because decisions are made without widespread consultation, and as there is a clear chain of command the transfer of tacit knowledge of experts to decision making is limited. Figure 10.1 shows differentiating beliefs related to authority system of an innovative BIM culture in a continuum of weak to strong.

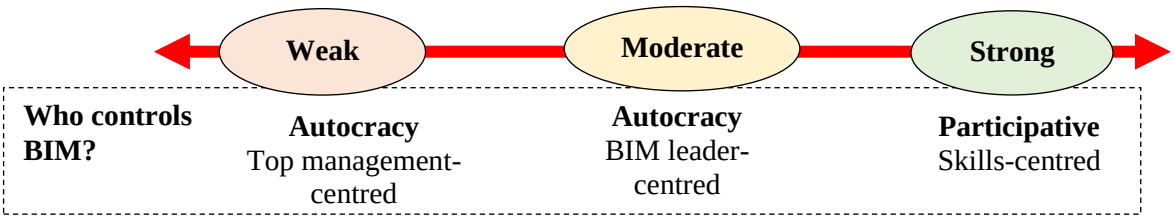

Figure 10.1. Differentiating beliefs related to authority systems in innovative BIM culture

Best way to organise

From the cross-case analysis, all the cases carried evidence to support the best way to organise creating a strong innovative BIM culture as the groupism, with a focus on organisational teams. Supporting patterns of underlying beliefs contain discussions that gave results; organisation's interest prevails above any personal interests; having a sense of belonging is necessary; and BIM success is a collective responsibility. Case D carried evidence for a weak innovative BIM culture demonstrating an individualistic approach to organise focusing on the employee level, emphasising on individual strengths, interests and roles.

When a BIM-enabled construction organisation underscores the importance of collaboration, shared goals and a strong sense of collective responsibility within organisational teams it strives to create a successful and innovative BIM culture. Therefore, when BIM is adopted in a group-oriented organisation, its implementation greatly improves as employees tend to withhold their dissent in favour of the overall well-being of the entire group. However, in a weak innovative BIM culture, organisations being employee focused raise a concern about potential diminishing of team cohesion due to excessive focus on individuality. In an individualistic organisation it is difficult to convince employees to accept BIM. Figure 10.2 presents differentiating beliefs of an innovative BIM culture in a continuum of weak to strong related to way of organising.

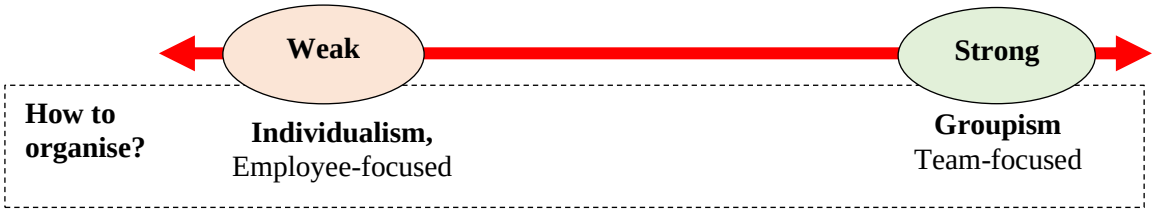

Figure 10.2. Differentiating beliefs related to way of organising of an innovative BIM culture

Best way to relate to each other

All the four cases provided evidence endorsing cooperation as the best way to relate to each other for cultivating a strong innovative BIM culture. These cases recognised the importance of working together to address challenges and the mutual reliance that contributes to such a culture. In a strong innovative BIM culture, people are mutually interdependent and actively working together, sharing knowledge and supporting one another to achieve common goals. This emphasis on sharing expertise, experiences and knowledge among team members allows them to seek ways to learn from each other and adapt to changes in technology and

methodologies. However, in a weak innovative BIM culture, which emphasise on competition as the best way to relate to each other, the willingness to share knowledge is hindered since it discourages collaboration among employees and create silos. Figure 10.3 summarises differentiating beliefs on how to relate to each other within an organisation with innovative BIM culture.

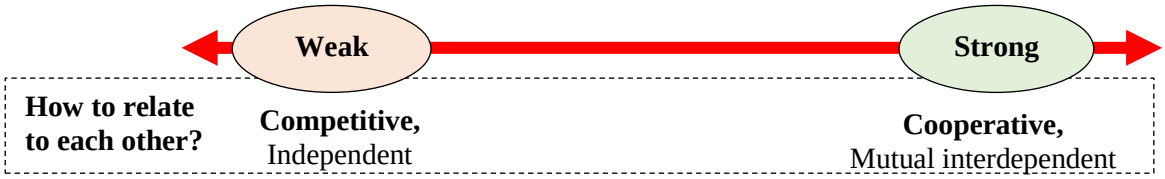

Figure 10.3. Differentiating beliefs on how to relate to each other of an innovative BIM culture

10.3.1 Underlying beliefs on nature of human nature of an innovative BIM culture

In Cases A and B, there were evidence endorsing that human nature is ultimately good and perfectible in a strong innovative BIM culture. They emphasise a high level of trust and giving autonomy to employees, and motivating employees through appreciations. In contrast, Cases C and D believed in nature of human nature as evil, which supported a weak innovative BIM culture. They had no practice of appreciating the use of BIM by employees and always expressed scepticism about the value of BIM and repeatedly questioning its purpose and benefits. Their BIM usage took a selective approach where people get motivated to use BIM based on the tangible benefits.

When a BIM-enabled construction organisation is cynical about human nature, it does not encourage BIM use and mistrusts its adoption by doubting its genuine purpose and inherent benefits. Therefore, in a weak innovative BIM culture, employees often prioritise their self-interests and their motivation to engage with BIM is primarily driven by individual gains. Conversely, in a strong innovative BIM culture, the organisation is optimistic and believes in the goodness of people, which ultimately encourage employees to use BIM and its benefits. Figure 10.4 shows differentiating beliefs on human nature of an innovative BIM culture in a continuum of weak to strong.

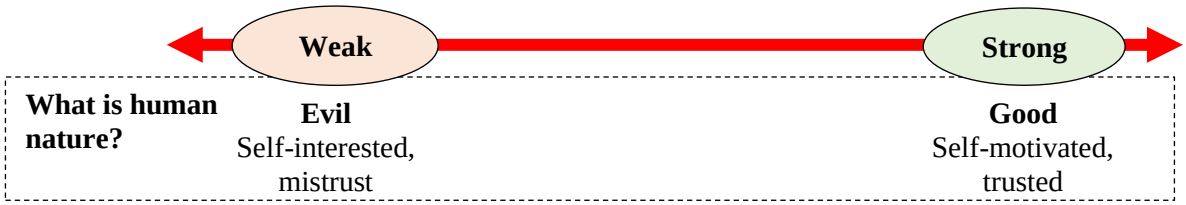

Figure 10.4. Differentiating beliefs on human nature of an innovative BIM culture

10.3.2 Underlying beliefs on nature of human activity of an innovative BIM culture

From the cross-case analysis, Cases A and B carried evidence to support the correct way to behave in strong innovative BIM culture, which is the doing orientation, emphasising a proactive quality and efficiency driven approach. Supporting beliefs contain being proactive in the BIM environment was the proper way to behave, BIM is a tool for efficiency, and quality delivery is the main priority. In addition, Case B showed their belief on 'being-in becoming' highlighting the value of continuous improvement, which supported a characteristic of a moderate innovative BIM culture. Carrying evidence to endorse a weak innovative BIM culture, Cases C and D exhibit a more reactive approach to BIM, with an underlying belief on being as the correct way to behave. Their decision to BIM use is primarily driven by client requirements and therefore, the cost of BIM is transferred to the client, with a limited investment in innovation.

When an organisation is reactive it is extremely challenging to promote BIM use as they try to avoid it if possible. Thus, there is a diminished use of BIM and lack of interest or engagement in proactive BIM training. A weak innovative BIM culture that leans heavily towards fatalism naturally fails to attract or retain innovators right from the outset. In contrast, a strong innovative BIM culture emphasising a proactive approach to BIM implementation recognises the importance of being ahead of the curve by improving quality and efficiency. In a moderate innovative BIM culture, employees adopt a balanced approach, aiming to reconcile and find common ground between their personal requirements and the external opportunities present in the environment through continuous improvement. Figure 10.5 presents differentiating beliefs on the correct way to behave in an innovative BIM culture in a continuum of weak to strong.

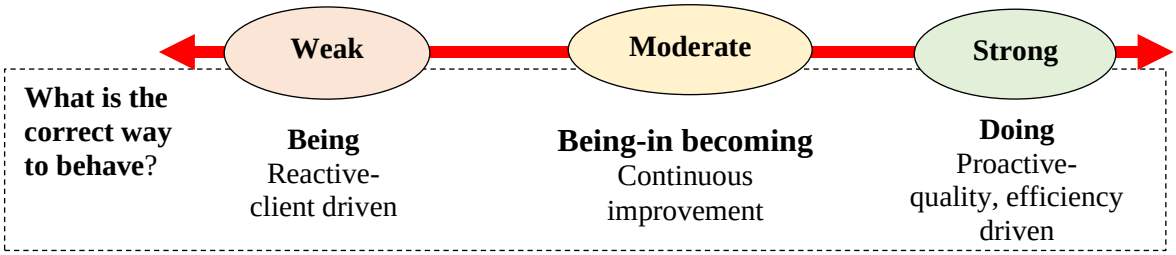

Figure 10.5. Differentiating beliefs on the correct way to behave in an innovative BIM culture

10.3.3 Underlying beliefs on the nature of reality and truth of an innovative BIM culture

From the cross-case analysis, Cases A and B provided substantiating evidence favouring the adoption of the pragmatic and scientific method as the best way to determine truth in a strong innovative BIM culture. The supporting beliefs contain truth is determined by trial and error,

and objective testing is a source of truth. Cases C and D also showcased evidence of a weaker innovative BIM culture demonstrating a cost-based approach to make decisions. Despite occasional instances of calculated decisions, these cases consistently adhered to the traditional dogma of selecting the most cost-effective solution, with decision-making solely reliant on cost justification.

A strong innovative BIM culture that prioritises pragmatism, provides a more favourable disposition towards embracing trial and error, taking risks and acknowledging both mistakes and unsuccessful attempts. In contrast, within a weaker innovative BIM culture, where adherence to dogmas, rules, systems and entrenched procedures is pronounced, the propensity for employees to undertake the necessary risks for successful BIM use diminishes. Such a weak innovative BIM culture, heavily influenced by moralistic principles, lacks the encouragement to challenge traditions and experiment with new approaches essential for effective BIM utilisation. In a moralistic BIM-enabled construction organisation, new efforts are pursued only when there is a high degree of certainty in their non-failure. Figure 10.6 demonstrates differentiating beliefs on how decisions are made and truth is determined in an innovative BIM culture in a continuum of weak to strong.

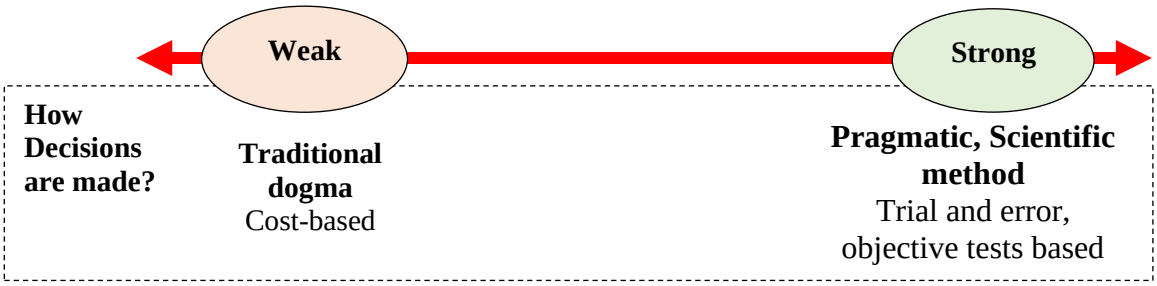

Figure 10.6. Differentiating beliefs on the best way to determine truth in an innovative BIM culture

10.3.4 Underlying beliefs on organisation's relationship to the environment of an innovative BIM culture

Cases A and B provided substantiating evidence favouring the organisational dominance as the correct way to relate to the environment in a strong innovative BIM culture. This is underscored by the beliefs BIM use provides a competitive advantage, using BIM for visualisation is an effective way to persuade clients, and survival and growth lie within own control. In addition, Case B showed their belief on harmonising highlighting the value of collaboration, which supported a characteristic of a moderate innovative BIM culture. They emphasise the need for working closely and collaboratively with clients and consultants to foster a collaborative environment. Carrying evidence to endorse a weak innovative BIM culture Cases C and D exhibit a submissive nature to the environment. They believed that

the best way to survive is to maintain the *status quo* unless forced otherwise. Thus, their BIM use is driven only by the client demands and contractual obligations.

In a weak innovative BIM culture, the organisation perceives that their very survival is beyond their control and it adopts a fatalistic stance and remain passive in the face of turbulent external conditions. Their approach is one of accepting whatever role or space the environment assigns them. Conversely, strong innovative BIM cultures share the belief that their actions can shape the environment they operate within. Their active domination over environment gives them the ability to gain competitive advantage to thrive and expand. Figure 10.5 presents differentiating beliefs on how to relate to the environment in an innovative BIM culture in a continuum of weak to strong.

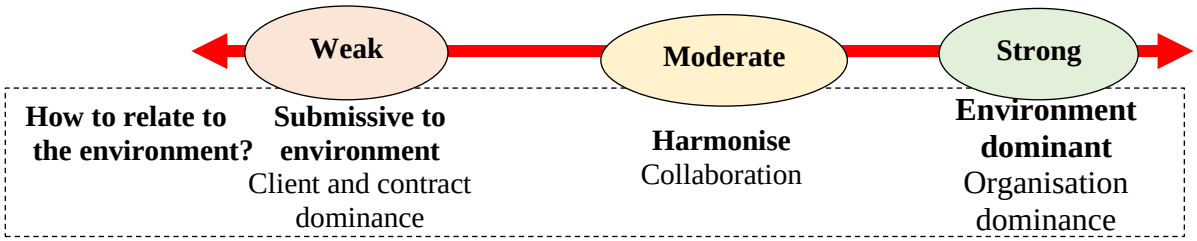

Figure 10.7. Differentiating beliefs on the best way to determine truth in an innovative BIM culture

10.3.5 Underlying beliefs on nature of time of an innovative BIM culture

Case B carried evidence to support that in a strong BIM culture the time orientation is on future, where they held the beliefs BIM success is a matter of long-term planning and previous BIM experience should shape the future. Supporting a moderate innovative BIM culture Case A supports present orientation having emphasise on immediate benefits of BIM. In weaker innovative BIM culture, Cases C and D prefer and rely on proven conventional methods with a reluctance embrace BIM.Organisations with weak and moderate innovative BIM cultures fixated to live in the past and struggle to appreciate the significance of BIM, as their attention is directed towards proven or existing approaches. If the BIM practices are not aligned with the preferred organisational practices, employees easily disregard the novel innovations offered by BIM. A strong innovative BIM culture favours a future orientation with an emphasis on long term planning.

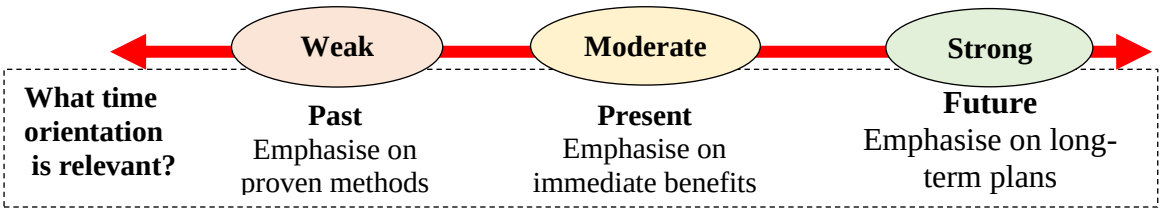

Figure 10.8. Differentiating beliefs on the best time orientation in an innovative BIM culture

10.3.6 Diagnostic tool for analysing innovative BIM culture

A novel innovative BIM culture diagnostic tool to determine underlying beliefs of BIM-enabled construction organisations was developed incorporating the insights from the cross-case analysis of Cases A, B, C and D presented in subsections 10.2.1 to 10.2.6. First, the dominant underlying belief corresponding to each cultural dimension were identified. These beliefs have then been positioned along a continuum ranging from a weak to strong innovative BIM culture as demonstrated in Figure 10.9. As innovative BIM culture often remains unnoticed and unquestioned, many members struggle to recognise or explain its dynamics. This is precisely where the diagnostic tool proves its significance. The tool serves to reveal underlying beliefs of a BIM culture that might elude detection or expression among employees. It delves into eight key elements that shed light on questions such as: who controls BIM? how to organise and relate one another in a BIM environment? what is human nature? how to make decisions and behave in a BIM setting and what time orientation is relevant? The questions correspond to the cultural dimensions *viz.*: human relationships; nature of human nature; nature of human activity; the nature of reality; organisation's interaction with the environment; and nature of time.

Within each of the cultural dimensions, distinct underlying beliefs were identified for both weak and strong innovative BIM culture. However, in certain instances, certain cultural dimensions exhibited underlying beliefs that did not neatly align with either extreme end of the continuum. Instead, they showcased elements from both weak and strong cultures. Consequently, these dimensions were situated in the middle of the continuum, representing a moderate culture. The innovative BIM culture within a construction organisation can vary widely and is not restricted to fixed positions on the continuum and might fall anywhere along the continuum, encompassing the entire spectrum from weak to strong. If a BIM-enabled construction organisation is positioned on the left side of the continuum with leaning towards a weak innovative BIM culture, it should transit towards the right side of the continuum with strong innovative BIM culture. This transition necessitates the development of well-planned strategies.

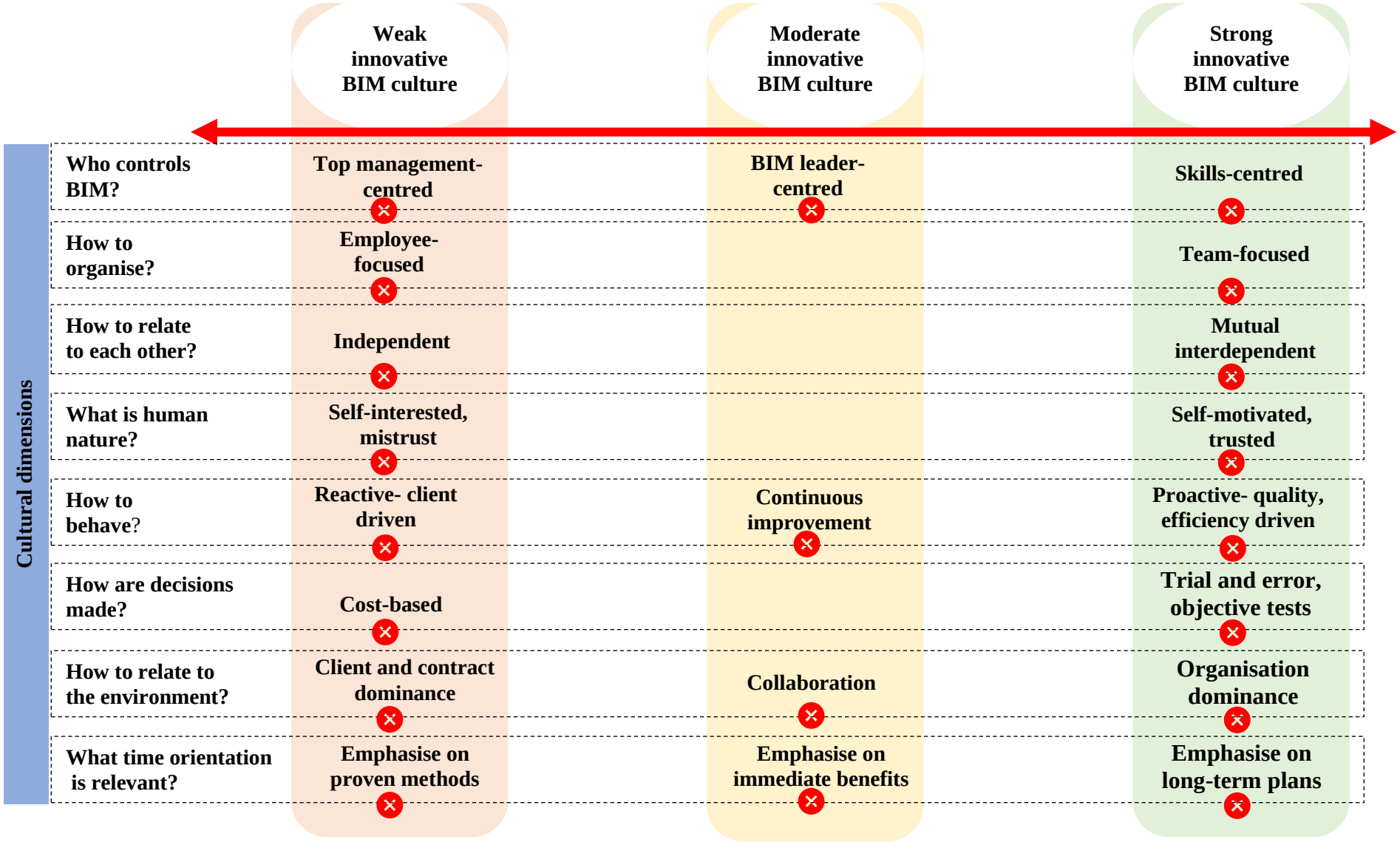

Figure 10.9. Diagnostic tool for analysing any given innovative BIM culture

10.4 Strategies towards a strong innovative BIM culture

With the innovative BIM culture diagnosis, construction organisations utilising BIM can discern where they stand on the continuum. Some organisations may find themselves on the weaker end of the continuum and aspire to progress toward the stronger end. Achieving this transformation requires carefully crafted strategies that bolster a strong innovative BIM culture while diminishing weaker aspects. Therefore, organisations must pinpoint what areas to strengthen and what areas to eliminate. The behaviours highlighted in the cross-case analysis served as the foundation for devising strategies that guide BIM-enabled construction organisations in their journey towards cultivating a strong innovative BIM culture (for a comprehensive list of identified behaviours, refer to Appendix 2.). Accordingly, the strategies for enhancing a strong innovative BIM culture were formulated by drawing inspiration from the positive behaviours observed within it. Simultaneously, strategies were suggested to eliminate unfavourable behaviours in a weak innovative BIM culture.

For referencing purposes, a coding system was established to denote each pattern of behaviours in each individual case. The assigned notations are as follows:

- POB: Patterns of behaviours; and
- Cases A, B, C, D.

For instance, if the code "A.POB1" is provided within the cross-case analysis, it refers to the first pattern of behaviour in Case A. Further, for each cultural dimension, *viz.* human relationships; nature of human nature; nature of human activity; the nature of reality; organisation’s interaction with the environment; and nature of time separate tables were prepared and attached as Annex 2 as listed below.

- Appendix 2(A): Cross case analysis of patterns of behaviours, patterns of underlying beliefs and underlying beliefs on nature of human relationships.
- Appendix 2(B): Cross case analysis of patterns of behaviours, patterns of underlying beliefs and underlying beliefs on nature of human nature.
- Appendix 2(C): Cross case analysis of patterns of behaviours, patterns of underlying beliefs and underlying beliefs on nature of human activity.
- Appendix 2(D): Cross case analysis of patterns of behaviours, patterns of underlying beliefs and underlying beliefs on nature of reality and truth.
- Appendix 2(E): Cross case analysis of patterns of behaviours, patterns of underlying beliefs and underlying beliefs on organisation’s relationship to the environment.
- Appendix 2(F): Cross case analysis of patterns of behaviours, patterns of underlying beliefs and underlying beliefs on nature of time.

In the subsequent subsections of this chapter, references will be made to specific appendices where cross-case evidence for each cultural dimension can be found. For example, *10.3.1 who controls BIM,* the reference points to **Appendix (2A). Best authority system.** Where this section refers to a particular behaviour as A.POB1, it implies that the reference pertains to the first behaviour within Case A, located in Appendix 2(A) within the section related to the best authority system.

A.POB1= *1.Centralise decision-making authority with the BIM manager*.

After coding the behaviours found in all cases accordingly, they were synthesised together to deducing strategies promote strong innovative BIM culture. For example, Table 10.2 shows how the strategy *Give BIM team the control over BIM direction, allowing them to take ownership and accountability for its success* [(B.POB1-5), (C.POB7-10), (D.POB4-7)] was derived based on the behaviours found in cases.

Table 10.2. Example of strategy development based on patterns of behaviours

Code	Patterns of behaviours considered to develop the strategy
(B.POB1-5)	1. Top-down approach to decision-making 2. Top management has BIM knowledge 3. Delegation of decision-making power to the digital team 4. Digital team controls BIM direction 5. Seek consultation and input from digital engineering team during decision-making
(C.POB7-10)	7. BIM team possesses the skills yet lacks the power 8. BIM team provide background information needed for decision making 9. BIM is not integrated in organisational strategy 10. BIM team remains in the role of supporters
(D.POB4-7)	4. IT department possesses the skills yet lacks the power 5. Seek input from experts and employees when necessary 6. No BIM specialised team 7. Decision-making focuses on evaluating software capabilities, cost, and ease of use

10.4.1 Nature of human relationships: who controls BIM?

To promote a strong innovative BIM culture, the BIM-enabled construction organisations should be operated in a participative authority system, as opposed to maintaining an autocratic authority system. Thus, BIM direction is controlled by those with BIM skills, particularly the BIM team. To build a strong innovative BIM culture behaviours promoting the skill-centred authority system should be introduced and strengthen. This can be accomplished through the following strategies related to empowerment of BIM team (for cross-case analysis of identified behaviours, refer to Appendix 2 (A). Best authority system).

Empowerment of BIM Team

- Give BIM team the control over BIM direction, allowing them to take ownership and accountability for its success [(B.POB1-5), (C.POB7-10), (D.POB4-7)].
- Involve the BIM team in decision-making processes to ensure that their expertise is considered, leading to more effective and relevant choices [(B.POB10), (C.POB10-12)].
- Actively seeking individuals with BIM knowledge during recruitment to ensure that the organisation continues to bring in fresh talent that aligns with its BIM culture (B.POB9).
- Create a clear career path from technical roles to leadership positions to encourage individuals with BIM expertise to stay within the organisation and contribute to its growth (B.POB6-8).
- Eliminate the centralised decision making, where top management makes all the decisions about BIM without having a proper knowledge on BIM and its implications [(A.POB1-14), (C.POB1-6) and (D.POB1-3)].

10.4.2 Nature of human relationships: how to organise?

In a strong innovative BIM culture, an ideal way to organise is in teams and an organisation with such culture promotes teamwork and participation. Therefore, the organisation should eliminate any employee focused approaches that could potentially disrupt the collective focus of the team. This can be accomplished through the following strategies related sense of belonging and open and candid communication (for cross-case analysis of identified behaviours, refer to Appendix 2 (A). Best way to organise).

Sense of belonging

- Ensure the company's BIM mission is communicated and understood by all employees (B.POB1).
- Help employees grasp how their work contributes to larger company objectives (B.POB4).
- Emphasise that the organisation's goals and interests take precedence over personal agendas, promoting a collaborative and unified approach (A.POB4).
- Eliminate individualistic approaches such as ad hoc learning and training (D.POB1-6)

Open and candid communication

- Encourage meaningful and outcome-driven discussions, where decisions are made based on thorough deliberation and analysis [(A.POB1-7), (C.POB3-9)].

- Encourage clear and structured communication, especially in formal settings, to ensure effective information dissemination and understanding [(A.POB1-7), (B.POB6), (C.POB3-9)].
- Cultivate an environment where employees feel comfortable and empowered to raise their concerns and ideas during meetings [(A.POB2), (B.POB2-5), (C.POB1-2)].
- Encourage the sharing of practical insights and lessons learned [(B.POB1-5), (C.POB7-10)].
- Create an environment, where informal discussions such as brainstorming and idea sharing are welcomed [(A.POB3), (B.POB6), (C.POB5-6)].

10.4.3 Nature of human relationships: how to relate to each other?

Being cooperative and interdependent on one another to face challenges promotes a strong innovative BIM culture. Therefore, employees should refrain from being competitive with each other to build a strong BIM culture. This can be accomplished through the following strategies related to mutual support and learning; technical support; feedback loop and shared success; and effective task allocation (for cross-case analysis of identified behaviours, refer to Appendix 2 (A). Best way to relate to each other).

Mutual support and learning

- Encourage employees to mentor each other and offer assistance when needed [(A.POB1), (B.POB1-4), (C.POB5-6), (D.POB5-6)].
- Create an environment, where seeking help from colleagues, regardless of seniority, is encouraged and normalised (B.POB3).

Technical support

- Ensure that team members know how to reach out to the BIM team for support, whether through designated email addresses or communication platforms (B.POB6), (C.POB2-4).
- Seek guidance from external contacts, such as industry experts or partners, to bring fresh insights and best practices to the organisation(C.POB6).

Feedback loop and shared success

- Implement a structured feedback loop where employees can share their experiences, challenges, and suggestions for improvement [(A.POB4-7), (B.POB8-9), (C.POB10-12)]
- Encourage open feedback and constructive criticism among team members to promote a culture of improvement [(A.POB4-7), (B.POB8-9), (C.POB10-12)].

- Share success stories and testimonials that showcase how BIM has enhanced connectivity and collaboration within the team [(A.POB2-5), (B.POB7), (C.POB11), (D.POB6)].

Effective task allocation

- Ensure that project workloads are distributed fairly among team members to prevent burnout and maintain a healthy work environment [(B.POB1-4), (C.POB5-6), (D.POB5-6)].
- Assign tasks based on individuals' strengths and skills to ensure that projects are tackled with the right expertise maximising efficiency [(B.POB4-6), (C.POB1-7), (D.POB1-3)].

10.4.4 Nature of human nature: what is human nature?

In a strong innovative BIM culture, there is an underlying belief in the inherent goodness of employees. They are regarded as capable of self-governance and are entrusted with their responsibilities. There is a high level of trust in their ability to perform the tasks effectively, and they are naturally inclined to proactively engage with BIM. Conversely, in a weak innovative BIM culture, employees are seen as driven by self-interest and therefore mistrusted and lack autonomy. Therefore, the following strategies related to autonomy; appreciations, celebrations and learning from mistakes; and training and education should be implemented to strengthen behaviours that foster a strong innovative BIM culture and to eliminate behaviours that contribute to a weaker culture (for cross-case analysis of identified behaviours, refer to Appendix 2 (B)).

Autonomy

- Empower self-motivated staff members to enhance their sense of ownership and to encourage them to drive their own growth [(A.POB1-3,6-7), (B.POB4-9), (C.POB8), (D.POB1)].
- Foster a supportive learning environment to encourage employees to seek knowledge without fear of judgment [(A.POB4), (B.POB10-15)].

Appreciations, celebrations and learning from mistakes

- View mistakes as learning opportunities that encourage employees to take calculated risks and innovate[(A.POB5,8), (B.POB8), (C.POB1-3)].
- Promote verbal appreciations reinforce positive behaviour and contributions, boosting morale and motivation [(B.POB1-4), (C.POB5-8), (D.POB2-3)].
- Celebrate innovative ideas and contributions to encourage a culture of creativity and continuous improvement [(B.POB3), (C.POB4)].

Training and education

- Tailor training to the needs of different teams and provide in-house training and access to external resources to diversify learning options and promotes skill growth [(A.POB4), (B.POB12-13), (D.POB4)].

10.4.5 Nature of human activity: how to behave?

The prominent way to behave in a strong innovative culture takes a proactive approach, which revolves around a commitment to enhancing quality and efficiency. In contrast, a weaker BIM culture tends to rely solely on client demands, leading to a more reactive stance. It becomes imperative to adopt the following strategies related to strategic investment; collaboration and communication; sharing lessons learned; training and education to strengthen behaviours that foster a strong innovative BIM culture and to eliminate behaviours that contribute to a weaker culture (for cross-case analysis of identified behaviours, refer to Appendix 2 (C)).

Strategic investment

- Move away from making decisions solely based on client requirements and prioritise internal strategic planning to drive initiatives [(A.POB1-3), (B.POB1,5), (C.POB1-2), (D.POB1)].
- Refrain from focusing solely on short-term needs and prioritise long-term strategic investments to maximise benefits over time [(B.POB9-11), (C.POB4)].
- Overcome limited investment in innovation by allocating more resources to research and development of BIM-related technologies [(A.POB4), (B.POB1), (C.POB4)].
- Align BIM objectives with the organisation's goals such as quality and efficiency [(A.POB6-11)].
- Ensure that top management is fully committed to BIM adoption and understands its benefits for quality and efficiency improvement [(A.POB1-5), (B.POB1-5)].

Collaboration and Communication

- Maintain regular communication with software vendors to stay updated on industry trends and updates [(B.POB15), (C.POB5-6)].
- Use BIM as a centralised platform to link information, enabling better communication and coordination among different stakeholders (B.POB15).
- Leverage BIM to exceed client requirements and expectations, showcasing the value of quality and efficiency enhancements [(A.POB5-11), (B.POB10-11), (C.POB5-6)].

Sharing lessons learned

- Actively share valuable insights and lessons learned through the use of relevant case studies [(B.POB16), (C.POB9-11)]

Training and education

- Support employees by granting access to various learning platforms like LinkedIn Learning [(B.POB12-14), (C.POB5)].
- Set aside specific hours within daily or weekly tasks for focused learning activities [(B.POB17-18), (C.POB6), (D.POB4-5)].
- Arrange training sessions, webinars, and industry-wide meetings to enrich employees' knowledge [(B.POB19), (C.POB5- 8), (D.POB3)].
- Eliminate the practice of maintaining existing skills by investing in regular upskilling programs to enhance employee capabilities (B.POB19), (C.POB5- 8), (D.POB2-3)]

10.4.6 Nature of reality and truth: how are decisions made?

In a strong innovative BIM culture decisions are grounded in pragmatic scientific methods, promoting the use of objective tests, and trial and error. Conversely, in a weak BIM culture, decisions consistently lean towards prioritising cost justification. Such cultures select BIM vendors solely based on cost, discontinue use of technologies when there are no immediate financial gains, and over emphasis on cost-effective alternatives. Therefore, the following strategies related to trial and error; training and education; technical support; and data-driven decision making should be enacted to strengthen behaviours that foster a strong innovative BIM culture and to eliminate behaviours that contribute to a weaker culture (for cross-case analysis of identified behaviours, refer to Appendix 2 (D)).

Trial and error

- Utilise small case projects as testing grounds for new methods before applying them to larger projects, ensuring successful integration [(A.POB3-13), (B.POB2-3), (C.POB2), (D.POB2)].
- Conduct case studies and gather feedback from various stakeholders to refine BIM approaches based on real-world experiences [(A.POB3-13), (B.POB2-3), (C.POB2), (D.POB2)].

Training and education

- Use questionnaires to assess current employee proficiency levels in BIM, enabling tailored training solutions [(A.POB1-13), (B.POB1-11)].
- Prioritise practical and job-relevant training that directly enhances employees' work tasks and productivity [(A.POB1-13), (B.POB1-11)].

- Incorporate ongoing feedback and improvement in training based on employee inquiries and suggestions [(A.POB1-13), (B.POB1-11)].

Technical support

- Rely on readily accessible technical support (Ex: Help desks, BIM team) and resources to address challenges effectively [(A.POB-5), (B.POB8-10)].

Data-driven decision making

- Utilise IT-based systems to extract and evaluate data, including BIM 360, for project-based assessments [(A.POB10-13), (C.POB1-6), (D.POB1-3)].
- Adopt data mining and reporting methods such as Power BI to gain deeper insights into project performance [(A.POB10-13), (B.POB1-5)]
- Implement dashboards to extract specific metrics and analyse real-time progress toward objectives [(A.POB10-13), (C.POB1-6), (D.POB1-3)].

10.4.7 Relationship to environment: how to relate to the environment?

In a strong innovative BIM culture, the preferred approach for interacting with the organisational environment is marked by a sense of dominance. Conversely, within a weak innovative BIM culture organisations find themselves controlled by clients and contracts, leading to a submissive stance towards the environment. To transition towards a stronger culture, an organisation must encourage dominating behaviours while discouraging submissive ones. The ensuing strategies related to marketing and client engagement; strategic integration and leadership; and team development and expertise can be employed to facilitate this transition (for cross-case analysis of identified behaviours, refer to Appendix 2 (E)).

Marketing and client engagement

- Leverage BIM as a tool to demonstrate the technological prowess to clients, giving a competitive edge in winning projects [(A.POB1), (B.POB5), (C.POB1-4), (D.POB2-3)].
- Promote adoption of BIM as a key marketing strategy in company website, public platforms [(A.POB4), (B.POB5), (C.POB1-4), (D.POB2-3)].
- Foster collaborative relationships with clients and consultants to ensure clear communication and alignment throughout the project [(A.POB6), (B.POB6-10), (C.POB1-4), (D.POB3)].

Strategic integration and leadership

- Establish a clear and comprehensive strategic BIM mission and objectives, aligning them with the company's overall goals and aspirations [(A.POB4), (B.POB1), (C.POB8), (D.POB4)].
- Take an active leadership role in BIM coordination meetings to ensure effective communication, collaboration, and problem-solving among stakeholders [(A.POB2), (B.POB3-5), (C.POB1-4), (D.POB1-2)].
- Maintain control over the decision-making process at the construction project level by utilising BIM data and insights to make informed choices [(A.POB3), (B.POB5).
- Commit to continuous progress and improvement by consistently evaluating BIM practices, refining strategies, and enhancing capabilities (C.POB7-8), (D.POB5-7).

Team development and expertise

- Modify the recruitment strategy to attract and onboard individuals with deep expertise in BIM, bolstering the team's capabilities (B.POB2).

10.4.8 Nature of time: what time orientation is relevant?

To promote a strong innovative BIM culture, the BIM-enabled construction organisations should adopt a future-oriented perspective. This entails prioritising long-term planning and advantages over fixating on established traditional approaches and immediate present gains. Consequently, the strategies aimed at fostering a strong BIM culture should concentrate on eradicating behaviours rooted in past orientations while enhancing those aligned with a future-oriented mindset (for cross-case analysis of identified behaviours, refer to Appendix 2 (F)). These strategies are related to clear guidelines, plans, and protocols; well-defined responsibilities and roles; and technology integration.

Clear guidelines, plans, and protocols

- Actively develop comprehensive guidelines, plans, and protocols for digital engineering and BIM implementation [(A.POB1-3), (B.POB1-4), (C.POB1-3), (D.POB1-5)].
- Ensure BIM guidelines, plans, and protocols documents are readily accessible and regularly updated to reflect the latest industry standards and internal best practices [(A.POB1-3), (B.POB1-4), (C.POB1-3), (D.POB1-5)].
- Eliminate the exclusive focus on short-term needs and immediate client demands, as it may hinder long-term strategic planning and development [(A.POB1-3), (B.POB1-4), (C.POB1-3), (D.POB1-5)].

Well-defined responsibilities and roles

- Clearly define roles and responsibilities within digital engineering and BIM teams to avoid confusion and ensure efficient task allocation [(A.POB1-3), (B.POB1-4), (C.POB1-3), (D.POB1-5)].

Technology integration

- Eliminate the practice of reverting to traditional methods when BIM lacks information or completeness, preventing the full integration of technology [(C.POB1-3), (D.POB1-5)].

10.5 Framework to manage construction organisations towards a strong innovative BIM culture

This section presents the framework developed to manage construction organisations towards a strong innovative BIM culture as indicated in Figure 10.10. The framework is composed of four main components. The initial part labelled as organisational BIM culture manifestations, which represent identifying the existing organisational BIM culture. The second part of the framework illustrates the use of innovative BIM culture diagnostic tool. The third part of the framework outlines the strategies designed to cultivate a strong innovative BIM culture. Lastly, underlying beliefs that can be found in a strong BIM culture are presented in fourth part. Figure 10.10 shows how to read the framework and more detailed explanations of each of these segments follow in the subsequent paragraphs.

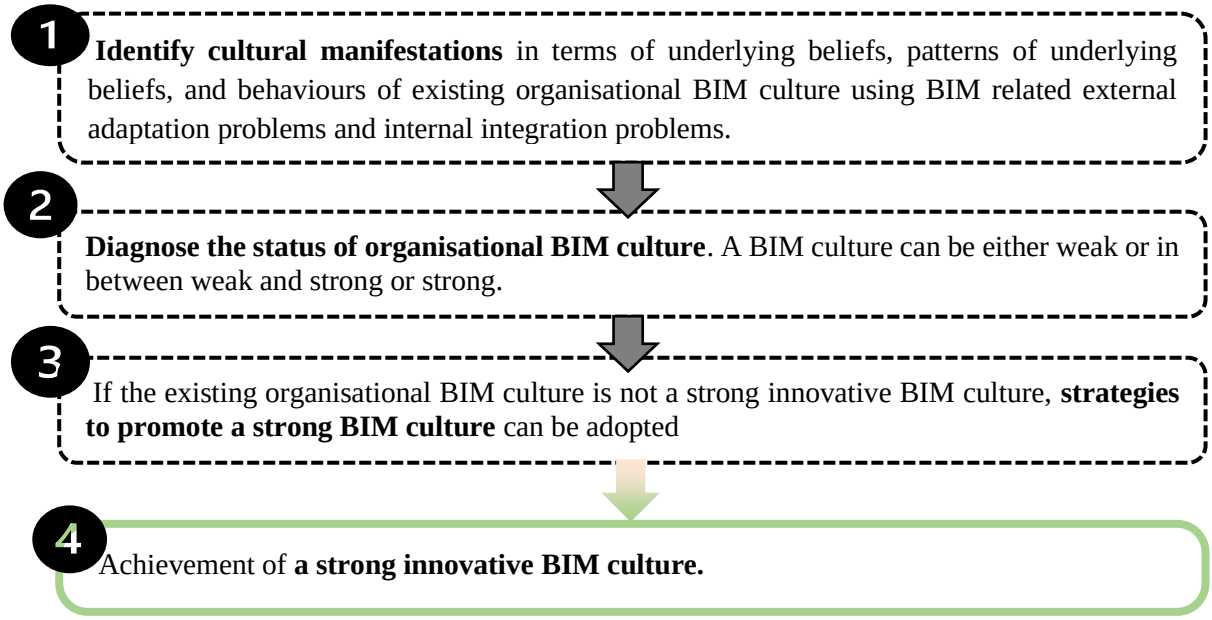

Figure 10.10. Guide to read the framework

In the process to manage construction organisations towards a strong innovative BIM culture begins by initially uncovering the organisation's existing BIM culture. The organisational BIM culture becomes apparent through the cultural manifestations in terms of underlying beliefs, patterns of underlying beliefs and behaviours. However, delving into these underlying beliefs and their patterns can be challenging due to their deep-seated and concealed nature. To address this, the study introduced a methodology to extract cultural manifestations from BIM-enabled construction organisations by indirectly questioning BIM-related problems in external adaptation and internal integration. For a comprehensive understanding of this methodology, refer to sub section 2.3 and Chapter 3. The interview guideline attached in the Appendix 1(B) provides a list of possible questions that can be employed for this purpose. Once the responses to the external adaptation and internal integration problems are collected from the employees, these responses should be analysed to derive underlying beliefs, patterns of underlying beliefs and behaviours. The process for achieving this is elucidated in the within-case analysis presented in Chapters 6 to 9. To facilitate this analysis, the coding process outlined in Figure 5.2 can be applied. Through this systematic approach, the cultural manifestations of the existing organisational BIM culture can be found in terms of underlying beliefs, patterns of underlying beliefs and behaviours.

After extracting the underlying beliefs and patterns of underlying beliefs that define the existing organisational BIM culture, the innovative BIM culture diagnostic tool can be employed to determine the position of the existing BIM culture on the spectrum ranging from weak to strong, as illustrated in the second part of the framework. An innovative BIM culture can be either weak or in between weak and strong or strong. If the organisational BIM culture is situated towards the weaker end of this continuum, the strategies detailed in third part of the framework can be implemented to foster a strong innovative BIM culture. These strategies are expounded upon in greater detail in section 10.3. They encompass a set of behaviours that need to be rectified or strengthened, contingent upon the current state of the organisational BIM culture. By addressing these behaviours, the aim is to facilitate the shift of the existing BIM culture from its weaker position on the continuum to a strong innovative orientation.

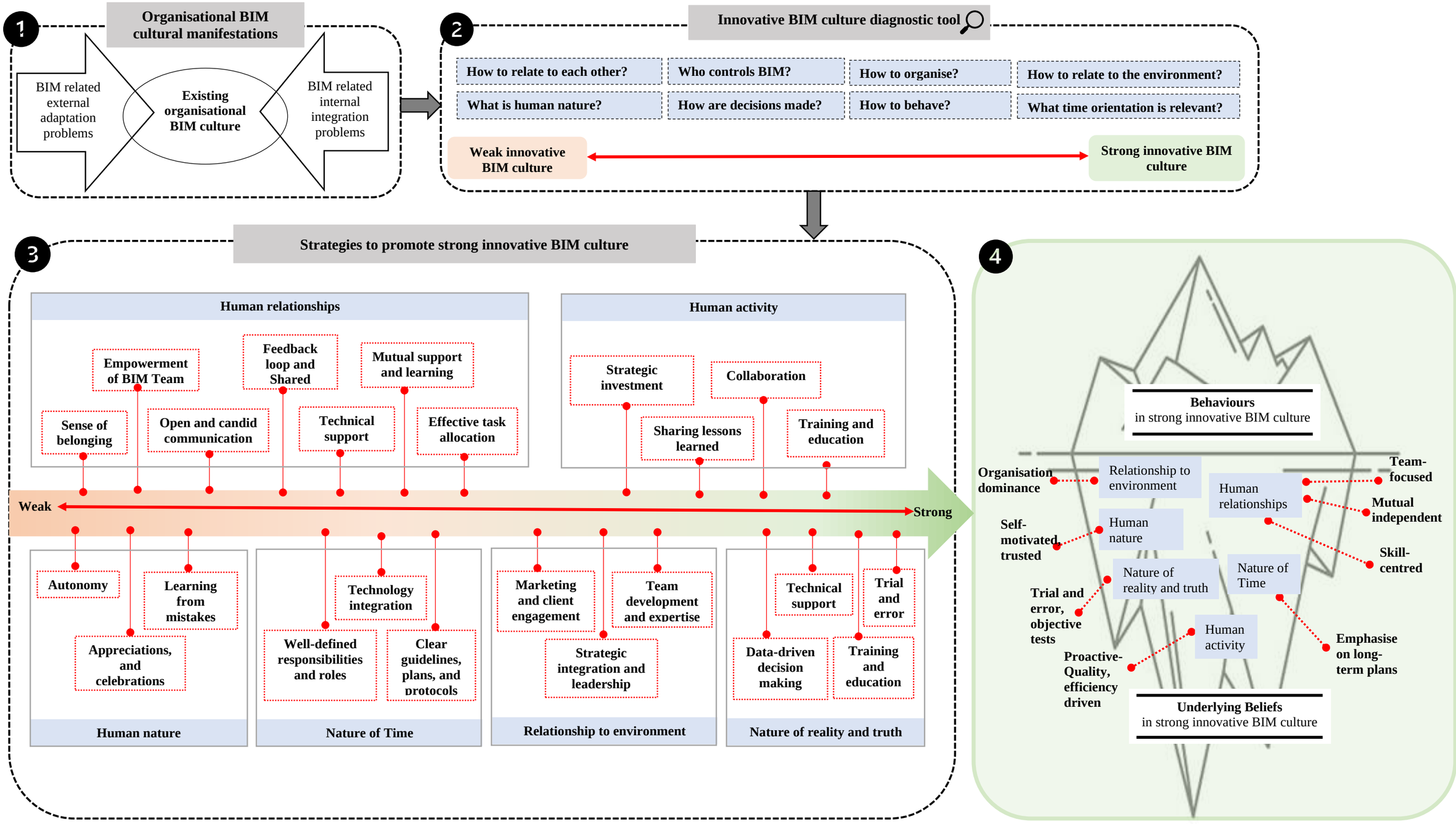

Figure 10.11. A framework to manage construction organisations towards a strong innovative BIM culture

10.6 Summary

This chapter encompassed a comprehensive analysis across Case A, B, C, and D. The analysis delved into the identifying underlying beliefs and their patterns within innovative BIM cultures. These findings were then analysed through the lens of Schein's theory on innovative culture, leading to the identification of varying sets of underlying beliefs characterising innovative BIM cultures along a spectrum. This outlined that an innovative BIM culture could be classified as weak, somewhere between weak and robust, or strong. Utilising these distinctions, a tool was formulated to diagnose the status of innovative BIM cultures within construction organisations. Moreover, a subsequent in-depth investigation was conducted into the behaviours manifested within each culture, from which corresponding strategies were derived for each cultural dimension. Ultimately, this process culminated in the development of a framework designed to manage construction organisations toward cultivating a strong innovative BIM culture.

CHAPTER 11: FRAMEWORK VALIDATION AND DISCUSSION

11.1 Introduction

In the preceding chapter, an analysis was conducted involving multiple cases, namely Cases A, B, C and D. This cross-case analysis led to the formulation of a framework intended to effectively guide construction organisations in nurturing a strong innovative BIM culture. The initial segment of this current chapter focuses on the validation and refinement of the proposed framework as presented in Figure 10.11 using expert interviews with four BIM professionals. The subsequent segment of the chapter delves into a comprehensive discussion of the results outlined in Chapter 10, drawing connections to the existing body of relevant literature.

11.2 Framework validation and refinement

To ensure the comprehensiveness, significance, and coherence of a framework it is necessary to validate a framework (Bendak et al. 2020). The validation of the proposed framework further completes the final objective of this study. Validation of the proposed framework further completes the final objective of this study. This section presents the expert interview approach that was used to validate the framework. Similar approaches can be found in the studies by Bendak et al. (2020), Dao, Chen and Nguyen (2020) and Gunatilake (2013) and justify the approach adopted in this present study. A total of six professionals, including those who had previously taken part, were extended invitations to partake in the validation interviews. In this study, the advantages of familiarity are considered more significant than the potential bias that could arise due to the participants' engagement. Ultimately, four professionals expressed their agreement to participate. All the experts were construction professionals involved in BIM for between two or more years and were selected from managerial level (2) and operational level (2). Their profiles are presented in Table 11.1. Semi-structured interviews were conducted face-to-face with each interview lasting between 30 - 60 minutes. Before the interviews, participants were provided with a document detailing the developed framework along with its constituent elements, accompanied by innovative BIM culture diagnostic tool and the list of strategies to promote an innovative BIM culture. Real-time notes were taken of the responses given by the interviewees and the conversations were recorded. At the onset of the interviews, interviewees were guided through the developed framework. The provided document, along with its accompanying figures, offered supplementary support during this explanation process.

Table 11.1. Interviewee profile of the BIM experts

BIM Expert	Description
BE1	BIM manager with 11 years of BIM experience, and 11 years of industry experience.
BE2	VDC coordinator 11 years of BIM experience, and 35 years of industry experience.
BE3	Construction coordinator 3 years of BIM experience, and 5 years of industry experience.
BE4	Senior project coordinator services and BIM 5 years of BIM experience, and 24 years of industry experience.

The questions were aimed to validate the framework for its completeness and practical suitability to use in BIM-enabled construction organisations. In this context, the term validation does not adopt a positivist stance, meaning the pursuit of an ultimate truth through language that represents an unchanging social reality (Seale 1999). Instead, the term is employed to encompass specific criteria for evaluating the quality of qualitative research outcomes as delineated by (Strauss & Corbin 1990). The criteria included fit, applicability, logic and depth. The criteria fit was to create the resonance ensuring that the findings are aligned with the experiences of the professionals for whom they are intended. Applicability establishes the practical utility of the findings. The criteria logic confirms the coherent progression of ideas and addressing any notable gaps in logical reasoning, while the criteria depth ensures that the findings possess substantial and meaningful content (*ibid*). The development of interview questions to validate the framework aligns with the previous studies of Rathnayake (2021) and Gunatilake (2013). The questions asked during the interviews are summarised in Table 11.2.

Table 11.2. Summary of expert interview questions for framework validation

	Main question	Criteria covered
1.	What do you think about the clarity and the structure of the framework (understandable)? • Title, general outlook • Flow and sequence • language	Logic and fit
2.	What do you think about level of applicability and completeness of the contents of the framework? • Overall • Section 1- Organisational BIM cultural manifestations • Section 2- Innovative BIM culture diagnostic tool • Section 3- strategies to promote strong innovative BIM culture • Section 4- Strong innovative BIM culture	Applicability and depth
3.	Do you have any additional thoughts or recommendations for framework? • Improvements, inclusions, deletions	Depth and fit
4.	Would you recommend the framework for use by BIM-enabled construction organisations?	Applicability and fit

11.3 Results of the validation interviews

During the interviews experts were asked to consider the validity of individual components as well as the overall framework. The collective response was affirmative, with all interviewees agreeing that the developed framework, including its components, was indeed valid. The interviewees were in consensus that the framework is well-structured and clear, and they found its flow and logic to be easily understandable, signifying a strong logical foundation. They all agreed that the framework is suitable for practice. As constructive feedback, BE2 stated that incorporating a purpose statement would assist when the framework is practically used in a company. Nonetheless, their responses revealed the need for some additional information to enhance the framework and its constituent elements. These include:

Section 1- Organisational BIM cultural manifestations: All participants agreed that it is necessary to identify the existing organisational BIM culture before achieving the desired innovative BIM culture. They all agreed that the interview guideline used in the current study in first place is suitable to find the organisational BIM culture. They believe that the interview questions are well-designed and comprehensive. Some of the indicative comments from experts were:

> *" I reckon you have got very good questions, if you got to answer to those questions, you have got all covered, you are going to get lot of information."* (BE1)
>
> *"As soon as you enter any discussion on BIM or digital strategy, you find that people present their aspirational goals rather than reality, you know, it would always what we would like to be doing, it is not BIM reality it never what is across there whole organisation, so it is good you do not ask judgemental questions, So, how and the why sort of questions are probably good ones."* (BE2)
>
> *"I come up with extra questions, and when I go back and read it, you have got them already."* (BE3)

Section 2- Innovative BIM culture diagnostic tool: All the interviewees agree that this tool is very interesting and makes sense how the different conditions caused different cultural orientations. They agreed that all the cultural dimensions and differentiating beliefs are applicable. BE2 identified a need for clarification with respect to 'how to relate to the environment'. The interviewee asked the rationale behind placing collaboration and organisational dominance in these positions.

Section 3- Strategies to promote strong innovative BIM culture: All the interviewees agreed that strategies developed are applicable in real life context, where all of them emphasised that they currently use some of the given strategies. During the interviews strategies were discussed one-by-one, and there were suggestions from the interviews to change the wordings of the strategies to improve the meaning. For instance, BE1 commented on the strategy *ensure that top management is fully committed to BIM adoption and understands its benefits for quality and efficiency improvement*. A change of order of words was requested to rephrase it as *ensure that top management understands benefits for quality and efficiency improvement to enhance their full commitment*. BE1 contended that instead of emphasising the need to ensure the top management's commitment, it is more practical to demonstrate the advantages to them. Further, BE1 explained the successful experience in implementing this strategy in their company. Further, improvements were suggested for the strategy *use BIM as a centralised platform to link information, enabling better communication and coordination among different stakeholders*. BE2 suggested to use the terms *single point of truth* instead of centralised platform saying that these are common BIM words used for that. BE4 provided comments on the strategy *eliminate individualistic approaches such as ad hoc learning and training*. BE4 mentioned that even though individualistic approaches should be avoided it is essential to note that ad hoc learning and training remain necessary to nurture champions. Therefore, it was suggested to use the term 'minimise' instead of 'eliminate.' The strategy was revised to accommodate this aspect as *minimise individualistic approaches such as ad hoc learning and training while nurturing BIM champions.*

Section 4- Strong innovative BIM culture: All the interviewees agreed that this framework promotes a strong innovative BIM culture. They emphasised that it is necessary to make sure everyone in the organisation use BIM wholeheartedly creating an innovative BIM culture which prioritises group over individual self and encourage risk taking.

All the interviewees contended that they recommend the framework for use by BIM-enabled construction organisations. The key results of the validation interviews are summarised in Table 11.3.

Table 11.3. Summary of validation results

Criteria	BE1	BE2	BE3	BE4
1. Clarity and the understandability of structure of the framework				
• Title, general outlook	Well structured, clear and understandable			
• Flow and sequence	Well structured, clear and understandable			
• Language	Clear and understandable			
2. Level of applicability and completeness of the contents of the framework				
• Overall	Comprehensive and applicable to construction organisations			
• Section 1- Organisational BIM cultural manifestations	Applicable in real practice			
• Section 2- Innovative BIM culture diagnostic tool	Applicable in real practice			
• Section 3- Strategies to promote strong innovative BIM culture	Applicable in real practice			
• Section 4- Strong innovative BIM culture	Applicable in real practice			
3. Additional thoughts or recommendations for framework? • Improvements, inclusions, deletions	Rephrase a strategy	A purpose document could assist the framework Change of words in a strategy		Change of words in a strategy and rephrase a strategy
4. Would you recommend the framework for use by BIM-enabled construction organisations?	Yes	Yes	Yes	Yes

11.4 Discussion of case study findings

This section discusses the empirical findings presented in cross case analysis in Chapter 10 and discusses the underlying beliefs found in an innovative BIM culture - it is further supported with behaviours related to strategies employed to cultivate and reinforce the strength of such an innovative BIM culture. The findings from a cross case analysis are subject to thorough critical review by comparing and contrasting with existing literature.

11.4.1 Innovative BIM culture in construction organisations

Results revealed that a strong innovative BIM culture is built on core principles of participative authority, with a strong focus on the skills of the BIM team. It also prioritises the teamwork for effective organisation and in terms of interpersonal relationships, cooperation rooted in mutual interdependence is highly valued. In such a culture there is a fundamental belief in the innate goodness of human nature, characterised by self-motivation and trustworthiness. This culture is driven by a commitment to quality and efficiency, with a proactive and action-oriented approach. Seeking the truth is best achieved through a pragmatic approach that encourages experimentation and objective testing. Moreover, there is an inclination towards exerting control over the environment, accompanied by a future-oriented mindset that places great importance on long-term planning. These underlying beliefs were uncovered by analysing underlying beliefs of BIM-enabled construction organisations against the cultural dimensions *viz.:* nature of human relationships; nature of human nature; nature of human activity; nature of reality and truth; relationship to environment; and nature of time respectively.

11.4.1.1 Nature of human relationships: who controls BIM, how to organise and how to relate to each other?

The selection of an appropriate authority system for BIM direction significantly influences the level of innovation and effectiveness of implementation. The cross-case analysis revealed that participative authority is most effective in creating a strong innovative culture at organisational level. In such a culture, the BIM team wields authority over decisions related to BIM direction, and these decisions are arrived at through consensus within the group. The proficiency and expertise of the BIM team empower them to make well-informed decisions. This has been proven true in BIM construction project context, as argued by Omer et al. (2022), who stated that involving team members in the decision-making process not only boosts their confidence but also encourages them to freely express their opinions and ideas about the project. Tung and Yu (2016) further emphasised that opting for a participative authority system could empower employees to have a meaningful say in their

work situations, creating an environment conducive to innovation. According to (Chang et al. 2019) a participative authority system promotes innovation in organisations by harnessing the information and intelligence of team members, breaking down hierarchical barriers that may stifle innovation, by actively engaging individuals in the decision-making process. Alternatively, Zhang et al. (2021) highlighted the adverse effects of authoritarian cultures on innovation within organisations. Such cultures tend to impede the flow of information, hinder knowledge sharing and ultimately restrain an organisation's capacity for innovation. In authoritarian systems, decision-making tends to be top-down, limiting the diversity of perspectives and ideas considered, which can be detrimental to innovation efforts.

According to the cross-case findings, a strong innovative culture favours groupism compared to individualism as the best way to organise. This encouraged working in teams and developing a collective mindset in a BIM setting. These findings closely align with the research conducted by de Almeida and de Brito (2017), identified clan culture as a conducive environment for the successful deployment of BIM due to its higher adaptability and the belief that optimal outcomes are achieved through collaborative work groups. Fuad, Musa and Hashim (2020) further supports this perspective by asserting that a clan culture places a premium on teamwork characterised by high cohesion and ethical values, which collectively stimulate innovation. Moreover, in the context of mining firms in Australia, a study carried out by (Javanmardi Kashan, Wiewiora & Mohannak 2021) emphasised that teamwork and collectivism are central to fostering an innovation culture. In contrast, the individualistic approach to organising within a BIM setting raises concerns about potential challenges linked to team cohesion. Lee, Seulki and Yu (2016) explained the prevalence of individualistic culture in the United States led to low acceptance of BIM. The authors (*ibid*) suggest that in societies emphasising individualism, the inclination to prioritise individual gains often outweighs considerations for the greater societal advantage.

The present study’s findings emphasise that a strong innovative BIM culture prioritises cooperation as the appropriate way to relate to each other. In such a culture people are mutually interdependent and actively working together, sharing knowledge, and supporting one another to achieve common goals. However, this finding contradicts the work of (Rameezdeen & Gunarathna 2003), who studied culture in construction organisations. They stressed that in contractor organisations typically emphasis on competitive orientation rather than a cooperative one in employee relationships. However, resonating with current study finding, Zakariyyah, John and Ijaola (2021) revealed that cooperation and assistance among employees are strongly encouraged in a BIM environment as a cultural orientation needed

for the successful BIM adoption. This can be attributed to the inherited collaborative working style enabled by BIM can effectively reshape the traditional competitive mindset, paving the way for the cultivation of a cooperative atmosphere within the organisation (Mignone et al. 2016). Further, Matthews et al. (2018) also emphasised that BIM has the power to integrate people and resources in best possible way to promote collaboration by allowing people to learn from one another. Rieger and Klarmann (2022) added that the groups with high-level cooperative cultures consistently outperform innovation, those with a lower emphasis on cooperation.

11.4.1.2 Nature of human nature: what is human nature?

The present study found that people in a strong innovative BIM culture believe in the inherent goodness of human nature and the capability of individuals to govern themselves. This cultural orientation places a significant emphasis on trust in employees and their autonomy in work and self-directed learning. (Che Khairil Izam Che et al. 2019) agreed that the belief in autonomy ultimately builds trust among individuals improving the BIM use in the company. While granting autonomy to employees might appear to compromise team orientation, it paradoxically reinforces the idea of teamwork within the company. When individuals feel trusted to carry out their responsibilities independently, it fosters a sense of responsibility and accountability, contributing to the overall effectiveness of team dynamics. A culture of trust and psychological safety encourages employees to take risks, share their innovative ideas, and experiment without fear of punishment or adverse consequences (Papadonikolaki & Wamelink 2017) and therefore promote innovation. Conversely, the study found that if a BIM-enabled construction organisation is cynical about human nature, it tends to discourage BIM use, and build mistrust on BIM by doubting its benefits. This creates a culture, which prioritises on self-interests and individual gains.

Additionally, the study found that when the organisations believe in goodness of people, they appreciate, celebrate and learn from mistakes. Accordingly, these organisations promote verbal appreciations reinforce positive behaviour and contributions, boosting morale and motivation. Research suggests that employees who receive regular recognition for their efforts tend to be more engaged, satisfied, and motivated. In a study by Pliskin et al. (1993), it was found that positive feedback and reinforcement can enhance employees' commitment to their tasks. The current study revealed that in the BIM context, celebrating innovative ideas encourage team members to think outside the box, propose new solutions, and continuously improve processes. This celebration manifest through acknowledgment in meetings, or dedicated innovation sessions. On the other hand, in BIM projects, where

precision and accuracy are essential, the ability to view mistakes as opportunities for improvement can prevent a culture of blame and fear of failure. Encouraging employees to take calculated risks and learn from their mistakes can lead to better project outcomes and the development of best practices (Hua 2014).

11.4.1.3 Nature of human activity: how to behave?

The cross-case analysis conducted in the study highlights the significance of the "doing" activity orientation within strong innovative BIM cultures. This orientation emphasises proactive, forward-thinking behaviour among the members of an organisation. Schein (1994) characterised such a proactive culture as "promethean," denoting organisations that are not only optimistic but also proactive and committed to continuous improvement. A study conducted by Ribau, Moreira and Raposo (2017), focused on innovation in small and medium-sized enterprises (SMEs) sheds light on the advantages of proactive behaviour. The research suggests that companies with a proactive stance are more likely to excel in innovation compared to their reactive counterparts. Proactive firms take the initiative in various aspects of their operations, including internationalisation. They leverage their internal capabilities and identify market prospects, often leading to more successful and sustainable growth. In contrast, a reactive company responds to shifts in its operational circumstances and views internationalisation as a reactive solution to these alterations. This reactive behaviour is reminiscent of the "innovator's dilemma" discussed by Christensen (2013). The innovator's dilemma describes the situation where established organisations are often reluctant to adopt disruptive innovations because they are focused on maintaining their existing business models. Accordingly, organisations operating under a reactive paradigm might comply with BIM due to client requirements but miss out on the transformative potential of the technology due to their unwillingness to proactively engage with it. This reluctance can hinder the organisation's ability to adapt to industry changes and seize new opportunities, ultimately limiting their innovation potential.

The current study found that as BIM-enabled construction organisations to be proactive, these organisations need to align BIM objectives with broader organisational goals such as quality and efficiency. This ensures that BIM adoption is not seen as a standalone initiative but as a means to achieving strategic objectives. According to (Eastman, C. M. et al. 2011), this ensures that BIM adoption is not seen as a standalone initiative but as a means to achieving strategic objectives. Further, the study’s findings reveals that leaders who understand the benefits and actively support BIM adoption are necessary to promote a strong innovative BIM culture aligns the previous work of Siebelink et al. (2021). Their study

(*ibid*) highlighted the significance of top management's commitment in the success narratives of BIM implementation. Additionally, the research found that regular communication with software vendors is needed to stay updated on industry trends. Further, a BIM-enabled construction organisation with a proactive BIM culture goes beyond to fulfil client requirements to enhanced client satisfaction and to open new opportunities. Satisfied BIM clients are more likely to engage in repeat business and recommend the organisation to others (Elhendawi et al. 2020). It was also found that such culture prioritises investing in regular training and upskilling programs, given the rapidly evolving nature of BIM.

11.4.1.4 Nature of reality and truth: how are decisions made?

The study found that a strong innovative BIM culture emphasis on adopting a pragmatic and scientific method to determine the truth. Koops et al. (2015) suggests that in societies with a pragmatic orientation, prioritise certain beliefs such as determination and self-control, frugality, maintaining social connections, collaboration, fairness and the ability to adapt and capacity to relativise. These beliefs are deemed essential for achieving success within the dynamic and unpredictable business environment (Hartmann 2006). This approach aligns with the finding of the study principles of evidence-based management, where decisions are rooted in empirical data and sound scientific methods found in BIM-enabled organisations. In a strong innovative culture people use small case projects as testing grounds to effectively manage risks while optimising their integration of innovative BIM methods.

It was also BIM-enabled companies often base their decisions on cost-benefit analyses that primarily focus on financial justification, which hinder the adoption of new technologies and innovative practices due to short-term financial considerations. However, use of cost-benefit analysis in decision-making within BIM-enabled organisations has been prevalent norm (Siebelink et al. 2021). Those who solely depend on the cost-benefit analysis are unaware of its element of uncertainty, subjectivity, and bias when estimating and evaluating the pros and cons of various options (Adler & Posner 1999). Similarly, as discussed in Koops *et al.* (2015), organisations with normative orientations tend to be tightly bound by established traditions and norms. Their approach lacks flexibility and places greater emphasis on immediate gains and short-term financial outcomes, sometimes overlooking the long-term quality, suitability, and sustainability of projects. This unwavering adherence to tradition can impede the adoption of innovative practices and align with the findings of this study.

11.4.1.5 Relationship to environment: how to relate to the environment?

The study revealed that strong innovative BIM cultures hold a dominating perspective towards its environment and believe that organisations with such cultures have the power and control to shape and manipulate the external environment to suit their own interests. This perspective significantly impacts how BIM-enabled organisations leverage BIM technology to gain a competitive advantage. In the study most of the cases used BIM as a marketing strategy and published BIM success stories in company website, public platforms. Adekunle et al. (2022) was in congruence with this sentiment and highlighted that such organisations develop the capacity to swiftly adapt their strategies and operate with agility, ultimately resulting in faster and more cost-effective task execution. Consequently, they gain a competitive advantage compared to their rivals. Ferreira, Coelho and Moutinho (2020) found that certain clients show a preference for choosing innovative contractors over those with conventional approaches, recognising the added value they bring to projects. However, dominating orientation toward the environment can have its downsides, particularly in the context of collaboration within BIM-based construction networks (Oraee et al. 2019). The current study also found that to foster a collaborative environment, a harmonious orientation that emphasises working closely and cooperatively with clients and consultants is essential. Conversely, the study also reveals that BIM-enabled construction organisations with weaker innovative cultures tend to favour maintaining the status quo as a survival strategy, unless they are compelled to change. Klein et al. (2022) explained that psychological evidence suggests that there is a tendency of decision-makers to stick to an existing situation or decision perceiving it is beneficial due to the fear of losing control. This psychological inertia can significantly affect the final decision to adopt BIM, since status quo option serves as an anchor against which alternatives are judged (*ibid*). In other words, construction organisations with weaker innovative cultures may resist BIM adoption due to a fear of disrupting established practices and routines.

Additionally, the study discovered that to create a dominating innovative BIM culture, establishing a clear and comprehensive strategic BIM mission and objectives is crucial and modifying the recruitment strategy to attract individuals with deep expertise in BIM. This strategy aligns with the idea of talent acquisition for innovation, where BIM skilled team can bring fresh perspectives, advanced skills, and knowledge of best practices to the team (Davies, McMeel & Wilkinson 2015).

11.4.1.6 Nature of time: what time orientation is relevant?

A strong innovative BIM culture holds the implicit belief that future holds greater significance as compared to the past and present time frames, which are considered less relevant in terms of time. This might be since the benefits of BIM typically materialise in the long term (Ahn, Kwak & Suk 2016). This future perspective stands in contrast to the argument put forth by Merchant, Rose and Rose (2014) who contended that organisations that solely concentrate on the far-off future may experience difficulties in initiating innovative projects This fixation on the distant future might lead to a perception of abundant time, resulting in a lack of urgency to innovate. However, Schein (1994) argued that organisations that are entrenched in their present practices may struggle to appreciate the value of novelty due to their exclusive focus on what is currently effective. The emphasis on present may often lead to dismissal of innovative ideas that do not align with the organisation's established ways of thinking. On the other hand, Rippa et al. (2019) advocate for the adoption of a temporal ambidexterity approach, which involves balancing present exploitation with future exploration, which can lead to higher levels of innovation. In addition, according to Schein (1994) it is ideal for organisations to adopt a near future orientation, which prioritises the immediate future, as this mindset is better suited to promoting innovation. However, the study found that long term oriented future perspective is a priority in a strong innovative BIM culture.

Ghaffarianhoseini et al. (2017) emphasised that it's crucial to have a correct understanding that BIM is a tool with long-term implications. The misconception of viewing BIM as a tool for short-term gains with an orientation towards present could lead to misguided expectations regarding its benefits (Lidelöw, Engström & Samuelson 2023). These misinformed expectations could lead to user disappointment and frustration with BIM, potentially resulting in its abandonment (Panuwatwanich & Peansupap 2013). Conversely, users who appreciate the need for long-term investment in BIM to reap positive returns tend to be more satisfied and continue with its adoption (*ibid*). According to Jacobsson and Linderoth (2010) when operations are organised around projects (as in construction projects), there is a strong emphasis on time, reinforced by contractual regulations and incentives. These contextual factors shape the frames of reference for individuals and affect how they interpret events or new phenomena. Consequently, individuals tend to pay attention to events and phenomena that lead to immediate actions and benefits. This short-term orientation makes it challenging to allocate the time and resources needed for experimenting with technology.

11.5 Summary

The first part of this chapter outlined the validation of the framework developed in Chapter 10 Cross-case analysis. The validation was carried out based on the interviews with four BIM experts. All the experts agreed that the framework is suitable to apply in the construction organisations to promote a strong innovative culture. The second part of the chapter discussed the findings of the present study with the existing literature.

CHAPTER 12- CONCLUSION

12.1 Introduction

Having discussed the findings of the study in Chapter 11, this chapter revisits each objective of the study to draw conclusions and explains how the objectives have been achieved within the specified scope. Therefore, the chapter first reflects on the key research findings under each of the study's objectives. The subsequent sections expound the contribution made to knowledge and practice as a part of the study. The chapter then provides the key recommendations while acknowledging the limitations of the study and later explains the considerations for future research.

12.2 Summary of research aim and objectives

The research investigated the concept of innovative BIM culture in BIM-enabled construction organisations. Thus, the research aim was to investigate and analyse the BIM cultural manifestations in BIM-enabled construction organisations to manage such organisations towards strong innovative BIM culture. The aim was achieved through the below objectives.

1. To review the concepts of 'BIM', 'organisational culture' and 'cultural manifestations' to define the concept of 'innovative BIM culture' and premised upon the aforementioned to develop a conceptual framework to manage innovative BIM culture;
2. To develop a methodology to derive cultural manifestations encompassing behaviours and patterns of underlying beliefs in BIM-enabled construction organisations;
3. To analyse cultural manifestations encompassing behaviours and patterns of underlying beliefs to derive underlying beliefs of BIM-enabled construction organisations and develop a tool to diagnose an innovative BIM culture;
4. To derive strategies to promote underlying beliefs of a strong innovative BIM culture in BIM-enabled construction organisations; and
5. To develop and empirically validate a framework to manage construction organisations towards a strong innovative BIM culture.

12.3 Summary of key research findings

This subsection delves into the primary conclusions drawn from the research in relation to each of the established objectives.

12.3.1 Objective 1: Review the concepts of "BIM", "organisational culture" and "innovative culture" to define the concept of "innovative BIM culture" and premised upon the aforementioned to develop a conceptual framework to manage innovative BIM culture

In this study BIM was interpreted as an innovation that leverages existing technological tools and processes to generate and manage design and project information; where such subsequently enables multiple stakeholders to collaboratively engage in the design, construction and operation of a facility. With the use of BIM, the changes and modifications to processes, technologies, structures and behaviours contribute to a cultural shift in the organisation, resulting in a complete transformation, creating an organisational BIM culture.

Behaviours and underlying beliefs were identified as cultural manifestations that give rise to every cultural context. The notion of underlying beliefs serves as the cognitive foundation of organisational culture, constituting its essence. These underlying beliefs encompasses all the invisible cultural manifestations *viz.* values and underlying assumptions. While values and basic assumptions are often portrayed as two separate levels, Schein (2010) emphasises that it is the values held by individuals or groups that ultimately drive their behaviour. When individuals or groups demonstrate behaviours to solve problems in the organisational setting, the underlying value that initially motivated that behaviour becomes deeply ingrained as a basic assumption within the organisational culture. Hofstede *et al.* (1990), further uphold the concept of underlying basic assumptions by referring to them as: "taken for granted values." This term implies that the underlying assumptions are deeply ingrained and often go unquestioned within a culture. Schein (1984) underscores that these underlying basic assumptions, or taken for granted values, are considered the core or essence of the culture; this is because they form the foundational beliefs and principles that shape the behaviour and thinking of individuals within the culture. This simplification condenses the levels of organisational culture into two facets: the superficial level (encompassing observable behaviours); and the core level (comprising the underlying beliefs). This reductionist approach provides a more streamlined understanding of organisational culture, delineating between surface-level manifestations and the underlying beliefs that drive them.

The working definition developed for organisational BIM culture was:

> *'The patterns of underlying beliefs guided by behaviours and artifacts, that was learned by members of a BIM-enabled organisation as it solves its problems of external adaptation and internal integration, that has worked well enough to be*

deemed valid and are subsequently passed on to new members as the accepted and accurate way to perceive, think, and feel about BIM in relation to those problems.'

This definition underscored that organisational BIM culture is shaped by the patterns of underlying beliefs guided by behaviours and artifacts. These patterns become evident through how a BIM-enabled construction organisation responds to internal integration and external adaption problems posed by BIM implementation. External adaptation problems pertain to the challenges an organisation faces with the introduction of BIM while adjusting to changes in its operating environment for survival. Internal integration problems, on the other hand, relate to the challenges an organisation faces while integrating new processes, structures and practices to support BIM use within the group. The conceptual framework was developed representing the patterns of underlying beliefs and underlying beliefs of the organisational BIM culture is presented in Figure 3.1. This framework incorporated the concepts elaborated in the previously mentioned working definition.

Further the working definition and the conceptual framework were extended to define innovative BIM culture incorporating the innovative culture theory by Schein (1994). Accordingly, the innovative BIM culture was defined as:

> *'an organisational BIM culture, which is giving priority to underlying beliefs of groupism, participative authority, goodness in human and mutability, pro-activity, pragmatism in decision making, organisational dominance, and near-future orientation corresponding to the cultural dimensions viz. nature of human relationships (best authority system, best way to organise, correct way to relate to each other); nature of human nature; nature of human activity; nature of reality and truth; relationship to environment; and nature of time.'*

Accordingly, the conceptual framework in Figure 3.1 was refined to produce an extended conceptual framework to understand organisational innovative BIM culture with ideal underlying beliefs as shown in Figure 3.3.

12.3.2 Objective 2: Develop a methodology to derive cultural manifestations encompassing behaviours and patterns of underlying beliefs in BIM-enabled construction organisations

Conceptualising organisational BIM culture as patterns of underlying beliefs guided by artifacts and behaviours treats culture as a root metaphor, as something that an organisation 'is'. This holds the ontological assumption that reality is socially constructed and its meaning

is given by people creating multiple realties. Thus, acceptable knowledge construction was expected through subjective meanings and social phenomena with rich and thick descriptions. Axiologically, this aligns with the value-bound stance that the researcher plays a more active role in the research process. Hence, the research philosophy adopted here is interpretivism, underpinned by the cultural philosophical standpoint that regards culture as a root metaphor.

Understanding organisational BIM culture requires uncovering hidden underlying beliefs shared among organisational members that are not easily discoverable due to their taken-for-granted nature. Revealing the underlying beliefs is difficult and needs a distinct and well-thought-out methodology to be employed. These methodological difficulties stem from not knowing what cultural elements determine the organisational BIM culture, questions to be asked to collect data and the process of collecting data. Further, how the collected data can be analysed in a way to derive underlying beliefs, patterns of underlying beliefs and behaviours in BIM culture context. Despite the abundance of quantitative culture studies in practice, quantitative approaches were not adopted since they merely study the superficial level of the cultural aspect, providing insufficient depth to understand the underlying beliefs that define organisational culture. Using a qualitative methodology facilitated the gathering of data tailored to the specific context. Employing a case study research strategy, coupled with multiple qualitative data collection techniques such as semi-structured interviews, direct observations and documentation enhanced the data collection and further allowing data triangulation. Additionally, conducting a pilot case study prior to the main case studies to verify the viability of data collection and data analysis process further added value to the study.

The guideline for conducting semi-structured interviews was developed to extract behaviours and patterns of underlying beliefs within the organisational BIM culture through an approach of in-direct questioning. The process of developing interview questions was guided by the working definition of organisational BIM culture as outlined in Sub Section 3.2.2. This definition emphasises that the organisational BIM culture emerges from the patterns of underlying beliefs that come to the fore as employees address the problems tied to internal integration and external adaptation in a BIM environment. Accordingly, the scope of interview question development revolved around both external adaptation and survival problems. The external adaptation and survival problems include BIM strategy, BIM goals, means to accomplish goals, criteria to measure performance and remedial actions. The internal integration problems encompassed areas such as common language, group

boundaries, power allocation and status, intimacy, reward allocation and punishments and ideology. The responses pertaining to each problem provided insights to extract patterns of underlying beliefs and behaviours.

Given the complexity and subjective nature of the cultural manifestations expected to be uncovered in the study, a cautious approach was necessary in both preparing the interview guideline and conducting the interviews. The interview questions were prepared to inquire about challenges, obstacles or critical situations faced by interviewees in the BIM setting. To delve deeper into their responses, the questions like what were the reasons? and why was it done? were incorporated in the guideline, aiming to extract the rationales behind their behaviours. These questioning strategies were instrumental in bringing patterns of underlying beliefs to the surface that were not directly accessible to the researcher. Additionally, interviewees were encouraged to provide illustrative examples while responding, allowing to collect rich data for analysis. These provided examples not only helped to clarify and substantiate the interviewees' answers but also shed light on their reasoning.

The pilot case study affirmed that providing prompts for each interview question, prevent participant from misunderstanding the questions due to the use of theory-based terminologies in questions (i.e., mission, vision). This approach was particularly beneficial in preventing participants who might be inclined to provide vague responses when they do not fully grasp the question. The strategic and sparing application of probing questions allowed participants the time and space to contemplate their responses to the interview questions. This technique of employing probes to fill gaps proved highly effective in eliciting supplementary insights from the participants. Data analysis of the pilot case study demonstrated the feasibility of extracting patterns of patterns of underlying beliefs from collected data. Data analysis was carried out using a three-level coding system (comprising open, axial and selective coding), with assistance from the NVivo software application. Open coding involved identifying common incidents and interpretations from interviews, observations, and document analysis. These codes uncovered the behavioural patterns. Subsequently, axial coding was employed to extract the patterns underlying beliefs that drove these behaviours. Lastly, selective coding was utilised to deduce core underlying beliefs by examining the identified patterns of underlying beliefs and behaviours against the cultural dimensions. This approach proved to be an effective methodology to derive cultural manifestations encompassing behaviours and patterns of underlying beliefs in BIM-enabled construction organisations.

12.3.3 Objective 3: Analyse cultural manifestations encompassing behaviours and patterns of underlying beliefs to derive underlying beliefs of BIM-enabled construction organisations and develop a tool to diagnose an innovative BIM culture

Each within case analysis involved identification of patterns of underlying beliefs and behaviours and these patterns were further analysed to find underlying beliefs that underpinned them. This process entailed correlating the patterns of underlying beliefs with the eight distinct areas of cultural dimensions delineated in Table 3.1. These areas were derived from six cultural dimensions that emerged from the literature review: nature of human relationships (best authority system, best way to organise, correct way to relate to each other); nature of human nature; nature of human activity; nature of reality and truth; relationship to environment; and nature of time. The outcomes of these analyses, detailing the cultural manifestations of Cases A, B, C and D, are succinctly summarised in Tables 6.2, 7.2, 8.2, and 9.2 respectively. Overall, there were both similar and contrasting underlying beliefs among four cases. That means there were differentiations in the underlying beliefs among the organisations for same cultural dimension. For example, while Cases A and B believed the nature of human nature is good, Cases C and D believed it to be evil. The similarities and differences of underlying beliefs evidenced through the patterns of underlying beliefs across the Cases A, B, C and D are summarised in the Table 10.1. The conditions for weak, moderate and strong innovative BIM cultures were found through the cross-case analysis of underlying beliefs and patterns of underlying beliefs using the Schein's innovative culture theory as the analytical tool.

A strong innovative BIM culture consists of underlying beliefs that include a participative authority system, which centred around the skills of the BIM team as best authority system. It also involves a preference for groupism as the best way to organise, emphasising teamwork. In terms of the best way to relate to each other cooperation focused on mutual interdependence was emphasised. There is an underlying belief in the inherent goodness of human nature, characterised by self-motivation and trustworthiness. Driven by quality and efficiency with a proactive approach towards doing orientation was believed to be the best way to behave. The best way to find the truth was pragmatic, encouraging trial and error, and objective testing. Additionally, there is a disposition towards dominating the environment, accompanied by a future-oriented mindset that places significance on long-term planning. These underlying beliefs are corresponding the cultural dimensions of nature of human relationships (best authority system, best way to organise, correct way to relate to

each other); nature of human nature; nature of human activity; nature of reality and truth; relationship to environment; and nature of time respectively.

12.3.4 Objective 4: Derive strategies to promote underlying beliefs of a strong innovative BIM culture in BIM-enabled construction organisations

The behaviours highlighted in the cross-case analysis (refer to Appendix 2) served as the foundation for devising strategies that guide BIM-enabled construction organisations in their journey towards cultivating a strong innovative BIM culture. Accordingly, the strategies for enhancing a strong innovative BIM culture were formulated by drawing inspiration from the positive behaviours observed within it. Simultaneously, strategies were suggested to eliminate unfavourable behaviours in a weak innovative BIM culture. Strategies were derived corresponding to each cultural dimension.

The strategies pertaining to the cultural dimension **nature of human relationships** include empowerment of BIM Team, sense of belonging, shared success, open and candid communication, feedback loop, mutual support and learning, effective task allocation and technical support. Accordingly, to cultivate a strong BIM culture, it is crucial to grant the BIM team control over its direction, enabling ownership and accountability. Further, effective communication of the company's BIM mission is essential, ensuring alignment across all employees. This connects individual responsibilities to overarching company goals and prioritises a unified focus on organisational success. It is also necessary facilitate clear and structured communication in formal settings, while encouraging the exchange of practical insights, lessons learned and informal brainstorming to foster innovation. Providing technical support through designated email addresses or communication platforms and supplement internal knowledge by seeking input from external industry experts nurture a strong innovative BIM culture. Further, in a strong culture, a balanced workload distribution among team members to mitigate burnout and promote a healthy work atmosphere should be maintained.

Under the cultural dimension **nature of human nature**, the strategies for building a strong innovative BIM culture emphasise trust in employees' inherent capabilities and goodness. The strategies found in the study were autonomy, appreciations, celebrations and learning from mistakes and training and education. In such a strong culture, autonomy should be pivotal, achieved by empowering self-motivated staff to take ownership of their growth and encouraging a supportive learning environment. Mistakes should be viewed as opportunities for learning and calculated risk-taking, while verbal appreciations and celebrations amplify positive behaviours and innovative contributions. Additionally, a culture of continuous

improvement should be nurtured through tailored training, in-house learning and external resources, catering to various teams' needs and promoting skill diversification.

In a strong innovative BIM culture, the **nature of human activity** takes a proactive approach prioritising quality and efficiency improvements over reactive responses to client demands. To cultivate this culture, organisations can adopt strategies that reinforce proactive behaviour such as strategic investment, collaboration, sharing lessons learned and training and education. Strategic investment involves moving beyond client demands, focusing on internal strategic planning and allocating resources to research and development. Collaboration and communication should be enhanced through regular engagement with software vendors and utilising BIM as a centralised platform for improved stakeholder coordination. Sharing lessons learned should be promoted through valuable case studies, while training and education are facilitated through accessible learning platforms and dedicated learning time. Lastly, eliminating skills stagnation should be achieved by investing in regular upskilling initiatives.

Pertaining to the cultural dimension **nature of reality and truth**; in a strong innovative BIM culture, decisions are informed by pragmatic scientific methods, relying on objective tests, trial and error and data-driven insights. In contrast, a weaker culture tends to prioritise cost justifications, making choices based solely on financial considerations. To cultivate a robust culture, organisations can adopt strategies like trial and error, training and education, technical support and data-driven decision making. Emphasising trial and error involves using smaller projects as testing grounds and refining approaches through case studies and stakeholder feedback. Training and education are to be tailored to employees' needs, incorporating practical and job-relevant training with ongoing improvements based on feedback. Accessible technical support and resources should be provided to address challenges effectively. Data-driven decision-making can be leveraged on IT-based systems, data extraction and evaluation tools like BIM 360 and Power BI, bolstered by dashboards for real-time progress analysis.

In a strong innovative BIM culture, **the relationship to environment** is characterised by organisational dominance, whereas a weaker culture tends to exhibit submission to clients and contracts. To strengthen the culture, organisations should encourage dominant behaviours while discouraging submissive tendencies. Strategies for this transition include leveraging BIM to showcase technological prowess in marketing, establishing collaborative relationships with clients, aligning BIM objectives with company goals, and taking an active leadership role in coordination meetings. Maintaining control over decision-making through

informed choices using BIM data, commitment to continuous improvement and recruitment strategies that attract BIM experts further enhance the culture. Relating to the **nature of time**, to nurture a strong innovative BIM culture, construction organisations should embrace a future-oriented time perspective. This entails prioritising long-term planning and benefits over fixating on conventional approaches and immediate gains. To achieve this shift, strategies should target the elimination of past-oriented behaviours while enhancing future-focused ones. Comprehensive and accessible guidelines, plans, and protocols for BIM implementation ensure alignment with the latest standards and industry best practices. Clear role definitions prevent confusion and avoiding the reversion to traditional methods when BIM is incomplete promotes full technology integration.

12.3.5 Objective 5: Develop and empirically validate a framework to manage construction organisations towards a strong innovative BIM culture

A framework to manage construction organisations towards a strong innovative BIM culture was developed as presented in Figure 10.10. The framework was validated through four semi-structure interviews with BIM experts. The framework comprises four primary components. The first component identifies the existing organisational BIM culture. This is facilitated by identifying cultural manifestations, encompassing underlying beliefs, patterns of these beliefs and associated behaviours. These cultural manifestations can be derived through indirect questioning the BIM related external adaptation problems and internal integration problems. The external adaptation and survival problems include BIM strategy, BIM goals, means to accomplish goals, criteria to measure performance and remedial actions. The internal integration problems encompassed areas such as common language, group boundaries, power allocation and status, intimacy, reward allocation and punishments and ideology. The second part outlines the utilisation of an innovative BIM culture diagnostic tool. This tool assesses the organisation's position on the spectrum ranging from weak to strong innovative BIM culture. An innovative BIM culture can be categorised as weak, in between weak and strong, or strong. If the organisational BIM culture leans towards the weaker end of this spectrum, the strategies outlined in the third part of the framework can be implemented to nurture a strong innovative BIM culture.

12.4 Contributions to knowledge

According to Phillips and Johnson (2022) originality in PhD research can manifest through various means, which include, but are not confined to: *"looking at areas that people in the discipline haven't looked at before, making a synthesis that hasn't been made before, carrying out empirical work that hasn't been done before, and adding to knowledge in a way*

that hasn't been done before" (p. 78). The following sections outline how this research makes substantial contributions to knowledge aligned with these areas.

12.4.1 Looking at areas that people in the discipline have not looked at before

BIM, as a disruptive innovation, goes beyond being a mere technological addition and has become paradigm shift in how construction projects are approached. It has not only significantly impacted established technologies, workflows and processes within construction organisations but has also deeply influenced on the cognitive and behavioural aspects of individuals involved. As a result, the implementation of BIM becomes intricately intertwined with the cultural fabric of the organisations. Previous studies have argued that it is crucial to understand organisational culture in BIM context since the implementation can be impeded by cultural barriers, such as resistance to change, concerns over job displacement and conflicting value systems. However, prior research has predominantly concentrated on the technological aspects of BIM while neglecting the cultural perspective of BIM, which pertain to the human elements. The absence of consideration for organisational culture in the context of BIM has faced significant criticism, as numerous studies have highlighted that a lack of comprehension regarding organisational culture acts as a significant hindrance to the successful implementation of BIM. Thus, this study examines the areas of BIM and organisational culture that has been overlooked in the construction industry context.

Many existing studies that reference organisational culture tend to view it primarily as either a factor contributing to the success or failure of BIM implementation. One such perspective is presented by Rayner and Al-Hajj (2015) who argue that successful BIM adoption is contingent not only upon technical elements, but also heavily influenced by the organisational culture within the construction company. Various other studies also reveal a correlation between BIM and organisational culture. For instance, Zakariyyah, John and Ijaola (2021) delve into the relationship between cultural orientation and strategic capability. Only a couple of prior studies have genuinely focused on organisational culture in the context of BIM. One such study, conducted by de Almeida and de Brito (2017) analyses the organisational culture of construction companies in Brazil to identify cultural aspects that necessitate modification for the successful implementation of BIM. Another study by Knobel et al. (2021) investigates the integration of BIM within the organisational culture of an architectural firm based in South Africa.

However, none of these previous studies have explored the development of an organisational BIM culture based on cultural manifestations in terms underlying beliefs, patterns of underlying beliefs and behaviours within contractor construction organisations. No study

has investigated methodologies to: unearth underlying beliefs within an organisational BIM culture; the conditions under which these underlying beliefs contribute to weak or strong innovative BIM cultures; or the strategies that can be employed to cultivate a robust innovative BIM culture wherein every member of the organisation wholeheartedly embraces BIM. In this context, the present study makes a valuable contribution to the existing knowledge by addressing a crucial area that has been overlooked by previous scholars in this field.

12.4.2 Making a synthesis that has not been made before

While numerous prior studies have acknowledged the significance of organisational culture in influencing the success of BIM as an innovation within construction organisations, a comprehensive understanding of the innovative BIM culture in such contexts remains absent. The discussions on BIM and organisational culture have predominantly occurred in isolation, with limited exploration of the interplay between these two critical elements. To address this gap, the present study seeks to bridge these two areas by applying Schein's organisational culture theory and innovative culture theory to shed light on BIM use within construction organisations. This is among the earliest endeavours to apply general organisational culture theories in organisational BIM setting. The study contributes to the expanding literature on BIM and organisational culture by not only formulating a definition of organisational BIM culture and but also refining and extending it to define an innovative BIM culture. As Summers (2001) stressed a significant aspect of contributing (conceptual) to the field involves refining the conceptual definitions of existing constructs and identifying and defining new constructs for inclusion in the conceptual framework. Consequently, the proposed working definitions presented in this study constitute **conceptual contributions** to the existing knowledge in BIM and culture field.

The current study provided **theoretical contributions** by both the theory building and theory testing. This study developed a conceptual framework to manage construction organisations towards a strong innovative BIM culture (depicted in Figures 3.3). This conceptual frameworks as identified by Meredith (1993) can be characterised as ‘conceptual deduction’. Conceptual deduction starts with the formulation of a conceptual framework based on set of theories and principles to explain a specific phenomenon by conceptual induction. Once the conceptual framework is established, next ramifications, or consequences from this framework are then compared with real-world observations or empirical data to see if they align with reality (*ibid*). The conceptual framework for this study was developed through a synthesis of preceding research, encompassing BIM, and cultural manifestations (underlying

beliefs, patterns of these beliefs, and corresponding behaviours). The foundation for these frameworks draws from notable studies and theories: definition of BIM (Siebelink, Voordijk & Adriaanse 2018; Succar 2009); behaviours and underlying beliefs as cultural manifestations (Cameron & Quinn 2006; Hofstede 1998; Schein 1983, 1984, 2010); underlying beliefs – Value Orientation Theory (Hills 2002; Kluckhohn & Strodtbeck 1961); underlying beliefs – Innovation culture theory (Schein 1994); and external adaptation problems and internal integration problems (Knobel et al. 2021; Schein 2010). The developed conceptual framework was used as the basis to examine existing organisational BIM cultures of construction organisations and derived conclusions from it. According to Meredith (1993) deductive reasoning lead to inescapable conclusions since the ramifications are derived from a well-established conceptual framework and logically follow from the framework itself. The conceptual framework of this study also fulfilled the functions including shaping the study's concept, establishing a foundation for the research, and offering a point of reference to guide the interpretation of findings as highlighted by Rocco and Plakhotnik (2009).

12.4.3 Carrying out empirical work that hasn't been done before

Quantitative research method has been preferred over qualitative methods in the organisational culture research (Schein 2010). Similarly, the studies that gave attention to organisational culture in BIM context had mostly employed quantitative research methods. de Almeida and de Brito (2017) used questionnaire and organizational culture assessment instrument (OCAI) based on the competing values framework (CVF) created by Cameron and Quinn (2006). Further, Zakariyyah, John and Ijaola (2021) also adopted a quantitative research approach and used factor analysis, correlation, and regression as statistical tools to assesses the cultural orientations and strategic capability required for BIM adoption. Knobel et al. (2021) followed a mixed-method approach to collect data using both interviews and survey to measure BIM's manifestation in an organisational culture. Hofstede, Hofstede and Minkov (2010) argued that culture questionnaires in quantitative studies are thought to have only assessed organisational climate rather than actual organisational culture. Thus, despite their widespread use, it is argued that quantitative approaches merely study the superficial level of the cultural aspect, providing insufficient depth to understand the underlying beliefs that define organisational culture (Schein 2010).

This study made **methodological contributions** to the knowledge by developing a methodology to uncover underlying beliefs in cultural setting using a systematically developed case study strategy. A research paper titled as 'Guidelines for Using a Case Study

Approach in Construction Culture Research: An Application to BIM-enabled Organisations' was published based on these methodological contributions (refer to publications in page xviii). Accordingly, this study used a qualitative approach in collecting data since it aimed to identify underlying beliefs that are hidden beneath the conscious level of an organisational culture (Fellows, R & Liu 2009). Further, a case study strategy was employed, which helped to acquire a more profound understanding of a cultural phenomenon by delving into the tacit beliefs of people in BIM-enabled construction organisations. Use of a case study strategy with multiple sources of evidence (interviews, observation and documentation) allowed for data triangulation (Edwards and Holt, 2010). This study delivered tailored process to be followed to extract hidden beliefs in a cultural context using case study strategy.

The research explained how responses from employees for the problems tied to internal integration and external adaptation in a BIM environment could be used to derive patterns of underlying beliefs and then identify underlying beliefs by further analysing them. The interview questions for the study were developed around these problems. Therefore, the guideline for semi-structured interviews (Appendix 1(B)) contributed to the knowledge base on how to question the external adaptation problems and internal integration problems of BIM-enabled construction organisations. Further, the study provided a method to analyse collected qualitative data employing a coding level based on three-level coding system (open, axial and selective) using the software application NVivo. The open coding was undertaken considering the similar incidents and interpretations found in interviews, observations and document analysis, and they were correspondingly coded to find patterns of behaviours. Next, axial coding was used to extract the patterns of underlying beliefs. Finally, in the selective coding underlying beliefs were derived by analysing the patterns of underlying beliefs and behaviours identified against the cultural dimensions. This method can be used effectively identify underlying beliefs in a cultural setting. Thus, current research contributes to knowledge by providing a methodology to be used to extract the underlying beliefs, patterns of underlying beliefs and behaviours in an organisational BIM culture.

12.4.4 Adding to knowledge in a way that has not been done before

The current study has advanced previous research on BIM use in construction organisations, by presenting a framework to manage construction organisations towards a strong innovative BIM culture. This framework is supported with a method to find the existing organisational BIM culture a diagnostic tool to be used to assess the organisation's position on the spectrum ranging from weak to strong innovative BIM culture, where an innovative BIM culture can be categorised as weak, in between weak and strong, or strong. Dale et al. (2019) identified

strategies and guidelines as mechanisms for improving the integration of science into policy and practice. This study also empirically contributes to the knowledge by providing strategies to nurture existing organisational BIM cultures towards strong innovative BIM cultures.

12.5 Practical implications

The current study has contributed to the understanding of BIM implementation process through a cultural lens. The thesis introduces a framework for effectively managing BIM-enabled construction organisations to foster a strong innovative BIM culture in Chapter 10, Figure 10.11. This framework comprises several key components: a conceptual framework for recognising the existing organisational BIM culture, a diagnostic tool for analyse any given innovative BIM culture ranging from weak to strong, and strategies for cultivating a strong innovative BIM culture.

The provided conceptual framework for comprehending the organisational BIM culture serves as a valuable resource for upper management, BIM managers and change agents. It empowers them to identify the prevailing BIM culture, pinpoint the aspects of organisational culture impacted by BIM implementation, and determine the areas that require further investigation to fully grasp the BIM culture's dynamics. Given that BIM necessitates a shift in mindset and behaviours, the process of uncovering underlying beliefs becomes a pivotal phase in steering the future trajectory of a construction organisation embracing BIM. This can be used to examine and discuss the internal organisational dynamics when an external consultant is brought in to facilitate BIM integration. Additionally, construction firms nowadays are outlining their core values regarding BIM and innovation through philosophical statements. This framework proves beneficial in pinpointing the underlying implicit beliefs that should be articulated in such statements.

The examination of four distinct case study organisations underscores the presence of divergent underlying beliefs and distinctive behaviour patterns inherent to each context. Recognising similarities or disparities in these underlying beliefs provides valuable insights for leaders in BIM-enabled construction organisations. This understanding shed light on the strengths and weaknesses of the innovative BIM culture, which can either facilitate or hinder the BIM implementation. This study concluded that the innovative BIM culture in construction organisations can be anywhere in the spectrum of weak to strong. By pre-emptively identifying these points of resistance, the organisation's development plan can be adjusted to facilitate a smoother integration of BIM. Thus, the diagnostic tool for analyse innovative BIM culture of construction organisations can be used in change management

process to successfully implement BIM. Using insights from underlying beliefs strategically is key to the success of a change management process. Instead of directly contradicting these beliefs, a more effective approach involves addressing them tactfully. This approach increases the likelihood of a successful change management process. For example, if an organisation intends to bring a group level reward system to encourage employees to embrace BIM by fostering a sense of groupism, but their core underlying beliefs emphasise individualism, the implementation should be approached in a way that aligns with their initial belief. The goal should be to create an environment that reinforces this belief initially, while gradually allowing for a shift in perspective as members come to recognise the limitations of this approach on their own.

The diagnostic tool introduced in the research can also serve as a benchmarking tool for organisations and enables to evaluate their existing BIM culture and, over time, measure their advancements. This serves as a valuable means to monitor the efficiency of implemented strategies and ascertain their impact on the organisation's innovative BIM culture. BIM managers should leverage the diagnostic tool developed in the research to assess their organisation's BIM culture. This tool can aid BIM managers in identifying areas where underlying beliefs and cultural dimensions need adjustment, guiding the development of targeted strategies for cultivating a stronger innovative BIM culture.

For BIM managers, the findings from this research offer valuable insights into practical strategies for fostering an innovative BIM culture within their organisations. Firstly, BIM managers should recognise the significance of a participative skill-centred authority system. By involving experts and digital teams in decision-making processes, BIM managers can tap into the tacit knowledge of their skilled workforce, leading to more informed and effective decisions regarding BIM initiatives. Secondly, BIM managers should emphasise collaboration and teamwork by adopting a group-oriented organisational structure. This encourages a sense of belonging and shared goals, vital for nurturing innovation within BIM projects. Thirdly, BIM managers should prioritise building a cooperative and interdependent work environment. Encouraging knowledge sharing, open communication, and mutual reliance among team members can enhance the collaborative spirit necessary for innovation. Additionally, BIM managers should create an atmosphere that values proactive behaviour and a forward-thinking approach. By promoting a culture that encourages experimentation, continuous improvement and a focus on long-term benefits, BIM managers can instil an innovative mindset in their teams.

Recruiters responsible for BIM projects should accurately and transparently convey the innovative BIM culture to prospective candidates. This practice is crucial to ensure that individuals who are the best fit for the BIM project are selected. By understanding the underlying beliefs that define an innovative BIM culture, recruiters gain valuable insights to effectively communicate and align candidates with the project's ethos. For example, if a BIM-enabled organisation that believe in participative authority system needs to hire a BIM manger, recruiters should look for his ability work as a of a collective leadership team, where decisions were collectively reached through consensus. If the manager perceived himself to be in a position of authority, the group of leaders who had selected him envisioned him otherwise, tensions may be emerged due to the contrasting beliefs about the decision-making process within the organisation.

12.6 Limitations and recommendations for future research

The research focused on conducting an in-depth qualitative case study within the context of four large BIM-enabled construction organisations in Australia. The study was tailored to this specific context and its conclusions were not intended to be applied to other groups. Nonetheless, the findings remain dependable in similar research settings. Even though the research approach was qualitative, the interview questions developed offer a chance to enhance the survey tool for upcoming studies. The researcher advocates using open-ended questions to ensure a comprehensive investigation of the information. Nevertheless, the interview protocol could serve as a foundation for creating more descriptive quantitative metrics in the future.

The study focused on conducting an in-depth qualitative case study within the context of four large BIM-enabled construction organisations in Australia. Because of the specific context details and the nature of the chosen case study approach, there was no attempt made to generalise the study's conclusions to other populations. Nonetheless, the findings remain dependable in similar research settings. Therefore, future research could utilise the insights from the present study in diverse geographical settings, considering the variations in national cultures in different countries. Since, the study was limited to large sized contractor organisations. Given that cultural studies are context specific, future studies could focus on investigating the organisational BIM culture in small and medium-medium sized enterprises.

The study's timeframe also poses an additional limitation. The representation of the organisational BIM culture captured here can be compared to a snapshot providing insights into a specific moment in the organisation's lifecycle that cannot be replicated. Thus, the study is cross-sectional in nature, which offers only a static viewpoint. However, it is

important to recognise that organisations are in a constant state of change: environments shift, meanings evolve and cultural dynamics transform. Thus, a longitudinal study could be conducted to understand how underlying beliefs emerge from new learnings in an organisational BIM culture.

Another limitation of the research lies in the qualitative methodology employed for identifying strategies to promote a strong innovative BIM culture. This aspect could be perceived as a methodological limitation since the study does not rely on statistical data to substantiate and rationalise the strategies. Hence, future research could statistically test the significance of these strategies. Further, future studies could focus on further analysing the interrelationships among the different drivers/strategies making an impact on innovative BIM culture in organisations. For example, the studies could use the analysis techniques such as Pearson Correlation Coefficient, and Principal Component Analysis (PCA).

The validity of the final framework in this study was confirmed through a series of expert interviews. However, the study did not assess its practicality and real-world application, as this was not within the research scope. Consequently, it is suggested that the final framework be implemented within specific BIM-enabled construction organisations to evaluate its effectiveness in real-world scenarios. This practical testing will help determine the framework's validity in actual practice.

It is important to note that this study mainly focused on gathering insights from contractors' viewpoints. The methodology developed through this research has the potential to be adapted for uncovering the underlying beliefs that shape the organisational BIM culture within client and consultancy organisations. Exploring the perspectives of other stakeholders such as clients and consultants would provide also alternative angles of insight creating a BIM culture at project level.

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APPENDICES

Appendix 1(A) Candidate case selection- Preliminary interview guideline

Project title: A framework to manage BIM-enabled construction organisations towards a strong innovative BIM culture

Researcher`s use only

Code:	Date:
Duration:	Venue:

Section A: Demographic Information

- What is your position in your organisation?

Section B: Background Information of the Case Study Organisation

- Size of your organisation: No of employees, Scale
- Past and ongoing BIM construction projects (examples)
- Annual turnover of your company
- Number of years in business
- Organisational structure

Appendix 1(B) Case study- Semi-structured interview guideline

Project title: A framework to manage BIM-enabled construction organisations towards a strong innovative BIM culture

Researcher`s use only

Code:	Date:
Duration:	Venue:

Section A: Demographic Information

1. How many years of industry experience do you have?
2. How long have you been with current organisation and how long have you been working with BIM?
3. What is your position in your organisation?

Section B: General Questions

1. What exactly is BIM, in your opinion?
2. For what purposes in your role do you use BIM?
3. What BIM systems and tools have you employed?

Section C: External Adaptation and Survival Problems

1. **<u>BIM Mission, Strategy, Goals</u>**

1.1 How did the idea of implementing BIM come about? How did the decision make? Who were the key players?

1.2 What was the key reason for using BIM in your organisation? What were the primary justifications for investing in BIM?

1.3 What is the fundamental mission statement of your organisation?

1.4 What is your understanding on the BIM vision of your organisation? How do you think that the BIM vision of your organisation will reinforce the organisation mission?

1.5 What are the main objectives and goals specific to BIM implementation in your organisation? From where did these BIM objectives come from? Are they entirely based on logic and formal reasoning or are they influenced by the beliefs and biases of someone in the organisation?

2. **Means of Accomplishing BIM Goals**

2.1 How do you think BIM implementation has affected the existing organizational structure? How is the BIM team structured in the organisation?
2.2 How do employees in your organisation communicate with one another in the BIM environment? Who decided on those? Do you think current communication methods are effective in accomplishing BIM objectives?
2.3 Have you come across any issue related to BIM systems and processes (software/Hardware/Networks)? What do you do to address these issues? Who do you contact? What kind of tools and methods you have used? How you use them?
2.4 What factors were considered while selecting a BIM vendor?

3. Measuring BIM Performance

3.1 Have your company's BIM performance and practises been evaluated? When? What tools and strategies do you employ? What are the metrics?
3.2 How do you get to know that you are not meeting goals and targets in BIM implementation? How do you react if you get to know that important BIM objectives are not being met?

Section D: Internal Integration Problems

4. Common Language and Concepts

4.1 Do you think your language and way of thinking have changed since your organization adopted BIM?
4.2 Did use of BIM resulted to create shared language of jargon and acronyms? What are some examples?
4.3 How do you capture experiences and lessons learned from BIM projects in your organisation? How do the team members share their BIM project knowledge and experiences of with one another?

5. BIM Team Boundaries

5.1 Can you recall what it was like to start using BIM? How did you feel it? Do you believe that BIM will result in improving construction practices?
5.2 How the use of BIM resulted in changes in staff roles and responsibilities?
5.3 What steps were taken to make sure that staff transitioned smoothly into new roles and responsibilities?
5.4 How do you assign BIM-related roles in your organisation? What methods and tools are employed?

6. Power, Status and Intimacy

6.1 What kind of meetings are held in related to BIM? How often the BIM meetings are held?

6.2 Who speaks at BIM meetings? Is everyone involved? How are the decisions made in BIM meetings? In a BIM meeting do you feel encouraged or discouraged to voice your disagreement face-to-face?

7. Rewards and Punishments

7.1 In the BIM environment of your organisation, what is considered as a reward or a punishment? Does your organisation use any rewards to encourage BIM use?

7.2 What signals do you pay attention to so that you can understand how you do when using BIM?

8. Ideology

8.1 Can you explain any area in BIM implementation that was least under the control of the team members?

8.2 What changes would your organisation make if it were to implement BIM systems again?

Section E: Final remarks

Please discuss if there were any major problems, obstacles, challenges or critical situations encountered when using and implementing BIM.

a. What were the problems?

c. What were the main reasons?

d. How did you solve the problems? What kind of tools, techniques, and methods were used? Why was it done? What were the outcomes? how did you manage it? What types of assistance did you receive when implementing BIM?

e. Do you think that there is a solution for every problem being encountered?

****

THANK YOU!!!

Appendix 1(C) Case Study-Observation guideline

Project title: A framework to manage BIM-enabled construction organisations towards a strong innovative BIM culture

Researcher`s use only

Code:	Date:
Duration:	Venue:

Section A: Descriptive notes on activities, events, and physical settings

Office layout	
Furniture	
Spacing	
Equipment	
Notice boards	
Other	

Section B: Reflective notes on personal thoughts of the researcher- impressions and ideas

Appendix 1(D) Case Study-Documentation guideline

Project title: A framework to manage BIM-enabled construction organisations towards a strong innovative BIM culture

Researcher`s use only

Code:	Date:
Duration:	Venue:

Section A: Descriptive notes about the source of document and material reviewed

Guidelines	
Meeting minutes	
Written protocols	
BIM implementation/execution plans	
Organisational structure	
Templates	
Notice boards	
Work schedules	
Other	

Section B: Reflective notes

Appendix 1(E) Framework Validation- Expert interview guideline

Project title: A framework to manage BIM-enabled construction organisations towards a strong innovative BIM culture

Researcher`s use only

Code:	Date:
Duration:	Venue:

Main question	Comments
5. What do you think about the clarity and the structure of the framework (understandable)? • Title, general outlook • Flow and sequence • language	
6. What do you think about level of applicability and completeness of the contents of the framework? • Overall • Section 1- Organisational BIM cultural manifestations • Section 2- Innovative BIM culture diagnostic tool • Section 3- strategies to promote strong innovative BIM culture • Section 4- Strong innovative BIM culture	
7. Do you have any additional thoughts or recommendations for framework? • Improvements, inclusions, deletions	
8. Would you recommend the framework for use by BIM-enabled construction organisations?	

Appendix 2(A): Cross case analysis of patterns of behaviours, patterns of underlying beliefs and underlying beliefs on nature of human relationships

Case	Cultural manifestation	Conditions for weak organisational BIM culture	Conditions for moderate organisational BIM culture	Conditions for strong organisational BIM culture
Best authority system				
A	**UB**		**Autocracy (BIM leader-centred)**	
	PUB		**1. Presence of a powerful leader is critical in a BIM setting.** **2. Ultimate decision-making power resides with the authority positions.**	
	POB		1. Centralise decision-making authority with the BIM manager. 2. BIM manager provides the technical support and training. 3. Approach the BIM manager for assistance with insuperable problems. 4. BIM manager acts as the communication channel between top management and general employees. 5. BIM manager is responsible for mentoring new employees. 6. BIM manager controls the BIM operations. 7. Hold the BIM manager in high esteem for their expertise. 8. BIM manager develops standards, protocols and procedures. 9. Top management exclusively collaborates with the BIM manager for strategic decisions on BIM implementation. 10. Top management set BIM objectives. 11. Project manager makes decisions at project level. 12. Minimal involvement of BIM team in decision making. 13. BIM team is dispersed in different projects. 14. Employees are bound by the established BIM protocols and lack power to determine BIM policies.	
B	**UB**			**Participative (Skills-centred)**
	PUB			**1. Skills and expertise serve as sources of power.** **2. Ultimate decision-making power resides with the authority positions.**
	POB			1. Top-down approach to decision-making. 2. Top management has BIM knowledge. 3. Delegation of decision-making power to the digital team. 4. Digital team controls BIM direction. 5. Seek consultation and input from digital engineering team. during decision-making. 6. Career progression from technical roles to leadership positions is common within the organisation. 7. Innovation is driven by technical expertise (digital team). 8. Digital engineering team remains updated through constant communication with software vendors and industry trends. 9. Recruit people with BIM knowledge. 10. Digital team is best qualified to manage the direction of BIM development.
C	**UB**	**Autocracy (top management-centred)**		
	PUB	• **Ultimate decision-making power resides with the authority positions**		
	POB	11. There is a decision-making hierarchy 12. BIM is controlled by the top management 13. Top management selects BIM vendors and software 14. Top management controls the resources 15. Top management buy-in is necessary		

		16. BIM needs should be justified for top management to take actions 17. BIM team possesses the skills yet lacks the power 18. BIM team provide background information needed for decision making 19. BIM is not integrated in organisational strategy 20. BIM team remains in the role of supporters 21. BIM team clarify technical issues 22. Top management lacks BIM knowledge		
D	**UB**	**Autocracy (top management-centred)**		
	PUB	**1. Ultimate decision-making power resides with the authority positions**		
	POB	1. BIM is controlled by the top management 2. Top management makes key business decisions 3. Top management buy-in is necessary 4. IT department possesses the skills yet lacks the power 5. Seek input from experts and employees when necessary 6. No BIM specialised team 7. Decision-making focuses on evaluating software capabilities, cost, and ease of use		
Best way to organise				
A	**UB**			**Groupism**
	PUB			**1. Discussions gave results** **2. Organisation's interest prevails above any personal interests**
	POB			1. Hold regular meetings 2. Employees are proactively encouraged to raise their concerns in meetings 3. Consider a diverse range of perspectives when making decisions 4. Encourage formal communication 5. Share the lessons learned 6. Include relevant BIM specialists during discussions 7. The open office environment and design with minimal walls
B	**UB**			**Groupism**
	PUB			**1. Having a sense of belonging is necessary** **2. BIM success is a collective responsibility**
	POB			1. Mission is shared among employees 2. Build personal relationships with each other beyond work-related duties 3. Take an active interest in each other's lives 4. Employees understand how their individual contributions contribute to the company's larger objectives 5. Employees show genuine care and concern for each other's well-being 6. Engage in informal communication 7. Value the diverse skills and contributions of all team members 8. Encourage innovation and championship behaviours 9. Employees take ownership of their learning process and actively participate in acquiring the knowledge and skills
C	**UB**			**Groupism**
	PUB			**1. Discussions gave results**
	POB			1. Employees collaborate to analyse and address challenges related to specific tasks 2. Learn from each other's experiences and practical insights

				3. Tacit knowledge is exchanged that might not be captured through formal channels 4. Lessons from past experiences are shared to improve future approaches 5. Employees engage in spontaneous conversations and informal interactions 6. Encourage brainstorming and idea-sharing through informal discussions 7. Technical expertise is shared and leveraged to solve complex challenges 8. Formal discussions are structured and organised 9. Formal discussions are documented through email chains and records
D	**UB**	**Individualism**		
	PUB	• **Training should cater the individual interests**		
	POB	1. Training is provided based on individual interests, role and as-need basis 2. Tailor the training to individual employees' specific needs and interests 3. Training intensity and depth may vary based on individual job roles 4. Ad hoc learning 5. Employees are encouraged to take initiative in identifying their training needs and seeking opportunities for self-improvement and skill enhancement 6. Acknowledge the strengths of different roles within the organisation		
Best way to relate to each other				
A	**UB**			**Cooperation**
	PUB			**1. Mutual interdependence is best suited to problem solving**
	POB			1. Offer mutual assistance and support to colleagues without hesitation 2. Share the lessons learnt from BIM projects through BIM sessions 3. Encourage continuous learning and a growth mindset 4. Open to change and willing to adapt their approaches for the greater good of the team 5. Everyone feels accountable for the success and takes ownership of their roles and tasks 6. Team members trust each other, feel safe to express themselves 7. Conflicts are addressed openly and constructively, seeking resolutions that benefit all parties involved
B	**UB**			**Cooperation**
	PUB			**1. Mutual interdependence is best suited to problem solving**
	POB			1. Offer mutual assistance and support to colleagues without hesitation 2. Employees are willing to go the extra mile to help each other and work towards common goals 3. Employees do not hesitate to seek help from colleagues, regardless of their age or seniority 4. Employees actively share their expertise and knowledge with others 5. Encourage continuous learning and a growth mindset 6. The digital engineering team is seen as the go-to resource for digital and IT-related issues 7. BIM is seen as a tool that enhances connectivity and collaboration among team members 8. Engage in open and candid communication

				9. Work together to navigate the learning curve associated with BIM and other digital tools.
C	**UB**			**Cooperation**
	PUB			**1. Mutual interdependence is best suited to problem solving**
	POB			1. The workload is managed cooperatively to prevent overburdening any individual 2. A dedicated email address is used for colleagues to direct queries and seek assistance 3. BIM Team provides solutions and assistance 4. BIM Specialised individuals take on more complex tasks 5. Collaboration extends beyond immediate teams, promoting cross-functional cooperation 6. Reach out to external contacts for assistance and guidance 7. Ensure that the right expertise is applied to the right tasks 8. Offer mutual assistance and support to colleagues without hesitation 9. Rely on each other's strengths and skills for effective problem-solving 10. Share the lessons learnt 11. Encourage continuous learning and a growth mindset 12. Communicate openly and clearly
D	**UB**			**Cooperation**
	PUB			**1. Mutual interdependence is best suited to problem solving**
	POB			1. Seek assistance from colleagues when facing technical problems before resorting to external sources 2. Employees freely share their knowledge and expertise with one another 3. Lack of power struggles 4. Lack of individual rewards 5. Find intrinsic satisfaction and pride in being part of a collaborative team 6. Success and achievements are viewed as collective accomplishments

Appendix 2(B): Cross case analysis of patterns of behaviours, patterns of underlying beliefs and underlying beliefs on nature of human nature

Case	Cultural manifestation	Conditions for weak organisational BIM culture	Conditions for moderate organisational BIM culture	Conditions for strong organisational BIM culture
A	UB			**Good, perfectible**
	PUB			**1. Employees are viewed as being inherently good** **2. Employees are viewed as being capable of governing themselves**
	POB			1. Employees are trusted to do their job 2. Empower self-motivated staff members 3. Deliberate nurturing to instil self-belief and self-directed learning 4. Encourage continuous learning and development 5. Mistakes are allowed and no punishments available 6. Employees have the full autonomy on using BIM 7. Employees are trusted and respected for taking ownership of their work 8. View mistakes as opportunities for learning and growth, not grounds for immediate termination
B	UB			**Good, perfectible**
	PUB			**1. Employees get motivated by appreciations** **2. Employees should be open for learning and continuous growth** **3. Employees could be perfectible through training**
	POB			1. Practice of verbal appreciations 2. Acknowledge employees who use BIM in their daily tasks 3. Celebrate and recognise employees' innovative ideas and contributions through various communication channels 4. Trust employees and empower them to identify areas for improvement and suggest solutions 5. Encourage continuous learning and improvement 6. Maintain open communication channels, such as chat rooms and emails 7. Demonstrate responsiveness to employee suggestions 8. Tolerance for mistakes 9. Emphasis on character traits such as openness to learning, adaptability, and a willingness to try new approaches 10. Foster a supportive learning environment where employees feel comfortable asking questions 11. Intrinsic motivation to use BIM 12. Structured training approach 13. Evaluate which team or department needs the training and determine what deliverables they require from the BIM model 14. Digital team conducts inhouse training 15. Provide access to external resources
C	UB	**Evil, perfectible**		
	PUB	**1. Appreciations are not expected, but mistakes are highlighted** **2. Disagreements are normal and acceptable**		
	POB	1. Lack of emphasis on appreciations and rewards 2. Cautious of excessive rewards or encouragement that might lead to non-value-added activities 3. Meeting deadlines and milestones is emphasised, and there may be consequences for not doing so 4. Celebrations focus on team achievements rather than individual bonuses 5. Direct and assertive communication 6. Communication is direct and straightforward, even if it involves expressing disagreement or saying "no"		

		7. Employees address disagreements directly and face-to-face 8. Individuals are responsible for tracking and communicating their information needs		
D	UB	**Evil, perfectible**		
	PUB	**1. Employees are only driven by tangible benefits**		
	POB	1. Adopts a selective approach to BIM usage, where only specific individuals, such as design managers, are actively using BIM as part of the design process 2. Express scepticism about the value of BIM and repeatedly question its purpose and benefits 3. The motivation to use BIM is tied to personal advantages 4. Prefer familiar methods for communication and planning, like using drawings and whiteboard markers over BIM		

Appendix 2(C): Cross case analysis of patterns of behaviours, patterns of underlying beliefs and underlying beliefs on nature of human activity

Case	Cultural manifestation	Conditions for weak organisational BIM culture	Conditions for moderate organisational BIM culture	Conditions for strong organisational BIM culture
A	UB			**Doing, Proactive-Quality driven**
	PUB			**1. Being proactive in the BIM environment was the proper way to behave.** **2. Quality delivery is the main priority**
	POB			1. Proactively adopt BIM driven by top management's recognition of its benefits 2. BIM objectives primarily driven by upper management 3. Change directives and initiatives issued by upper management 4. Heavy investment in BIM development, even without specific client requests for BIM deliverables. 5. Identify areas for improvement and make changes to processes and systems 6. Accountability for Quality 7. Attention to Detail 8. Use BIM to integrate data management systems with quality checklists and approvals 9. Use BIM for clash detections and multiple simulations 10. Use BIM for easy tracking of quality reports 11. Use BIM for Request for Information (RFI) tracking, closing out issues, and managing subcontractor documentation like Inspection and Test Plans (ITPs)
B	UB		**Being-in-becoming**	**Doing – Proactive, efficiency and quality driven**
	PUB		**4. Continuous improvement was deemed essential**	**1. Being proactive in the BIM environment was the proper way to behave.** **2. BIM is a tool for efficiency** **3. Quality delivery is the main priority**
	POB		12. Embrace continuous learning and personal growth 13. Adapt to new tools, workflows, and technologies in the BIM field 14. Support and provide access to different learning platforms (e.g., LinkedIn Learning) 15. Engage in regular communication with software vendors for updates on industry trends 16. Actively utilise case studies to share valuable insights and lessons learned 17. Demonstrate high motivation for learning and staying up to date 18. Allocate dedicated learning hours within daily or weekly tasks 19. Organise training sessions, webinars, and industry-wide meetings for employees	1. Proactive implementation of BIM even without explicit client demands 2. Emphasis on continuous learning and development 3. Open to new ideas and skills acquisition 4. Trust in employees' abilities and input 5. Proactive leadership in training employees on new systems 6. BIM methodologies are explored actively to optimise time, cost, and delivery possibilities 7. Encourage to think innovatively and explore outside-the-box solutions 8. Use BIM as a centralized platform that links various pieces of information, streamlining communication and coordination 9. See the BIM benefits 10. Takes pride in meeting and exceeding clients' requirements and expectations 11. Leverage BIM for tracking and monitoring quality on construction sites
C	UB	**Being**		
	PUB	**1. The correct way to behave is being reactive, not proactive**		
	POB	1. Decisions and initiatives are often driven by client requirements rather than internal strategic planning 2. Cost of is BIM is transferred to the client 3. Prioritise short-term needs and immediate client demands over long-term strategic investments 4. Limited investment in innovation 5. Show a lack of interest or engagement in proactive training sessions		

		6. Do not risk the staff time needed for training 7. Lack of ownership in learning 8. Diminished use of technology 9. Exhibit disinterest in participating in lessons learned meetings 10. Hybrid use of 2D and 3D Drawings 11. Avoid BIM if it all possible		
D	UB	**Being**		
	PUB	**1. The correct way to behave is being reactive, not proactive**		
	POB	1. Respond to immediate needs and challenges rather than taking proactive measures to address potential future requirements 2. Maintain existing skills and capabilities rather than actively seek to upskill 3. Training is done as needed basis 4. Double the roles and responsibilities of existing personnel to support BIM projects 5. Employees have the right to keep BIM out, if that was preference		

Appendix 2(D): Cross case analysis of patterns of behaviours, patterns of underlying beliefs and underlying beliefs on nature of reality and truth

Case	Cultural manifestation	Conditions for weak organisational BIM culture	Conditions for moderate organisational BIM culture	Conditions for strong organisational BIM culture
A	UB			**Pragmatic, Scientific method**
	PUB			1. **Problems should be approached and resolved pragmatically** **2. Objective testing is a source of truth**
	POB			1. Rely on available and accessible technical support and resources 2. Use BIM model to streamline change management in construction projects 3. Encourage to take extra responsibilities to improve efficiency 4. Use technology to provide quick and effective solutions to issues on-site or in the field 5. Identify the root cause for problems and providing appropriate solutions 6. Focus on speed, convenience, and flexibility of working 7. Use BIM to find alternative methods of working 8. Encourage problem solving attitude 9. Emphasise on BIM benefits 10. Data-driven decision making 11. Use IT-based systems to extract and evaluate data from various sources, including BIM 360, to create project-based evaluations 12. Adopt data mining and reporting methods like Power BI to gain a better understanding of project performance 13. Use dashboards to extract specific metrics and analyse progress towards objectives in real-time.
B	UB			**Pragmatic, Wisdom, Scientific method**
	PUB			**1. Truth is determined by trial and error** **2. Experience, and expertise are critical in decision making** **3. Objective testing is a source of truth**
	POB			1. Test the systems before applying them in projects 2. Use small case projects to try out new methods before larger project integration 3. Conduct case studies to get feedback from different stakeholders 4. Seek feedback from various teams, not just the digital team 5. Evaluate project deliverables to identify essential aspects of the BIM model for employee training 6. Use questionnaires to assess employees' current level of skill in BIM 7. Use a tailored training methodology to meet specific requirements and responsibilities of each employee 8. Focus on practical and job-relevant training to benefit employees' work tasks 9. Continuous feedback and improvement in training based on employee inquiries and feedback 10. Recruit individuals with BIM skills and experience for the team 11. Constant communication with software vendors to stay updated on industry developments
C	UB	**Traditional dogma**		
	PUB	**1. Decisions ought to be cost-based**		

	POB	1. Emphasis on cost justification 2. Pitch ideas based on Cost-Benefit Analysis 3. Discontinue technologies without financial justification 4. Select most cost-effective BIM vendors 5. Use other cost-effective alternatives as much as possible 6. Inability to see the benefits, basic distrust for BIM		
D	UB	**Traditional dogma**		
	PUB	**1. Decisions ought to be cost-based**		
	POB	1. BIM on a particular project depend on the magnitude of the project 2. Assess the value of using BIM based on the cost-benefit analysis and the specific needs of each project 3. Use other cost-effective alternatives		

Appendix 2(E): Cross case analysis of patterns of behaviours, patterns of underlying beliefs and underlying beliefs on organisation's relationship to the environment

Case	Cultural manifestation	Conditions for weak organisational BIM culture	Conditions for moderate organisational BIM culture	Conditions for strong organisational BIM culture
A	UB			**Domination**
	PUB			**1. BIM use provides a competitive advantage** **2. Using BIM for visualisation is an effective way to persuade clients**
	POB			1. Use BIM as a tool to showcase their advanced technological superiority to clients, gaining a competitive edge in winning projects 2. Takes leadership and control in BIM coordination meetings 3. Control the decision-making process at construction project level 4. Use BIM as a marketing strategy 5. Involve early in the design process 6. Use BIM in Design and Construct projects
B	UB		**Harmony**	**Domination**
	PUB		**2. Collaboration with other stakeholders is a vital part**	**1. Survival and growth lie within own control**
	POB		6. Work collaboratively with clients and consultants 7. Early engagement with contractors for engineering expertise 8. Appointment of lead digital engineer for client deliverables 9. Work closely with architects and consulting engineers to foster a collaborative environment 10. Ensure deliverables are met during design and construction	1. Has clear strategic BIM mission and objectives 2. Revamp the recruitment strategy to attract individuals with BIM expertise 3. Establish dedicated digital engineering and research innovation teams 4. Continuous progress and improvement to develop own capabilities and strategies 5. Empower innovation
C	UB	**Submission**		
	PUB	**1. The best way to survive is to maintain the status quo unless forced otherwise**		
	POB	1. BIM use is driven by client demands and contractual obligations 2. Collects feedback from clients through surveys to gauge their performance 3. Emphasise client satisfaction 4. Prioritise maintaining positive relationships with clients 5. Rewards come through meeting the needs expressed by the clients 6. Avoid BIM if it all possible 7. Rely on traditional construction methods and practices 8. No BIM strategy or objectives available		
D	UB	**Submission**		
	PUB	**1. The best way to survive is to maintain the status quo unless forced otherwise**		
	POB	1. Exhibit hesitancy and scepticism towards the potential BIM benefits 2. Demand concrete evidence of advantages before using BIM 3. Implement BIM primarily due to external demands from clients and design consultants 4. Lack of internal initiative and strategy 5. See BIM models as non-contractual documents 6. Reverts to traditional 2D drawings when BIM models lack information or completeness 7. Upskills the employees only when external parties demand BIM usage		

Appendix 2(F): Cross case analysis of patterns of behaviours, patterns of underlying beliefs and underlying beliefs on nature of time

Case	Cultural manifestation	Conditions for weak organisational BIM culture	Conditions for moderate organisational BIM culture	Conditions for strong organisational BIM culture
A	UB		**Present**	
	PUB		**1. People are motivated by the desire for instant gratification and immediate results**	
	POB		1. Seek immediate benefits 2. Need to gain the buy-in from employees 3. Do not use BIM if the benefits are not proved	
B	UB			**Future**
	PUB			**1. BIM success is a matter of long-term planning** **2. Previous BIM experience should shape the future**
	POB			1. Actively develops and follows clear guidelines, plans, and protocols related to digital engineering and BIM implementation 2. Ensure that responsibilities and roles related to digital engineering are well-defined and allocated appropriately 3. Continuous improvement and adaptability 4. Previous experience in BIM is important for future
C	UB	**Past**		
	PUB	**1. Learning from past experiences is important**		
	POB	1. Hold lessons learned meeting after each project 2. Apply past knowledge in future projects 3. Document insights from lesson learned meetings serve as a reference for future projects		
D	UB	**Past**		
	PUB	**1. The most effective solutions lie within proven traditional methods**		
	POB	1. Rely on existing conventional methods and prefer established approaches 2. Reluctance to embrace new technologies Negative past experience with BIM 3. Less convinced about BIM benefits 4. Reliance on construction knowledge than BIM knowledge		

Appendix 2(F): Statement of Authorship for Published Works

University of South Australia

Statement of Authorship

Title of Paper	Guidelines for Using a Case Study Approach in Construction Culture Research: an Application to BIM-enabled Organisations
Publication Status	☒ Published ☐ Accepted for Publication ☐ Submitted for Publication ☐ Unpublished and Unsubmitted work written in manuscript style
Publication Details Relevant reference details	Alankarage, S, Chileshe, N, Samaraweera, A, Rameezdeen, R & Edwards, DJ (2023), 'Guidelines for Using a Case Study Approach in Construction Culture Research: an Application to BIM-enabled Organisations', Journal of Construction Engineering and Management, vol.149, no. 9, DOI: 10.1061/JCEMD4.COENG-1356
PRINCIPAL AUTHOR	
Name of Principal Author (Candidate)	Sonali Alankarage
Contribution to the Paper Brief description of your work in this publication	I was the primary contributor in this publication. As the principal author I involved in preliminary study, the literature review, collecting and analysing data. Further, I prepared the initial draft of the paper and revised the manuscript to address the comments received from reviewers.
Overall Percentage (%)	70%
Certification	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.
Signature *Signatures will be redacted by the Library at the time of publication*	[redacted] Date 07/09/2023
CO-AUTHOR CONTRIBUTIONS	

By signing the Statement of Authorship, each author certifies that:

I. the candidate's stated contribution to the publication is accurate (as detailed above);

II. permission is granted for the candidate in include the publication in the thesis; and

III. the sum of all co-author contribution is equal to 100% less the candidate's stated contribution.

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Contribution to the Paper Brief description of your work in this publication	I was the primary contributor in this publication. As the principal author I involved in preliminary study, the literature review, collecting and analysing data. Further, I prepared the initial draft of the paper and revised the manuscript to address the comments received from reviewers.
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Name of Principal Author (Candidate)	Sonali Alankarage
Contribution to the Paper Brief description of your work in this publication	I was the primary contributor in this publication. As the principal author I involved in preliminary study, the literature review, collecting and analysing data. Further, I prepared the initial draft of the paper and revised the manuscript to address the comments received from reviewers.
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