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A Hermeneutic Phenomenological Study into the impact of BIM on the Social Dynamics of the AEC professional in the workplace.

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A Hermeneutic Phenomenological Study into the impact of BIM on the Social Dynamics of the AEC professional in the workplace.

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DECLARATION

I certify that this thesis which I now submit for examination for the degree award of Doctor of Philosophy is entirely my own work and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within the text of my work.

This thesis was prepared according to the regulations for postgraduate study by research of the Technological University Dublin and has not been submitted in whole or in part for an award in any other Institute or University.

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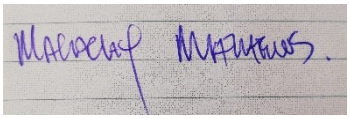
Signature of candidate:....  .....Date: 26th March 2021

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I thank my wife Amy, and my children for their constant encouragement, especially when the going got tough. I hope you will take pride in my achievement and in the knowledge that if the old man can do it, so can you.

Dedication

I dedicate this work to the memory of Maurice and Kay Mathews, my parents, without their love, understanding and sacrifice none of this would have been possible.

Abstract

A review of the literature published surrounding new digital design and construction technologies and associated processes described within the Architecture, Engineering, and Construction (AEC) community as Building Information Modelling (BIM) or Virtual Design and Construction (VDC) reveals a gap in the theoretical understanding of the impact these technologies are having on professionals who work in this industry. The central aim of this research is to discover if there has been a shift in social dynamics as a result of the adoption of BIM in the workplace and, if there has been, to discuss the meaning of this for the industry and the community who educate these professionals. This study is important as it seeks to develop an understanding of the impact of BIM from the perspective of those AEC professionals affected. The study of human beings is referred to as Anthropology. It is a social science and is characterised as the study of human societies, cultures, and development often affected by social or technical intervention. BIM is an example of a technological intervention that has been introduced into the complex design and construction industry. This multidisciplinary industry has relied on representation in the form of paper-based communication documents for 500 years. However, with the introduction of new technologies, the AEC industry is experiencing a digital transformation, characterised by a move from representation to simulation. The Author has conducted a study examining the lived experience of AEC professionals who have come into contact with the subject phenomenon in their workplace. The workplace is the locus for this research. It is defined as the place where the AEC professional conduct their day to day business. The subjects of this research study are a purposeful selection of industry professionals who have experienced the phenomenon and have told the Author their stories. These lived experiences have been analysed and interpreted using a suitable methodology to address the research question; in this case, Hermeneutic Phenomenology. The data analysis has identified four themes: Identity, Empowerment, Disarrangement and Collaborative Practice. The emergence of these themes and the discussion around them will add new knowledge into the subject area. The study concludes by discussing the implications of this research for the design and construction industry and educational institutions.

Journal Papers and Conference Proceedings Arising from the Study

Direct

1. Mathews, M., (2013) *BIM Collaboration in Student Architectural Technologist Learning.* Journal of Engineering, Design, and Technology.
2. Mathews, M., (2015a) BIM; *Postgraduate Multidisciplinary Collaborative Education;* BIM 2015, International Conference on Building Information Modelling (BIM) in Design, Construction, and Operations.
3. Mathews, M., (2015b) *Job Titles and Career Paths in BIM*, CITA BIM Gathering, Dublin November 2015.
4. Reinhardt, J., & Mathews, M., (2017) *The Automation of BIM for Compliance checking: a visual Programming Approach.* CITA BIM Gathering, November 23rd-24th, Croke Park, Dublin
5. Deegan, K., & Mathews. M., (2017) *BIM Building Information Management (not modelling).* CITA BIM Gathering, November 23rd-24th, Croke Park, Dublin
6. Peters, J., & Mathews. M.,(2019) *What is a BIM Design Model?* CITA BIM Gathering 2019, Sept 26th, 2019

Indirect

7. Mathews, Robles, & Bowe, (2017) *BIM+Blockchain; A Solution to the Trust Problem in Collaboration,* CITA BIM Gathering, Dublin November 2017.
8. Mathews, M., CoEngineers: *A Blockchain built for Engineers by Engineers* CITA Tech Live Conference, Dublin November 2018.
9. O'Reilly, A., & Mathews. M., (2019) *Incentivising Multidisciplinary Teams with new methods of Procurement using BIM + Blockchain.* CITA BIM Gathering 2019, Sept 26th, 2019
10. Mathews, M., *Incentivising Multidisciplinary Teams using BIM + Blockchain,* CBC International Symposium 6-7 June 2019 | Paris, France

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Journal / Conference Proceedings and Presentations Arising from this Study

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Nomenclature

(BAF) BIM Academic Forum

(BIM) Building Information Modelling/Management

(BREP) Boundary representation

(BSI) British Standards Institution

(CAD) Computer-Aided Design

(CITA) Construction Information Technical Alliance

(CLE) Collaborative Learning Environments

(FOMO) Fear of Missing Out

(GCS) UK Government Construction Strategy

(LOF) Learning Outcomes Framework

(NBS) National Building Specification

(PC) Personal Computer

(SBIM) Social BIM

Chapter 1. Introduction:

1.0 Context

The history of building design and its construction becomes relevant to this research from approximately 550 years ago. In 1452 the Renaissance architect Leon Battista Alberti completed a treatise on Architecture, "De re Aedificatoria." His treatise was written during the Renaissance. It was a fervent period of European cultural, artistic, political and economic "rebirth" following the Middle Ages (Scheer, 2014). Alberti's books covered many subjects, from town planning to engineering and the philosophy of beauty. At the centre of the work, Alberti posits a hypothesis that architecture is a purely intellectual endeavour. He, Alberti, deemed the Architect's knowledge of why as superior to the builder's knowledge of how, thereby placing the Architect above the builder as the building's true Author (Kolarevic, 2004; Scheer, 2014). With Alberti's elevation of architects over master builders came a need to externalise information so it could be communicated to tradespeople. This saw the development of orthographic abstractions familiar to the industry now as plans, sections, and elevations. Architects no longer had to be present on-site as the communication method moved from oral to paper-based representations (Kolarevic, 2004).

Kolarevic goes on to state that the rift between architecture and construction started to widen dramatically in the mid-nineteenth century when drawings became contract documents. Drawings were manufactured using a tool-set of pen/pencil on paper, creating a link between thought and artefact. The physical construction of the design idea became, in essence, the preserve of the craftsman/builder or as we now might term them, the general contractor. The Architect's conventional plan, section, and elevation became the standard method of conveying the architectural design form, but significantly at that time did not contain instructions on how to build it. The task of building, according to Alberti, was no longer the Architect's responsibility. The architects driving concern was the preservation of the design form. The division of the knowledge and skill set of the old master-builder as described by Alberti into the Architect and the Contractor has been followed by further division of the design responsibilities in recent years. The consequences of splitting the design from the construction, both conceptually and legally, were profound. Architects were removed from the apex of the hierarchal control structure

and their role on site became one of the contract administrations. Architects had detached themselves from the act of building (Kolarevic, 2004). Pevsner (1963) differentiates in his book, "An Outline of European Architecture", a bicycle shed is a building, whereas Lincoln Cathedral is a piece of architecture. A statement like this represents an intellectual tradition that has, until very recently, divided the world of building into two separate parts (Davis, 2006).

The rise of Engineering as a separate profession started in the 18th century. Professional Engineering recognises separate specialist disciplines, structural, civil, mechanical, and electrical within its overall Engineering domain. This movement was followed in the 19th century by recognising another new professional entity, "the Surveyor." Later, the Surveying profession recognised separate disciplines, such as quantity, cost & estimating, building, geomatics and building procurement. These Architecture, Engineering, and Construction (AEC) professionals are at the heart of this study. Upon entering third-level education to pursue their interest, AEC students are typically segregated into a domain silo where they stay until graduating with an education award and a path to professionalism in their chosen discipline. The separation of the disciplines starts early and continues into the industry in particular, the focus on discipline knowledge or the siloed approach of design and construction has preserved and reached a point where architects who are members of the American Institute of Architects (AIA) are prohibited from taking part in construction by the codes of conduct established by the AIA (Kolarevic, 2004).

Building design and construction has developed in the last 100 years, driven by innovation resulting from three industrial revolutions to incorporate a broader palette of materials and more complex construction methods. This has resulted in further dilution of the Architect's original mission, the Architect's knowledge of why, with specialist roles emerging in technical architecture, building engineering, digital surveying and building information management. Until the 1980s, the design and drawing tool-set consisted of pencil/pen on paper/tracing paper, remained unchanged. The procurement process remained linear, albeit with more actors involved creating a hierarchical flow of information. In the traditional method of designing, each of the above-mentioned specialists works on separate industry drawing sets and only on those elements for which they are responsible. This workflow consisted of sets of representative drawings on

tracing papers produced by the imposed and positioned over each other during the coordination meeting to check the compatibility of elements of the project (Czmoch & Pękala, 2014). Coordination of the separate sets of drawing data needed to be checked and coordinated before approval for the next round was granted. This process, the dependency on multiple set of drawings, created an environment where miscommunication and poor coordination carried over into the construction site causing problems (Gamil & Rahman, 2017). The introduction of digital computer-aided design (CAD) systems to the industry in the 1980s brought greater efficiencies. However, in reality, it merely swapped the pen for a mouse and the paper for a monitor and the process of creation and coordination stayed relatively the same. The use of CAD systems made this process easier, although it was time-consuming and not always successful (Czmoch & Pękala, 2014). The traditional building procurement process was, and when still practised is rife with miscommunication, inefficiencies, material waste and poor practice.

Egan (1998) states in his report "Rethinking Construction" that the industry recognises that it needs to modernise to tackle the severe problems facing it. The UK Government has commissioned other reports to highlight problems in the design and construction industry, most notably Latham (1994) and more recently Farmer (2017). Other industries throughout the later part of the 20th century and particularly in the early part of the 21st century were undergoing "digital transformation." Banking, publishing, travel and music are product-led service industries and are today almost unrecognisable from their original incarnation. Many shipyards and boatyards (the same can be said for aircraft building) started to eliminate drawings by working with a comprehensive three-dimensional digital model from design to completion (Kolarevic, 2004). This digital revolution in the shipbuilding industry did not go unnoticed in architecture. As CAD systems became more intelligent and more users wanted to share data associated with a given design, the focus shifted from drawings and 3-D images to the data itself (Eastman et al., 2011).

Building Information Modelling (BIM) can be traced back to a working prototype developed by Charles Eastman who published his findings in 1974, calling his prototype a Building Description System (Eastman et al., 1974). More research and development work was carried out, particularly in the UK by Robert Aish and in Europe with successful innovations in Finland and Holland Laiserin (as cited in Eastman et al., 2011). BIM developed as a set of technologies and processes in which software is used to create a

single virtual model of the geometry of a building, that is a visual representation of an intrinsic database containing information about construction materials and assemblies, as well as spaces and areas within the building. This single central file, generally referred to as "the model," can be worked on simultaneously by multiple users, and the geometry of the model is continuously updated within all plans, sections, elevations, and 3-D vignettes (Foxe, 2010).

The capability of the digital building information model extended beyond its original purpose of producing a coordinated set of design, tender and construction drawings into what Tobin (2008) in an article entitled "To BIM is to Build" describes as an added value network, including cost estimating, construction programming, energy calculations, mechanical and electrical systems model and a structural model. All of these activities stem from a single or federated set of digital building models providing a platform for multidisciplinary collaboration. Digital building models are programmable databases that visually simulate building elements. The challenge for successful collaboration now is not technology or process problems; these have been overcome. The challenges related to BIM and collaboration in the AEC industry are with the people, the professionals working in the industry. Deutsch (2011) argues that people problems, human issues, issues of communication and collaboration, firm culture issues, issues of motivation and workflow are all brought about or exacerbated by the advent of BIM into the workplace.

This research aims to provide the reader with a reliable document that has two main elements. The first has been to develop and test a research methodology with methods that other researchers can employ to gather and disseminate knowledge on the social aspect of the phenomenon of the digital transformation of the design and construction industry. The second element of this research is to put into action this methodology and methods to better understand the impact that this technological innovation named as BIM has had on the professional people who work in the design and construction industry.

1.01 Personal Motivation

The research described in this thesis stems from my initial interest in the educational aspects of emerging BIM technologies in the design and construction industry. Meadati & Irizarry (2010) state that accessibility and visualisation are the characteristics that help BIM to serve as a better learning and teaching tool. BIM technologies allow a skilled

designer to virtually create a building that is not just a representation as has been the traditional way, but a digital simulation of the proposed building, with connected building elements that can be explored and investigated using a visualisation tool-set.

The transformation from representation to simulation, which is a move from analogue to digital, from 2D to 3D, static information to dynamic data, affects every aspect of the design and construction industry and consequently the community who educate and work within its domains. BIM has a myriad of understandings, and this is because it spans across domains and intersects over time dimensions for the procurement of a building. These singular perspectives lead to understandings and definitions that are created by the professionals working from within the domain. Perceptions, understandings from professional domains who are creators of the digital model are different from those professionals who are consumers of the data hosted by the digital model. Information flows into and out of the model as it is needed along with the design, construction and building operation periods, further informing the user's perspective. Traditional building procurement practice and process has grown organically, meaning it has adapted as problems were solved, lessons learned, and innovation embedded. However, this has led to a myriad of different ways of doing things contributing to the complexity of building procurement.

This Author is an educator and wanted to investigate if BIM technologies and processes have impacted the professionals in the workplace. The Author wanted to better understand if BIM is changing how people in the industry work together and maybe consequently changing the dynamics of existing workplace relationships. Therefore, should this be the case, it posits a question about current AEC education: is it enough to merely teach students about BIM from a technical or management perspective, or do they need other skills? Are there other professional based skills that are not currently emphasised within our education program that are becoming more important in the world of AEC because of the implementation of BIM? For instance, if there are changes in the social dynamics, maybe design and construction education needs to stress group-based "collaborative" learning and communication skills within multidisciplinary groups. Furthermore, if BIM itself is continually developing and becoming more advanced, learning to learn will become ever more critical.

This knowledge generated may serve the direct connection between industry and the education and training of those working and planning to work in that industry and in turn new knowledge, will require new skills, and subsequent competencies to be embedded in the design of new and existing design and construction courses for the built environment.

1.1 Research Aims

The speed of digital transformation in the design and construction industry can be measured in terms of technological evolution, but the speed of culture (human) change is more difficult to measure. A desire to change is poles apart from actual change because it is often personal and can challenge deep-seated beliefs, habits and social norms. Having read extensively the literature surrounding the subject area of BIM, it became evident that the concentration of conference presentations, research and published literature predominantly deals with the technology applications and information process. For example, there are numerous papers published about BIM standards (Eastman, et al., 2009; Weygant, 2011; Edirisinghe & London, 2015). BIM Implementation (Coates et al., 2010; Arayici, et al., 2011; Smith, 2014). BIM Methodology (Jankowski, Prokocki, & Krzemiński, 2015; Gerber, Becerik-Gerber, & Kunz, 2010). BIM Education (Macdonald, 2012; Wu & Issa, 2014b; Underwood et al., 2015) and the BIM Process (Fridrich & Kubečka, 2014; Ding, Zhou, & Akinci, 2014). However, there is a distinct lack of research focused on the effects of BIM from a human perspective including the social and personal aspect surrounding the impact of BIM on the professional in the workplace. There is literature published on a subject that can be defined as Social / Collaborative BIM, which has examined subject areas such as situational awareness (Adamu, Emmitt, & Soetanto, 2015) social network theory in BIM (Al Hattab & Hamzeh, 2015) social BIMcloud (Das, Cheng, & Kumar, 2015) and collaborative BIM (Becerik-Gerber, Ku Kihong, & Jazizadeh Farrokh, 2012). However, these studies do not focus on the social and personal impact on working professionals of BIM adoption in the workplace. The aim was to bring new knowledge into the subject area of BIM, particularly the effect on the social dynamics of professionals in the workplace. This new knowledge will serve both industry and education to better understand the ripple effects of this technological innovation.

1.2 Research Objectives

The literature review highlights that BIM has been, and continues to be, a catalyst for change. It is a technological innovation becoming, as the published literature states, embedded in the design and construction industry and subsequently effecting change. The core of these BIM technologies provides a digital platform for social-driven collaboration. The objective of this study is to investigate the impact BIM has had and continues to have on social dynamics in the workplace. The dynamics are created through collaboration and relationships fostered in the design and construction industry brought about by digital BIM technologies and the associated processes. The research concentrates on interpreting the lived experience of a purposeful selection of AEC professionals who are experiencing the phenomenon in their workplace.

This study's phenomenon can be described as the impact of BIM on the social dynamics of professionals in their workplace. The study investigates broadly two types of working subjects; AEC professionals who have not been formally educated in these new digital technologies but have experienced the phenomenon in their workplace and AEC professionals who have pursued postgraduate education to learn about BIM technologies. A further objective of this study is to discuss what the Implications for Industry and education might be if changes are occurring in the workplace and what maybe what new skills and competencies might be needed by AEC professionals.

1.3 The Research Question

The research in this study seeks answers to the following question;

"With the introduction of BIM into the AEC workplace environment, what, if any, has been the impact on the social dynamics of engaged professionals in the workplace?"

Following the interpretive analysis of the resultant experiences, the potential implications for industry and education will be discussed later in the document.

1.4 Significance of the Research Phenomenon

> *The Engineering & Construction (E&C) industry strongly affects the economy, the environment, and society as a whole. It touches the daily lives of everyone, as the built environment surrounding people heavily influence the quality of life. The*

> *construction industry serves almost all other industries, as all economic value creation occurs within or utilising buildings or other "constructed assets." Given the sheer size of the E&C industry, even a small improvement would provide substantial benefits for society.* (Gerbert, Rothballer, & Renz, 2016)

The author has carried out an extensive review of the literature published surrounding new digital design and construction technologies and associated processes described within the (AEC) community as (BIM) or (VDC). This has revealed a gap in the theoretical and conceptual understanding of the impact these technologies and the associated collaborative, driven process is having on professionals who work in this industry. Rivard's (2002) study surveyed the impact of information technology on the Canadian AEC industry. Professionals answered a set of questions on their attitudes to introducing IT and CAD systems. However, the study did not examine their personal experiences of the adoption of new technologies. Similarly, Liu, Xie, Tivendal, & Liu (2015) surveyed the industry to collect data on "Critical Barriers to BIM Implementation in the AEC Industry." Their main conclusion was that the initial cost of investing in new technology was the more critical barrier, with time for training personnel also being significant, but again the personal experiences of the people impacted by it were not considered. Jupp & Nepal (2014) found that BIM introduced changes in working practices, both within an organisation and across organisations, which are often complicated and painful. They map out the new roles that have emerged with the introduction of BIM in the workplace but do not present any data on how professionals cope with role change and the dynamics this might have in the office. The Suermann & Issa (2009) paper "Evaluating industry perceptions of BIM impact on Construction" is atypical of the literature that has examined the impact of BIM on the firm, the project and the performance, but does not report on the impact of these technologies on the professional in the workplace. Deutsch (2011) in his book "BIM and Integrated Design", makes the case that the number one problem of BIM implementation in the workplace is not technology or business value propositions or even return on investment, but people.

1.5 Significance of this Research Thesis

Innovation in the industry is constant. New products are invented, new processes are created, new tools are invented. These derivatives will drive new processes that require

new skills to operate the new tools. Language is expanded to incorporate descriptions of the new product, the process, the tools, and the skill-sets. The Egan Report entitled "Rethinking Construction" (Murray, 2003) and the Latham Report "Constructing the Team" (Latham, 1994) both indicated the need for change in the design and construction industry. The industry adoption of digital technologies has started a digital transformation in the AEC industry (Fingland, 2019). Professionals working in the AEC industry will face the same problems that others faced during the first, second and third industrial revolution. These new digital skill-sets are driven by new technologies but perhaps more significantly new processes that are of an interpersonal communicative nature. These processes could have an effect on existing dynamics within the workplace. This study can contribute valuable knowledge that will reflect back into both the industry and the education programs that prepare graduates in their careers. This thesis is significant because it has at its core the people who work in the industry and holds true because it comes from the lived experience of those people in the industry.

1.6 Outline of the Thesis

Chapter 1 of the thesis introduces the study. It outlines the context of the phenomenon, states the author's personal motivation to carry out this study. It expands on the research study aims and objectives. It states the research question and its significance for the design and construction industry.

Chapter 2 is a literature review covering subjects directly related to the research question. The Author has purposefully included subject areas surrounding the phenomenon, including referencing other industries engaged with a digital transformation.

Chapter 3 is a standalone description of the research method and methodology and the rationale for the chosen research design. The author describes the journey to phenomenology as the chosen research method and the methodology employed to extract data for analysis.

Chapter 4 shows how the findings emerged using the analytical method to bring forth the themes. The themes are described in preparation for their discussion chapter.

Chapter 5 presents a discussion on the four themes of Identity, Empowerment, Disarrangement and Collaborative Practice and their accompanying motifs referencing them back into the literature.

Chapter 6 Offers a conclusion to the study and discusses the themes with the implications for both the AEC industry and AEC education. The research limitations are highlighted, and an outline for future research on the subject is discussed.

Chapter 2. Literature Review

2.0 Introduction

This research sets out to answer the question: "With the introduction of BIM into the AEC workplace environment, what, if any, has been the impact on the social dynamics of engaged professionals in the workplace?" This study draws on previous literature surrounding the topic of BIM and of the concept of social dynamics. The literature review headings go out wider than the specific subject area but are relevant to this research as the design and construction industry is broad, complex with many actors who have different perspectives on the same subject. The literature review will be presented under the following headings. BIM: Quid est hoc? (what is it), Digital Transformation; Collaboration, Collaborative Environments; Organisation for BIM, Implementation Frameworks and Maturity Levels; Social Dynamics, Hierarchies and Networks; and Current Trends in BIM and BIM Education.

2.1 BIM: Quid est hoc?

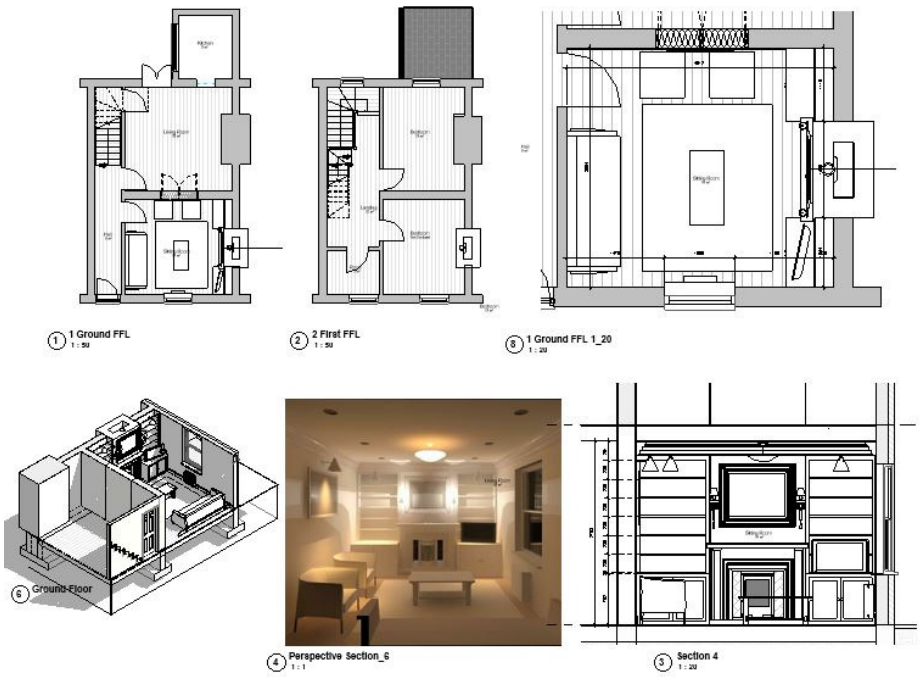


Figure 2.0 Authors own work; Plans, Sections, Elevations 3D View and Realistic Render views all from a single building model.

One might think that BIM needs no introduction, but it should come as no surprise that currently, BIM is an ambiguous term that means different things to different

> *professionals. This was also confirmed by empirical results found by this study indicating that BIM is not only defined in various ways according to particular professions but that there is also confusion at three different levels; for some, BIM is a software application (1); for others, it is a process (2) for designing and documenting building information; for others, it is a whole new approach to practice and advancing the profession which requires the implementation of new policies (3), contracts and relationships amongst project stakeholders.* (Aranda-Mena, Crawford, Chevez, & Froese, 2009, p.2)

Multiple BIM definitions are a consequence of the multidiscipline nature of the design and construction industry where different organisations and people create their own definitions of BIM based on the specific way they work with BIM. Thus, it is evident that there are differences in the way BIM is perceived by both different individuals and organisations within the design and construction industry (Abbasnejad & Moud, 2013). When looking at the development of what is most commonly understood in the literature as BIM, there is no indication that it is synonymous with one all-encompassing software solution (Holzer, 2007). There are many definitions and understandings of what BIM is, and in many ways, it depends on the perspective of the user or what is sought to gain from the approach (Abrishami et al., 2014). For instance, an Architect's BIM can be different from an Engineer's, which can be different from a Contractor's. However, BIM is both a technology and a process (Kubicki et al., 2019) it is both an artefact (a digital simulation of a physical building) and an activity (the interaction of a procurement supply chain using information and data created and contained in the artefact for use in the activity).

CAD and BIM technologies have a history that can be traced back to the 1960s. Ivan Sutherland and his Sketchpad program was a notable innovation (Sutherland, 1964). Solid modelling programs began to appear, building on developments in geometry's computational representation (Bergin, 2014). In the 1970s, the development work on constructive solid geometry (CSG) which when coupled with Boolean data type using two values of "true" and "false" allowed a designer to digitally "sculpt" form (Johnson, 1963). Around the same period of time "boundary representation" was being developed in the UK by Ian Braid at Cambridge (Braid, 1975) and in the USA by Bruce Baumgart at Stanford (Baumgart, 1974). Boundary representation (BREP) which is called surface

modelling gave more flexibility to the designer because it had a more extensive tool-set facilitating the production of more complex shapes. Both solid modelling and surface modelling remain essential techniques used to create "parametric" objects in BIM technology. These advances were productive but the seminal moment that powered the advance of BIM technologies was the use of a SQL database (Malaikrisanachalee & Vathananukij, 2010) to drive the graphic simulation and to capture and hold data associated with the graphically simulated objects. This data could then be made available for use by stakeholders in the process.

To understand the difference in a process facilitated by BIM technologies, it necessary to examine the philosophy behind representation (traditional) and simulation (new methodology). In this case, representation is a singular moment, an elevation, a section, a plan that is conceived from but is separate, separate in the manner that it is created separately to the overall building. Simulation is an "organic whole" where parts are intrinsically linked and dependent on the whole. Jonassen & Rohrer-Murphy (1999) argue that the principal role of a designer is to make decisions. Decision-making problems are generally well structured, whereas design problems are often ill-structured and require methods of investigation as part of an iterative cycle. (Jonassen & Rohrer-Murphy, 1999). When a designer moves from a world of representation to a world of simulation, they start seeing buildings through the lens of a database. The database allows the breakdown of architectural elements into its constituent components, and the building elements are categorised. These building elements are then broken down into categories of editable objects that have length, height and width, giving spatially coordinated volume. A new dynamic for design and construction is created, and the visualisation of this is compelling as a communication tool. Jonassen & Rohrer-Murphy (1999) state that as the nature of the problem varies, the nature of the thinking and activity required to solve those problems varies. BIM gives a designer (the creator of the artefact) and the construction professional (the consumer of the data) a tool-set that can bring better-informed variables to the decision-making process.

BIM spans across time dimensions from the concept design model to the facilities management/asset model. Jernigan (2008) argues that there are several inconsistencies and misinterpretations in definitions of BIM; consequently, each domain and the people who work within that domain will face challenges that are different in their intensity and

complexity. Perhaps the domains which will be most affected are those with the most in-depth legacies. Architecture, Engineering, Surveying, and Construction are the four domains involved in the procurement of buildings, often referred to as the supply chain. There are specialist services within the supply chain that are required in the complex world of modern buildings, but all can be connected back to one of the four main domains. It is worth examining each of the domains as this will provide a context to the examination of the lived experience of the professional.

Deutsch (2011) states that people are the crux, the key to advancing BIM and integrated design. Arayici et al., (2012) published a paper that investigated how BIM adoption for an architectural company helped to mitigate the management and communication problems in small construction projects. Part of the study reported on an action research approach for the BIM adoption process. The Architectural practice adoption process in the paper has been explained comprehensively under five themes thinking, creating, collecting, connecting, correcting. The paper has also critically elaborated on how BIM becomes a disrupter technology within each of those themes in architectural practice. Despite being a comprehensive study, the impact of BIM adoption on professionals working in the office is not mentioned. The action research methodology perhaps was not suitable to investigate and report on the social dynamics on the people directly involved. But this does highlight the focus on BIM technology and process rather than as Deutsch (2011) argues the importance of focusing on people, as they are the key to advancing BIM adoption.

2.1.1 Construction

Looking at the perspective of the "C" in AEC, Construction is as old as humanity itself. The requirement for shelter is a basic human need, and man has been constructing shelters for as long as history has been recorded. Our modern construction history for this research starts within the renaissance period and the separation of the master-builder into the Architect and contractor (Yates & Battersby, 2003). The master-builder was responsible for surveying, design, laying out the construction and selection of construction materials. He would have been Architect, Engineer, and Construction foreman. Unburdened in the modern era with the design of the building, the main contractor now concentrated on the construction of the building alone. Their aim is to deliver a building to the client while

realising the Architect's vision and creating a profit. Time is money soon became the mantra of the contractor (Herbsman, Chen, & Epstein, 1995).

Ku & Taiebat's (2011) research findings support the fact that BIM is growing as an essential component of construction operations. The advantages of creating a virtual digital construction model became all apparent to construction companies who were involved in a competing tender process. BIM has the potential to allow construction companies to estimate the cost of a project with more detail and accuracy while reducing the time and expenses needed (Sattineni & Bradford, 2011). Contractors who were at the sharp end of the procurement process and had to deal with the problems that arose from designs that were "represented" in 2D (Construction, 2014) surveyed the industry and found that:

- 75% of highly BIM engaged contractors perceive that BIM can capture the most detailed comprehensive information of a building project;
- 41% of contractors perceive that the reduction of design errors using clash detection as the top-ranking benefit of BIM adoption;
- 21-23% of contractors value efficiency in quantity take-off and cost estimating (reduced construction cost);
- 19% of contractors value 4D models to support construction analysis and planning.
  (4D is the dimension in the model covering construction sequencing).

Ahankoob, Manley, & Abbasnejad (2019) state in their survey findings that as contractors become more experienced in using BIM, they better understand the business values of BIM. The perceived efficiency in business processes by contractors denotes the positive influences of BIM on construction businesses. Watson (2011) reports that some contractors are already creating their own BIM models on projects where the designers have not used BIM. Others, over a period between 2013 and 2020, such as principal contractors Laing O'Rourke in the UK, and SISK and BAM in Ireland for example, have been actively promoting the use of BIM by their design partners and supply chain (BAM Supply Chain, 2021). As well as the advantages of highlighting design problems, the contractors can use the data to coordinate construction (Luth, Schorer, & Turkan, 2013).

One of the construction drivers is the current availability of BIM applications that link BIM models to established construction management software for programming and estimating/costing, delivering to the contractor valued 4D and 5D (5D relates to cost functions of the BIM model) capabilities (Watson, 2011) including nD for site coordination and health and safety matters (Sulankivi et al., 2010). In Ahankoob, Manley, & Abbasnejad's (2019) survey, they found 85.7% of the sample population from the AEC industry selected visualization and the generation of 3 D views as the primary use of BIM in their company. Identification of collisions between building elements was selected by 71.4% of the respondents as the second leading use of BIM, followed by quantity take-off and construction site layouts, which contributed to 53.6% of responses each.

2.1.2 Engineering

Engineering can be traced back to the Renaissance and beyond, but the rise of Engineering as a separate profession started in the 18th century. The first English engineering association, the Society of Civil Engineers chaired by John Smeaton, was created in 1771, and the second, the Institution of Civil Engineers in 1818. Globally, between 1750 and 1850, the engineering profession emerged (Picon, 2004). Professional Engineering itself recognises separate specialist disciplines, structural, civil, mechanical, electrical within its overall Engineering domain. Mechanical and electrical engineers design and install the infrastructure that makes a building work, including heating, ventilation, ICT and more. In the traditional design process, mechanical and electrical engineers were often presented with a building design mostly completed from the Architect. Consequently, they were not in a position to influence the design to maximize energy efficiencies (Fong, Goh, & Muhyiddin, 2018). Fong et al., (2018) state that mechanical engineers use copies of the Architect's plan layouts and overlay these with schematics directing "flows" such as hot and cold air, hot and cold water, acoustics, moisture and more (Wang Li & Leite Fernanda, 2014). The electrical engineers use the Architect's layouts and overlay these with schematics of cable runs, positions of equipment and control boards and more (Clevenger & Carey, 2010). Often the coordination of these building services was at best, hit and miss and often the first installation crew on site claimed the best route to the detriment of the following crews.

The 2D representation of building services caused costly alterations to both the building fabric and the estimated material cost of services installations (Grilo & Jardim-Goncalves, 2010). All significant headaches for the contractor, the designer and inevitably the client. Enter BIM, and now coordination of building services becomes a visualized reality and also brings with it its own set of added value parameters. The applied and data-driven nature of BIM makes it a good fit with the branches of engineering involved in building procurement (Dossick & Neff, 2009; Wang & Leite, 2016). BIM has a tool-set that can facilitate the engineer to become an early collaborator in the design and construction process. With the development of energy analysis applications for the digital model, mechanical and electrical engineers can now bring empirical evidence to the designer that can predict the building performance and directly influence the Architect's designed building form (Clarke, 2007).

2.1.3 Surveying,

Like engineering, surveying has a history going back to the great early Egyptian and Greek civilizations. More formal structures around surveying were established around the time of the first industrial revolution with a need to accurately lay out infrastructure and land boundaries. In 1792 the first Surveyors Club was formed in London which matured into the Institution of Surveyors in 1868, and it received its Royal Charter in 1881 ("Royal Institution of Chartered Surveyors RICS - Designing Buildings Wiki," n.d.). Whilst the first surveyors were concerned with the science of determining the three-dimensional position of points and the distances and angles between them, the Institute branched out into the area of professional management of land, property, construction and cost economics of building. As clients demanded stricter control of the cost of design and construction a new specialist emerged within the surveyor realm, the quantity surveyor or construction cost economist. The definition of a Quantity Surveyor according to one renowned Author (Seeley, 1997, p.40) is "a quantity surveyor is professionally trained, qualified and experienced in dealing with these problems on behalf of the employer. They are essentially a cost expert whose prime task is to ensure that the project is kept within the agreed budget and that the employer obtains value for money".

Both the professional and contractor's QS have roles and responsibilities in the pre-construction, construction, and post-construction phases on any given construction

project. They help to ensure that proposed projects are affordable and offer good value for money, helping the client and the design team assess and compare different options, and then track variations, ensuring that costs remain under control as the project progresses ("Quantity surveyor - Designing Buildings Wiki," n.d.). The traditional method of measurement involved taking the architects and engineers layouts and physically measuring off the drawings to quantify the building materials in an ordered manner to allow for totals to be calculated for costing purposes. Cartlidge (2012) states that bills (bill of quantities) are occasionally criticised in some circles as being outdated and unnecessary in the modern procurement environment. Methodologies have been developed and incorporated into digital spreadsheets as a checklist to ensure all items were accounted for. A long, laborious process that relied on the accuracy of the 2D drawing set and the experience of the quantity surveyor to accurately measure and calculate. Olatunji et al., (2010) argued that the work methodology of the quantity surveyor changed immediately with the introduction of BIM.

Solihin, Eastman, Lee, & Yang (2017) pointed out that at its heart, the building information model is a database that visualises this data in a spatially coordinated three-dimensional model. The BIM database can be queried for a set of results that can be calculated in a currency, so a BIM database has the potential to automate measurement and facilitate the preparation of accurate estimates (Aouad, Wu, & Lee, 2007). This is a disruption of the current practice of measurement either from hardcopy plans or measurement from a 2D digital plan on screen. Fong (2003) states that the result of the quantity surveyors' contribution to the procurement remains the same, but it is the process of getting there that is changing. Wu & Issa (2014c) have argued that BIM offers the capability to automatically generate quantity take-offs and measurement directly from a digital model of a building, a process that traditionally is very time-consuming for quantity surveyors. For less complicated buildings, it is entirely feasible that the cost can be controlled by the creator of the model using schedule templates. Physically measuring the quantities can be reproduced virtually with an increase in speed and accuracy. This is a direct challenge to the work of the quantity surveyor. Digital transformation can see existing roles submerge and new roles emerge. Gu & London (2010) argue that a new role is emerging for QSs following a requirement for "validation" of data that travels with the BIM. They state that quantity surveyors are in a position to pitch for this type of work.

2.1.4 Architecture

> *Building Information Modeling (BIM) is fundamentally transforming modes of design practice and standards of building design, delivery, and operation. BIM has matured from object-based parametric modelling developed by innovative software companies and university research programs into suites of software programs widely used in the architecture, engineering, and construction professions.* (Kensek & Noble, 2014 , p.1)

Architecture is the original built environment profession and can trace its history back to the 1st century AD to the oldest surviving work on the subject of architecture "De architectura," by the Roman citizen Vitruvius. Vitruvius's three principles of firmitas (durability), utilitas (utility), and venustas (delight) are still the founding principles of architecture today. A most significant development, which in essence defined architecture and the Architect, came from the renaissance writer, sculptor, artist, and Architect Leon Battista Alberti, who elaborates on the ideas of Vitruvius in his treatise, "De Re Aedificatoria". Alberti believed that proper architectural knowledge concerned the means of arriving at the form of the building (Scheer, 2014). The construction of the building was the concern of the contractor and not the Architect, and with a limited amount of materials for building at their disposal, the Architect could rely on the contractor to understand the construction techniques required to fulfil the vision. Scheer (2014) states that Architecture became a purely intellectual endeavour, and the Architect's proper domain of knowledge was what we would call theory, the reasons why buildings should be designed in certain ways.

The craft of drawing is synonymous with the development of architecture. Lyn & Dulaney (2009) state that hand drawing provides unique contributions to and opportunities within the development of architectural thought and work. Maintaining sketching and precision hand drawing as fundamental activities of the Architect extends the post-Renaissance tradition of architecture as a distinct design discipline directed to architectural ideas and relationships. The construction methods used during the Roman Empire can be understood from architectural drawings of that time Lohmann (as cited in Čuš Babič & Rebolj, 2016). It is evident that throughout history, 2D drawing in architecture and construction has served the presentation/visualisation aims of the drawing as well as its

function as an analytical tool during the design stage, communication of the design intent, and as the instructions for on-site activities (Barnes, 2017). In many schools of architecture, a conflict between hand drawing and digital media continues to be perpetuated. While some argue for the computer as the "new pencil", others maintain that the pencil cannot be replaced (Lyn & Dulaney, 2009). Scheer (2014) goes on to state that the long tradition of drawing in architecture, with its influences on the thinking of architects and on the very nature of architecture is in question for the first time since the Renaissance. The divorce of design from construction theorised by Alberti and realised in modern practice is being overthrown by the replacement of drawing (representation) by simulation.

BIM entered into mainstream Architecture in and around mid-2000, and according to Scheer (2014) it presented the first serious challenge to a tradition lasting over 500 years. Susskind & Susskind (2015) argue that a digital transformation is set to disrupt architecture and architects where technology will not destroy the profession but it will democratise it. The replacement of drawing by simulation is overthrowing the separation of "design" and "construction" (Scheer, 2014). One added value of BIM in architecture is that simulation informs on building performance. Eastman et al., cited in Kensek & Noble (2014) argue that there seems to be broad recognition that architectural design will have an increasingly strong analytical base. The digital model provides a platform for predictive analysis of "flows." Flows are air, energy, moisture and acoustics all affected by sunlight, barometric pressures, materiality, architectural form and human occupancy. Kolarevic (2004) states that another kind of architecture is also emerging, using building performance as a guiding design principle and adopting a new list of performance-based priorities for the design of cities, buildings, landscapes, and infrastructure.

Traditional building procurement was based on a hierarchy and a separation of the professions indicated in Figure 2.1, who link through a linear movement of information with the initiator of the information (most often the Architect) controlling the flow of information (Davis, Love, & Baccarini, 2008). This model of information distribution is disrupted by a collaborative platform provided by cloud-based digital technologies and the common data environments highlighted as part of the BIM process.

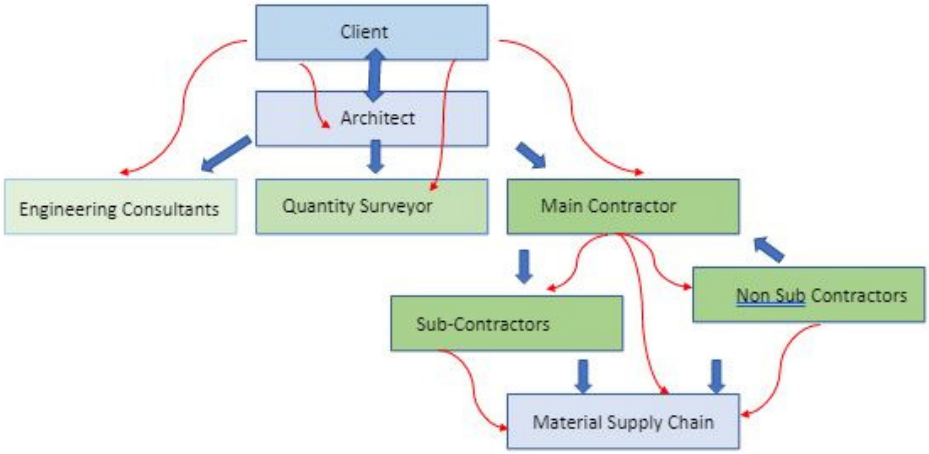


Figure 2.1, Author adapted from (P. Davis et al., 2008) showing the traditional hierarchy and separation of the professions in AEC.

The movement of information arising from this hierarchical process is sometimes described as sequential "over the wall" syndrome as reported by Hassan et al., (2018). The social dynamics of this are driven by the fragmented nature of the data supply in the industry and will bring difficulties to all professions and the supply chain resulting in delays, late supply and constructability related issues often pitting the contractor against the design team and client.

Kolarevic (2004) further states that while the legal definition of the Architect's role was becoming more defined, they were in effect losing control of the decision making in the building process. Facilitating collaboration amongst project stakeholders in the construction industry is one of the central tenants of BIM (Poirier, Forgues, & Staub-French, 2017). The fission of the past is giving way to digital fusion (Kolarevic, 2005). There is the potential of a single model to unite design and construction reestablishing not the master builder but the master-builder team.

2.2 Digital Transformation

> *Kodak's middle managers, culture, and rigid bureaucratic structure hindered a fast response to new technology which dramatically changed the process of capturing and sharing images. The film is a physical, chemical product, and despite a succession of new CEOs, Kodak's middle managers were unable to make*

a transition to thinking digitally. Kodak has experienced a nearly 80% decline in its workforce, loss of market share, a tumbling stock price, and significant internal turmoil as a result of its failure to take advantage of this new technology. (Lucas & Goh, 2013, p.1)

Boulton (2018) tells us that Westerman, a principal research scientist with the MIT Sloan Initiative on the Digital Economy, describes a digital transformation as a rethinking of how an organisation uses technology, people and processes to change business performance radically. The notion of 'disruption' and particularly that of 'disruptive innovation' is now widely used by researchers as well as management practitioners, and the construction industry is being described as ripe for disruption (Ernstsen et al., 2018).

It has been argued that digital transformation poses an even more significant perceived threat for several reasons: (Buisman, 2018, p1).

- *Technology is always changing — knowing where to start is not obvious, and the learning process never ends.*
- *For most people, implementing/using technology requires learning a new set of skills, and the learning curve can be steep.*
- *Embracing and implementing technology does not guarantee future success; in fact, most tech professionals and innovators will recommend the "fail fast" model — fail fast, learn, move on.*
- *There are no right answers — just educated bets based on calculated risk and perceived rewards.*

Caudron & Van Peteghem (2014) have shown that when a digital transformation takes hold, disruption can be expected. Having transformed retailing, publishing, travel and financial services, digital technology is changing the way we plan, build, maintain and use our social and economic infrastructure (Office HM, 2015). The next stage in the digital revolution has begun. Christensen (2013) states that the list of companies that have failed when confronted with disruptive changes in technology and market structure is a long one.

It is worth examining how digital transformation has directly affected other industries to give a context for changes happening in the design and construction industry. Christensen

et al., (2013) define sustaining innovations as incremental improvements on the dimensions traditionally valued by customers. Vaara (2010) states that disruptive innovations introduce a new value proposition. They either reshape existing markets or create new ones out of the blue. Rogers (2003) in his seminal book "Diffusion of Innovation," states that some innovations create a high degree of uncertainty, an uncomfortable state that may foster resistance to the technology. This uncertainty is one reason for the particular difficulties that computer technologies often encounter in the implementation process.

The music industry is an industry that directly and indirectly affects most of human society. It was one of the first industries to feel the full effect of digital transformation. Leyshon (2009) carried out an analysis of the musical economy, which has undergone significant changes since the 1990s as a result of software applications that have both enabled the Internet and developed compression programs such as MP3 that tipped an already struggling industry into a full-blown crisis of reproduction. The music industry has spent a decade and more grappling with the technological invention, continually reinventing itself. All facets of the industry have been affected. At its outset, music is created, as are buildings, as a translation of creativity into a form of expression that becomes a commodity for a multi-user experience. The start and the end of music and building creation are comparable; it is what happens in between the start and finish that is of interest to this study. Just as music was the first to encounter the full force of digital disruption, so it looks set to be the first to re-emerge with a value chain entirely reinvented for digital (Thomas, 2014). The creation process has benefitted from digital technologies allowing broader participation of artists with direct to consumer (D2C) platforms. The overall effect of digital in the music industry has been to democratise content creation, distribution, and consumption — a situation un-dreamt of a decade ago. The threat is to their revenue stream rather than the music itself, but the revenue stream they had grown dependent on was built upon the basis of inconveniencing their customers, through the introduction of new formats every decade or so (O'Dwyer, 2014). Plasketes (1992) describes how this is not unusual in the history of the music industry, given every advance in recording has been accompanied by the cries of those whom technology has left behind.

Millar, Lockett, & Ladd (2018) relate that relatively little academic research been published on the impact of disruptive technology on macro-systems such as societies or

ecosystems, or on specific strategies and instruments to leverage, mitigate, or ameliorate systemic disruption. Relatively little attention has been paid to the broader social impact of disruptive innovation and the inter-relationships of social, technical, environmental, and economic factors that pave the way for disruptive innovation and lay the foundations for adoption, success or failure (Millar et al. 2018).

2.3 Collaboration and Collaborative Environments;

2.3.1 Collaboration

Patel, Pettitt, & Wilson (2012) suggest a critical success factor for any community at work and outside work is the extent to which it can coordinate itself to communicate and achieve common goals, in other words, to collaborate. Abercrombie's (1961) research in England in the 1950s made a compelling case for discussion methods of teaching, contending that when people work in teams, they make more valid judgments than when working alone. This pioneering research had a profound impact on collaborative learning in medical education both in England and North America. Abercrombie (cited in Bruffee, 1999, p.12) showed that her medical students learned the critical element in successful medical practice: diagnosis, that medical judgment was arrived at more quickly and accurately when they worked collaboratively in small groups than when working alone. What is now standard medical practice in terms of collaborative diagnosis on hospital "rounds" was not always the case. Medicine has since transitioned from these humble beginnings to its current position as an assertive, scholarly discipline practising "evidence-based medicine" (Brown & Corry, 2011). Abercrombie pioneered the practice of getting medical students to examine the patient together, then to discuss the case as a group and arrive at a consensus being a single diagnosis that they could all agree on. Comparisons between the medical profession and the building profession are worthwhile in terms of the similarity in the growth of specialisms to address complex problem solving using a collaborative methodology. There is also a similar story in terms of the use of information technologies and simulated digital technologies for data and knowledge sharing. Medical diagnosis recognises that there are different levels of collaboration. The use of computer technology within medical decision support is now widespread and pervasive across a wide range of medical areas. Computer-aided diagnosis, as a relatively recent interdisciplinary methodology, interprets medical images by computer technology

(Gorunescu et al., 2011). As a problem arises and develops, it can be advantageous to invite specialists into the collaborative group who will add to the knowledge base. This might be short-lived or medium to long term involvement, but the specialist is on call to assist in moving the problem forward on a shared goal and often co-located basis using ICT technologies. The medical profession strives to be a collaborative multidisciplinary profession made up of many elements. It is the health of the patient, life and death, which unites the group in a shared goal culture.

The concept of "re-acculturation" is Bruffee's word for the process through which we switch membership from one community to another and the vital role of communication and information in the re-acculturation process. Bruffee (as cited in Kieran et al., 2007) defines it:

> *"Re-acculturation involves giving up, modifying, or renegotiating the language, values, knowledge, and mores that are constructed, established and maintained by the community one is coming from and becoming fluent in the language and so on of another community."*

Patel et al. (2012) state that collaboration is understood through people's interactions with each other, technology, information and the environment. Instead of being just considered as a technology, BIM is becoming a systematic method and process that is changing the project delivery. Porwal & Hewage (as cited in Zou, Kiviniemi, & Jones, 2017) state BIM promises to become a new international benchmark for building design and documentation across the industry based on improved efficiencies and collaboration capabilities (Aranda-Mena et al., 2009). BIM process is very much about collaboration. Collaboration is a social, human function and one that is not widely addressed as a skill in third level-built environment education. The current system of 3rd level built environment (BE) education is domain-specific, siloed and a divisor. (Spence et al., 2001). The opportunities for cross-domain experience in undergraduate BE education are minimal. It is quite clear that to improve the education of professionals for the built environment, we must improve how the various disciplines work together. The model Spence et al. (2001) proposes starts from the basis of the separate disciplines but promotes more significant relationships between the disciplines as education progresses. It leads to a breaking down of the narrow professional definitions of the disciplines and growth of

interdisciplinary knowledge and skills (Spence et al. 2001). It seeks to develop a building profession, not unlike the medical profession.

Achten & Beetz (2009) conducted a comprehensive literature review of all papers on the development of collaborative design published between 1983 and 2008. They conclude that:

> *Despite the many publications on collaborative design, it seems to be the case that there is still no agreement on a common definition of what collaborative design is. Much of the work in the field is technology-driven. By itself, this is no problem, but there is a strong tendency not to do any reality-check how much of the work is applicable in practice or to see what the actual demands from practice are.* (Achten & Beetz, 2009)

They go on the conclude that it is taken as an article of faith that collaboration "is a good thing," but there is almost no paper that does not identify (non) technical problems, frustrations, and hindrances to achieve collaboration and that given the increasing amount of collaboration in practice, this is probably an indication that the pedagogical and institutional setting of universities in this respect is disconnected with practice. I address these concerns in Chapter 6.

Fioravanti (2008) states that fundamental components of these design problems lie in a low and selfish collaboration among actors. Cloud-based collaborative BIM facilities provide a technical platform for collaboration, but it is his stated problem that poses a more complicated solution. Clayton et al., (2010) argue that the adoption of BIM disrupts the patterns of education that have been used throughout the past century. It is the educators that are more challenged than the students they teach to come to terms with reevaluating their pedagogy under the disruption that a digital transformation brings. However, there is now a growing number of academic papers describing examples of undergraduate and postgraduate cross-disciplinary BIM facilitated collaborations. (Becerik-Gerber, Ku, & Jazizadeh, 2012; Eadie et al., 2014; Thomas, Chisholm, Dempsey, Graham, & Stubbs 2014; Comiskey et al., 2015; Mathews, 2015). Research into collaboration emerges from a large number of disciplines and professional fields.

The exhaustive literature for all the factors and sub-factors relevant to collaboration is vast. (Patel et al. 2012) describes the factors of collaborative working: which is a framework for a collaboration model bringing together a large volume of academic papers dealing with collaboration from fields including psychology, business and management science, organisational and social psychology, and ergonomics/human factors (including joint cognitive systems and distributed cognition).

> *Application areas searched were primarily engineering, design, business, healthcare, and education. The literature base was extended and tested through a program of user interviews, user workshops, expert brainstorming sessions in the aerospace, automotive and construction sectors. Through a systematic review of the researched data, they built a summarised table of the main factor groups that form the framework for a model of collaboration. Many of the factors can be collaboration enablers or inhibitors, depending on how they are implemented and supported.* (Patel et al., 2012)

Patel et al. (2012, p. 21) further argue that It is clear that collaborative work is an inherently complex phenomenon. Patel's et al., the paper does not explicitly address BIM, but it provides valuable insights into and examples of existing workplace collaboration in the industry. Many researchers focus on the discussion of BIM technology. Few research papers address the importance of the collaborative process of BIM implementation (Lu, Zhang, & Rowlinson, 2013). What the (Patel et al., 2012) model does describe are relevant factors which companies can use to think about how they currently collaborate and identify where and how they do things well and where there is room for improvement and the CoSpaces Collaborative Working Model (CCWM) will also be useful for researchers in the future in providing a framework within which to assess collaborative performance, design new collaborative working structures, and evaluate collaborative working solutions.

2.3.2 Collaborative Environments

Collaboration not only happens at the person to person level but also, at the organisational level. Little attention has been given to inter-organisational collaboration in BIM-enabled construction projects. There is no clear evidence of successful collaboration approaches

of BIM adoption or the reasons BIM collaboration may potentially fail (Lu et al., 2013). However, many studies show that inter-organisational collaboration can improve the competitive advantage of firms, facilitate innovation, promote coordination and productivity, and other tangible and intangible collaborate benefit (Amabile et al., 2001). Professionals may establish a working relationship based on a mutual objective, but conflictual relationships and problems may arise during the work. Different collaboration attitudes and various personalities of professionals stimulate various relationships. These relationships may create either a positive or negative influence on the final project outcomes (Lu et al., 2013). The potential for future collaboration relies on cognitive perception, trust, and planning. Participants in the relational exchange can achieve social satisfaction when engaging in a relational exchange (Dwyer et al., 1987). Few scholars identify the importance of collaboration environment characteristics, despite the fact that a collaborative context is more likely to be successful (Amabile et al., 2001).

Collaboration practice has its own International Standard (ISO 44001) *ISO 44001:2017.* It specifies requirements for the effective identification, development, and management of collaborative business relationships within or between organisations. Richards (2010) states that BS 1192 (British Standard 1192) is the AEC industry standard for managing the production, distribution, and quality of construction information. The first edition was BS 1192-5:1990, which was replaced in 1998 by the second edition, BS 1192-5:1998. The third edition, 'Collaborative production of architectural, engineering and construction information. Code of practice' was published on 31 December 2007 and provided a complete code of practice that could be applied to 2D and 3D model-based information systems.

It is essential to distinguish between cooperation and collaboration in the procurement of a building. Definitions are often tailored to a particular environment (Patel et al., 2012). The two terms are often used interchangeably in most workplaces: collaboration and cooperation. Though they seem similar, they are quite different from one another. Researchers such as Kozar agree that it is vital to make a distinction between cooperation and collaboration (Kozar, 2010). The critical difference between these approaches to group work is that cooperation is more focused on working together to create an end product. At the same time, successful collaboration requires participants to share in the process of knowledge creation (Dillenbourg et al., 1995).

Collaboration is a human social activity that happens on many different levels. The social aspect of collaborative working is one that enables a sense of community, democratic interaction, teamwork and leadership with ease of communication, Owen, Grant, Sayers, & Facer, (cited in Adamu et al., 2015). Deutsch (2011) states that implementing BIM is an inherently social act. It is synonymous with sharing and collaboration. BIM is a collaborative approach to construction that involves integrating the various disciplines to build a structure in a virtual and visual environment (Lu et al., 2013). The Merriman-Webster (Merriman-Webster, nd.) dictionary definition of collaboration highlights two meanings:

- The action of working with someone to produce something;
- Traitorous cooperation with an enemy.

Trust is a social phenomenon; as such, an artificial model of trust must be based on how trust works between people in society (Abdul-Rahman & Hailes, 2000). Deutsch (2011) argues that trust is a critical factor for collaborative working; it is inherent in the need for meaningful social relationships among people who work together. To develop an understanding of the dynamics of knowledge creation, it is necessary to read into the creation of organisational knowledge and its transference from individual to group and its impact on the lived experience of the individual. Berger & Luckmann (2011) have published on the social construction of reality, and this refers to the theory that the way we present ourselves to other people is shaped partly by our interactions with others, as well as by our life experiences. The reality of everyday life is shared with others. However, how are these others themselves experienced in everyday life? Again, it is possible to differentiate between several modes of such experience. The most crucial experience of others often takes place in a face-to-face situation, which is the prototypical case of social interaction. All other cases are derivatives of it.

Nonaka (1994) states that organisational knowledge is created through a continuous dialogue between tacit and explicit knowledge. Tacit knowledge being the knowledge that is understood or implied without being stated. Explicit knowledge being that which can be expressed in words, numbers, and symbols, stored in books, computers, that can be articulated and easily communicated between individuals and organisations. Nonaka (2014) goes on to argue that while individuals develop new knowledge, organisations

play a critical role in articulating and amplifying that knowledge. Nonaka's paper deals with large scale organisations, but it can be referenced within a multidisciplinary collaborative team setup using a BIM procurement process. Nonaka's "four modes of knowledge conversion" socialization, combination, internalization, and externalization have strong resonance in the workings of a BIM-based multidisciplinary team although it has limitations in terms of multidisciplinary BIM team knowledge creation (Fong, 2003a). Each of the team members come to the table equipped with knowledge within their domain and experience of working with other design and construction professionals. Within the BIM collaborative, they are being asked to move from their domain-based community to a new open community. This challenges their working ethos and previous position (Bruffee, 1999). The team members' position could have been as a leader, the data keeper, or as a cooperative actor waiting to be called to play their part. The presuppositions of their place in the process are derived from the experience of traditional procurement, and the people involved can feel very comfortable within these positions. Procuring a new building or retrofitting an existing building can encapsulated and compared to developing a new product where a new product can be considered as a package of features and benefits, each of which must be conceived, articulated, designed and operationalized, or brought into existence (Dougherty, 2012).

Creating new knowledge and perspectives is fundamental to new product development. New product development often involves cross-functional linkages, where different participants join a team with differing viewpoints (Fong, 2003b). Fong states that project team members with diverse skills, knowledge, and experiences are required to work together to resolve the issues or problems encountered in a project. A team can be viewed as a socially constructed phenomenon or linking mechanism that integrates individuals and organisations (Horvath et al., 1996). Kasl, Marsick, & Dechant (1997) show how a model of team learning can be applied to multidisciplinary collaborative BIM team learning. The team learning model assumes that people in teams can learn collectively and that this learning is significant because of the growing importance of teams to organisational performance.

They later on expanded their definition of learning to acknowledge that learning involves the interplay of individual and group values, beliefs, norms, knowledge, and behaviour with that of the collectivity in which the individual or group is embedded. A significant

finding is that the collaborative nature of multidisciplinary project teams is essential in creating new knowledge (Fong, 2003a). Fong then extends Nonaka's four modes of knowledge conversion model to a more specific five-point model, including the processes of boundary-crossing, knowledge-sharing, knowledge generation, knowledge integration, and collective project learning. Fong's undated model is more specifically aimed at built environment multidisciplinary teams.

Fong (2003a) produced a model of the interrelationships between multidisciplinary knowledge creation processes. Through these interwoven processes, new or emergent knowledge is created within the project team. In constructivism, learning is represented as a constructive process in which the learner is building an internal illustration of knowledge, a personal interpretation of experience (Amineh & Asl, 2015). The physical environment plays a role in collaborative learning. Cognitive tools help learners to interpret and manipulate aspects of the problem; conversation/collaboration tools enable communities of learners to negotiate and co-construct meaning for the problem, and social/contextual support systems help users to implement the constructivist learning environments (CLE) (Jonassen, 1999). Jonassen's work on designing CLE's written before the mainstream adoption of collaborative BIM technologies bears scrutiny. The primary goal of this theory is to foster problem solving and conceptual development. It is intended for ill-defined or ill-structured domains. Building design can be a wicked, ill-defined, and ill-structured problem (Jonassen, 1999). Jonassen's model for designing CLE's is relevant as an educational learning model for collaborative teams, and it is relevant for multidisciplinary collaborative BIM procurement.

The goal of the learner is to interpret and solve the problem or complete the project. Related cases and information resources support understanding of the problem and suggest possible solutions; cognitive tools help learners to interpret and manipulate aspects of the problem; conversation/collaboration tools enable communities of learners to negotiate and co-construct meaning for the problem; and social/contextual support systems help users to implement the CLE (Jonassen, 1999).

2.4 Organisation for BIM; Implementation, Frameworks and Maturity Levels

Deutsch (2011) in his book BIM and Integrated Design, attests that the critical problem of BIM implementation in the workplace not being technology or business value propositions or even return on investment, but people. He stated that the challenge is the social implications of technology and the associated work processes on firm culture and workflow brought about by implementing BIM. The National Building Specification (NBS) has a BIM Survey now is in its tenth year of annual publication and provides an insight into BIM adoption and implementation: "We have been monitoring BIM adoption in the UK for almost a decade, and during this period, the overall trend of BIM awareness and adoption has grown from little more than 10% in 2011 to around 70% in 2019. However, the latest survey shows some stagnation in adoption" (Shillcock & Advisor, 2019).

Evidence from the annual NBS survey indicates stagnation in the adoption of BIM, and this raises a question as to why this is the case. Shillcock & Advisor (2019) state that BIM necessitates significant change within an organisation and almost all respondents agreed that it requires changes to workflows, practices, and procedures. In 2019, the NBS asked the following question in one section of the report: "What are the barriers to using BIM?" (NBS, 2019. p. 22). There are fifteen different reasons given as barriers to BIM plus a final "other" catch-all. Of the fifteen reasons given, the following nine are directly related to people, professionals working in the industry:

- No Client demand
- Lack of in house experience
- Lack of training
- No time to get up to speed
- The projects we work on are too small
- Lack of collaboration
- The difference of expertise among collaborating parties in a project
- Don't see the benefit

- Unsure of the Government commitment to BIM (NBS, 2019)

How organisations go about assessing BIM suitability is a subject raised in published literature (Ganah & John 2013; Desai 2013) and the actual implementation of BIM has also been studied (Coates et al. 2010; Homayouni, Neff, & Dossick 2010; Murphy, 2014). Succar & Kassem (2015) define "BIM implementation" as the successful adoption of BIM tools and workflows within a single organisation and BIM diffusion as the rate BIM tools and workflows are adopted across markets. Succar (2010) defines BIM Maturity as the quality, repeatability, and degree of excellence within a BIM Capability and BIM Capability is the basic ability to perform a task or deliver a BIM service/product. Since April 2016, the UK Government has mandated that all Government commissioned construction projects to require BIM Level 2 compliance. The concept of BIM Levels (and BIM Level 2 compliance) has become the accepted definition of what criteria are required to be deemed BIM-compliant (McPartland, 2014).

The UK target maturity is defined as Level 2 BIM. It is distinguished by collaborative working that requires an information exchange process that is specific to that project and coordinated between various systems and project participants (Level 2 Standards - BIM Level 2 Guidance, n.d.). The British Standards Institution (BSI) describes BIM Level 2 maturity as a series of domains in which collaborative federated models are created. Each party can coordinate their models with those produced by other organisations to make a series of coordination checks (BSI, 2016). BIM concepts and tools encourage concurrent revolutionary and evolutionary changes across organisational scales — from individuals and groups, through organisations and project teams, to industries and whole markets (Succar & Kassem, 2015).

The multidisciplinary collaboration and the use of BIM require changes in the traditional roles, contractual relationships, and collaborative processes between the building actors, especially architects, engineers and builders (Sebastian, 2009). Traditional roles within the design and construction workplace are being disrupted by BIM implementation. New roles are emerging, and existing roles are being challenged both by new technologies and the process involved. The application of BIM to support an optimal cross-disciplinary and cross-phase collaboration opens a new dimension in the roles and relationships between the building actors (Sebastian, 2009). 2D CAD was the primary delivery application in a

traditional design process; this is considered a closed system. BIM applications are considered to be open systems. An open (collaborative) application disrupts the traditional role of the architect. The architect wants to remain in charge of the design performance. The architect is also anxious that the design creativity would be reduced or limited if detailed information is required since the early design phase (Sebastian, 2009).

Many papers cover the subject area of BIM Frameworks, by definition, a framework is a systematic set of relationships or a conceptual scheme, structure, or system (Jung & Joo, 2011). Singh, Gu, & Wang (2011) presented a conceptual framework that categorizes the features and technical requirements for a BIM-server. Chen (2011) developed a conceptual framework for a BIM-based collaboration platform that contains the model of BIM-supported integration for construction processes and the technological architecture for the system. Macdonald (2012) describes the "IMAC" framework that has been developed from this work to assist educators in benchmarking their curricula and to develop strategies for improvement. Ding et al., (2014) present a framework to identify gaps of existing work and evaluate new studies in this area and gives an overview of BIM applications in the construction industry. A substantial amount of research for frameworks on BIM Technology and process implementation therefore exists.

2.5 Social Dynamics, Hierarchies, and Networks:

Horne & Seagal (1997) write on Human Dynamics as a body of work that identifies and illuminates innate distinctions in the way people function as whole systems that include mental, emotional, and physical dimensions. Human Dynamics is a body of knowledge that can provide tools and practices so people can understand and value each other's unique capabilities. The term collaboration conveys the idea of sharing and implies collective action, oriented toward a common goal, in a spirit of harmony and trust (D'Amour et al., 2005). These relationships have a direct effect on how professionals work and whom they can work with. Each discipline develops a robust theoretical and discipline-based framework that gives access to professional jurisdictions that are often rigidly circumscribed (D'Amour et al., 2005). D'Amour's research is set within the professional health industry but can be easily interpreted in the design and construction industry.

Hierarchical organisational models are not just being turned upside down—they are being deconstructed from the inside out (McDowell et al., 2019). Some people seem to find collaboration difficult, and they do not feel comfortable in that setting. It is worth examining why this is. Some professionals are more driven by competition rather than cooperation. Others feel like collaboration favours mediocre performers over superstars (Riegel, 2017). People who for reasons of personality, cannot delegate decision making and by compulsion must have control over decisions and the environment for decision making (Wilson et al., 2007). Adamu et al., (2015) explore social BIM (SBIM) as a sociotechnical model of BIM that enriches the co-creation process for Levels 2 and 3 BIM. They reference "shared situational awareness" as a relatively new theory defined by (Endsley, 1995) and how this is beneficial in explaining dynamic decision-making processes. Collaboration facilitated by BIM technologies can have all the intentions and attributes of such dynamism.

2.6 Current Trends in BIM Education:

Architectural representation can be described as a singular moment, a group of lines that represent a building elevation, or a section through the building, or a plan of the building at a selected level. These pieces of grouped linework should coordinate with the other groups of linework to form a representative picture showing the height, length, and width of the building and the elements within the building. Digital building simulation is an organic whole where parts, in this case, the building elements are intrinsically linked and dependent on the whole. A change to the plan results in instantaneously updated elevations and sections and vice versa. The "I" in BIM is now the dominant feature through the design, construction, and building operation (Azhar et al., 2012). Jonassen (1999) states that the principal role of a designer is to make decisions. The cognitive perspective on what is a problem can be considered as a question to be resolved. Decision-making problems are generally well structured, whereas design problems are often ill-structured and require methods of investigation as part of an iterative cycle (Jonassen & Rohrer-Murphy, 1999). When a technical designer moves from a world of representation to a world of simulation, and they start seeing buildings through the lens of a database, where the database allows the breakdown of architecture into its constituent components, the building is categorized into building elements. The building elements are broken down into the categories of editable objects that have length, height and width, giving

spatially coordinated volumes, areas and perimeters. A new dynamic for a design created and the visualization of this is compelling as a teaching and learning tool. Jonassen (1999) states that as the nature of the problem varies, the nature of the thinking and activity required to solve those problems varies.

A 2011 UK Government report (Government Construction Strategy - Publications - GOV.UK," n.d.) recognized that BIM, and the resultant information management skill set, provides a solution to the problems that have beset the design, construction, and building operation industry. This strategy required collaborative 3D BIM with all project and asset information, documentation and data being digital on its projects from April 2016 (Underwood et al., 2015). The design and construction industry has, over the years, tried to develop systems as solutions to these inherent problems (Björk, 1992). Generally, these were based on providing portals to allow efficient sharing of information and communication, such as Autodesk Vault, e Portal, Build online. These were fundamentally flawed because again it was imposing a new technology on an old process. They are tackling the problems arising from the process rather than tackling the process itself. Azhar Salman (2011) argues that BIM brings added value to the design, construction and building operation process. There are active BIM organisations in Ireland providing the industry with information, conferences and training schemes. There is also a very active Irish based BIM forum on social media, and there is an active Irish Revit user group whose meetings are well attended. The industry BIM community in Ireland might be small at present, but there is ample evidence through conferences with published proceedings the Construction Information Technical Alliance (CITA 2015,2017,2018) and social media outlets that the community is growing. This growth and coordination happening in the industry are not currently happening within the BIM education community. McAuley et al., (2019) highlight that the (BIM) roadmap outlines a series of recommendations to deliver a broad awareness and upskilling learning framework for both educators and industry through a National BIM Education Taskforce within the educational and training pillar. At present, however, the National BIM Education Taskforce has not been established.

McDonald & Donohoe (2013) surveyed fourteen higher education institutes in Ireland to establish the level of BIM uptake in AEC curricula. There was a common consensus from the six respondents of the need for a multidisciplinary approach to student learning.

However, as reported by Eadie et al., (2014) the preferred mode of delivery for BIM modules for both introductory and advanced BIM, is that they are both standalone modules and used for collaboration with other built environment courses covering both theory and software. Comiskey et al. (2015) reported on two undergraduate multidisciplinary collaborative projects that have proved to be very worthwhile, providing essential learning for the students and academics alike. Kelly et al., (2015) report on an initiative to pilot a multi-disciplinary project with students from the Architectural Technology, Quantity Surveying and Construction Management programs to explore the challenges and opportunities that exist with this form of pedagogical approach at Galway Mayo Institute of Technology. Thomas et al., (2014) report on collaborative BIM learning via an Academia-Industry Partnership. This initiative saw undergraduate students from architectural technology, construction management, and quantity surveying partner up in a collaborative workgroup to match and mirror a commercial BIM project in their region. The industry partner, in this case, was a contracting firm who were successful in a tender for a design and build project. The project was a reasonable attempt at undergraduate BIM collaboration and highlighted a common problem. Thomas et al., (2014) report that whilst the group approach and collaboration worked well within each discipline, the extent of collaboration between the disciplines was less successful. This was a consequence of having two groups with different priorities for their respective year outcomes.

Another problem in undergraduate multidisciplinary collaboration is the level of technical know-how both with the technologies and also the process (Thomas et al., 2014). There is a requirement for a new educational approach to be developed to allow for undergraduate collaborative assessment that can be reflected in the domain assessment to count in end of year mark. An undergraduate multidisciplinary collaborative elective module is one possible answer. Referring back to the multiple definitions of BIM taken from the different perspectives of the viewer, there are multiple ways to introduce BIM into domain-specific educational programs. However, the introduction of multidisciplinary collaborative modules brings with it another unique set of problems (Ghosh, Parrish, & Chasey, 2015).

The BIM Academic Forum (BAF) is a UK based academic collaborative with a mission to create a dynamic group to develop and promote the training, learning and research

aspects of BIM through strong collaboration and cooperation to promote the academic aspects of BIM (Underwood et al., 2015). The survey carried out in 2015 reveals a disconnect between built environment disciplines. This disconnect in academic education leads directly to professional silos. There has been a substantial amount of literature written on how, where, and when BIM could be introduced into a domain-specific curriculum. (Sacks & Pikas, 2013) published a comprehensive report on; Industry Requirements, BIM State of the Art, and Gap Analysis within BIM education for construction, engineering and management (CEM). The report targets what they term CEM being the more applied / science spectrum of design and construction.

Small groups and specific individuals within the Higher Education Institutes in Ireland have recognized the educational benefits and value to the AEC industry of BIM and have integrated BIM learning into undergraduate courses particularly within the architectural domain and more specifically the architectural technology program. These courses are developing independently of each other and independent of a structured set of learning outcomes. This is evidenced in a 4th-year Architectural Technology dissertation which compiled a national matrix of the current BIM learning outcomes with the cooperation of four out of five institutes of education who provide their BIM learning outcomes and modules embedded into their Architectural Technology courses (Donoghue, 2015). His concluding recommendation is for an education forum that will include all higher education institutes to map BIM learning outcomes with industry requirements. He further concludes that standards are not standards if they only apply to the individual Institute of Technology or University.

A 2015 report by the BIM Academic Forum (BAF) set up in 2011, is a representative group from Universities and Institutes of Education across the UK and Ireland, provides evidence of a response being book-ended with high uptake in the participating top-performing domains and little efforts by the partly participating low performing domains. This has had the effect of creating a disconnect between built environmental disciplines and a high level of detachment. However, this does not deflect from the need to meet industry demand. One task of the BAF is to set out a Learning Outcomes Framework (LOF). Their first publication released in 2013 entitled “Embedding Building Information Modelling (BIM) within the taught curriculum” (Underwood et al., 2013) provided a first attempt to break down and establish the potential learning outcomes requirements of 3rd

level education. The learning outcomes are non-domain specific and non-technology specific. They concentrate more on the role that BIM will play in the development of a digital economy and the reasons why BIM is needed. This initial set of learning outcomes gives the design and construction industry the first clue in a requirement for new skill sets for AEC professionals and the development of new job roles. Hayden and McDonnell (2012) found very little evidence of interaction between built environment courses in Ireland. Abroad educational institutions have invested in BIM technology and have developed teaching strategies referred to in (Barison & Santos, 2010; Macdonald, 2012; Kim, 2011).

McAuley et al., (2019) state that the third level education sector continues to be seen as the primary entity for upskilling in BIM. However, upskilling in BIM technologies and process only becomes actionable in the workplace if the conditions to work in that environment exist. Graduate and postgraduate students enter into the workplace with new skills that have emerged from innovation in the design and construction industry and so affect the dynamic of the workplace. This research aims to find out what the effects are, if any, on the social dynamics of AEC professionals experiencing the phenomenon in their workplace.

2.7 Summary

The author has read extensively around the subject matter of the research question and presents a summary of that reading. The topics included in this literature review go beyond the specific subject area but are relevant to bring a fuller understanding to the reader because the AEC industry involves many actors who have different perspectives on the same subject. In section 2.1 the author asks BIM Quid est hoc? what is it. There are multiple definitions of BIM as a consequence of the multidiscipline nature of the design and construction industry, and each domain interacts with the BIM model and the data contained depending on their need. This section gives a background on the technology development pointing the way to the industry move from representation to simulation. Each of the primary professions are reviewed, indicating the challenges faced when BIM is introduced into the working process. The section on digital transformation shows how disruptive new technological innovation can be, citing the music industry as an example. Collaboration and collaborative environments are referenced in the next

section citing as an example the development of collaborative diagnosis in the medical profession showing how multidisciplinary practice brings benefits to the end user. The section references the difficulties faced in the design and construction industry at both personal and organisational level. Section 2.4 references literature surrounding BIM implementation, frameworks and maturity levels showing there has been a substantial amount of research in these areas but indicating a gap in the literature surrounding the lived experience of the professional in the workplace. Social dynamics, hierarchies and networks are relevant to the research question as technological innovations impact existing dynamics and structures and are referenced in section 2.5. Hierarchical organisational models and situational awareness are inherent in collaboration facilitated by BIM technologies and process. Finally in section 2.6, current trends in BIM education are examined and this is referenced into the discussion in sections 6.1 and 6.2.

Chapter 3. Research Design:

3.0 Introduction

Selecting a suitable research methodology was undertaken in tandem with developing the research question. The author had been teaching undergraduate and postgraduate students, listening to their stories, and from this caught glimpses of a phenomenon and wanted to learn more about it. After completing a Master's degree in eLearning, the author was familiar with education research methodologies. However, it became evident very quickly that this knowledge would not be sufficient for this study, so more study and research would be required to develop a deeper knowledge and understanding of research methodologies, particularly qualitative research approaches.

Action research was the first possible research methodology explored. This was suitable as a methodology to the author because of the availability of a cohort of professionals who had chosen to pursue postgraduate studies in BIM on which the author was the lecturer. This would have been suitable because of the central tenet of action research being a methodological cycle of planning, action, observation, and reflection over a period of years. Action research is very often set in education, where the researcher's actions become the practitioners' research. It is a model of professional development that involved the self reflective cycle of observation, reflection, planning and action described in Kolb's (1984) theory of learning (Robertson, 2000). As the research question evolved, it became less of an educational study and the author started to see with more clarity the basis of the phenomenon. Action research as a research methodology is more appropriate to an exploration of a personal approach to teaching, developing a pedagogy based around improving the teaching and the students learning. This was interesting and held merit but was not the right choice for this phenomenon. The research methodology needed to move from one based on observation to one based on testimony and could allow the study to move away from education and into the physical location of the phenomenon and this was the AEC professional's workplace, so the research methodology moved from action research into phenomenology to more closely align with the research question. The research needed to be more specific and more precise as to where the phenomenon existed; its physical location. This was not, as first thought in the education environment. This is where the seeds were sown but not where they grew and impacted. The focus

moved to a physical location, and this was at the workplace of the AEC professional because this is where the social dynamics take place.

Phenomenology is a qualitative research method that is used to describe how human beings experience a particular phenomenon. Learning about phenomenology was a long and challenging process; it cannot be done in isolation from other philosophical belief systems. The author undertook an online philosophy course to understand better how and why phenomenology developed as an alternate belief system to the more established research paradigms.

One reason for the gap in the theoretical and conceptual understanding of the impact of BIM technologies and processes on the professionals in the AEC industry can be traced back to the lack of a suitable research methodology to study the phenomenon. One of the goals of this study is to develop and test a research methodology with methods that other researchers can employ to gather and disseminate knowledge on the social dynamics of this phenomenon surrounding the digital transformation of the design and construction industry.l

3.1 Research Paradigms

Denzin & Lincoln (2005) define a research paradigm as a basic set of beliefs that guide action, dealing with first principles or the researcher's worldviews. Denzin & Lincoln also contest that a paradigm is a set of beliefs that guide action that can be viewed as consisting of three main elements; ontology, epistemology, and methodology. There are different views on research paradigms, and Savin-Baden & Major (2012) state that most research is done under the rubric of positivism or post-positivism. Al-Saadi (2014) defines positivism as an epistemological position focusing on the importance of objectivity and evidence in searching for truth, where the world is unaffected by the researcher. Also, in positivism, facts and values are very distinct, thus making it possible to conduct an objective and value-free inquiry (Snape & Spencer, 2003). Positivists, according to Crotty (1998) assume that all individuals experience phenomena in the same way, and their perceptions and experiences can be quantified. However, this view does not account for the complexity of human experience and the social world in which humans interact, and the positivism research paradigm leaves out the common meanings of social phenomenon (Denzin & Lincoln, 1998). It also fails to ascertain deeper

underlying meanings and explanations (Rahman, 2016). The post-positivist social researcher assumes a learning role rather than a testing one Agar (as cited in Antonesa et al., 2006). Clark (as cited in Racher & Robinson 2003) has suggested that researchers and their perceptions are not detached from the inquiry. Guba & Lincoln (1994) identified what they deemed the four main paradigms social researchers use.

- Positivism
- Interpretivism
- Critical theory
- Constructivism

Positivism is a research paradigm used in the research world where scientific methods are verified and knowledge is something to be discovered. Its ontological assumptions are that reality is objective, and value is placed on rationality and truth. The researcher is neutral and lets the facts propose meaning.

Interpretivism is another paradigm and another way to approach knowledge. Interpretivism posits that social phenomena do not exist independently of our interpretation, but it is the interpretation or meaning-making of the interpretation that gives the social phenomena a reality. It is the researcher's active role in interpretivism that distinguishes this paradigm from positivism. Interpretivism is a line of inquiry on human activity viewed through the lens of text, text as a collection of symbols expressing layers of meaning, such as phenomenologists following an interpretivist line of inquiry work with interview transcripts. Researchers rely on the repeated reading of the text while being hermeneutically self-aware of pre-suppositions, the researcher sets out to capture the essence of the related lived experience. Miles and Huberman (1994) argue that this approach will lead to a practical understanding of meaning and action.

Critical theory seeks to challenge world views and the underlying power structures that create them. Guba & Lincoln (1994) place hermeneutic-dialectics at the centre of constructivist inquiry and they describe this as a process by which constructions entertained by the several involved individuals and groups are first uncovered and plumbed for meaning, and their constructivist methodology is both iterative and recursive.

Miles and Huberman (1994) state that social anthropologists will often start with a theory or conceptual framework which they bring out into the field for testing and refinement. Ethnography as a research paradigm is most closely associated with this methodology involving extended contact with a living community. The analytical method tends towards the descriptive with the use made of multiple sources, language, artefacts, rituals and relationships often expressed as patterns or rules around the society

Collaborative Social Research methodology can take two forms; first, reflexivity, specifically where the research and researcher remain in a questioning stance, this is typical of action research method with its cycle of planning, action, reflection and repeat. A second form this could take is termed dialectics, where researcher and activists have an opposing interpretation of the data. Miles and Huberman (1994) state that the analytical work here is in the creation and use of action related constructs and unpacking of taken for granted views, detecting the invisible and oppressive structures.

This research is set to a hermeneutic phenomenology methodology; the interviews are guided by Van Manen (1990), Gadamer (1997) and Ajjawi & Higgs (2007) research approaches.

Creswell (1998) states that a qualitative research design framework involves three fundamental elements; knowledge claims, strategies of enquires and methods of data collection. Savin-Baden & Major (2012) outline several different philosophies that qualitative researchers frequently work within; pragmatism, phenomenology, postmodernism/structuralism, social constructionism, and constructivism. Qualitative research examines people's words and actions in narrative or descriptive ways more closely, representing the situation as experienced by the participants (Maykut, Morehouse, 2002). A phenomenological approach is a focus on understanding the meaning of events for persons being studied (Patton, 1990).

Ontology and epistemology are philosophical positions taken by researchers that directly shape the researcher's approach to a problem. Maykut and Morehouse (2002) state that one’s position has important implications for research. It means that one must match research questions with methods of collecting and analysing data. The researcher’s positioning in philosophy will guide the investigation and interpretation of gathered data. Ontological issues relate to the nature of reality and its characteristics. Creswell (1998)

states that an ontological characteristic of a phenomenological study is evident in the multiple realities through which many people experience the same phenomena. Objectivism (Positivism) is directly connected to realism and the notion that there is an objective reality. Idealism (Subjectivism) is directly connected to the view where reality is mentally and subjectively constructed. Epistemology is concerned with the nature and forms of knowledge (Cohen et al., 2002). Guba and Lincoln (1994) state that epistemological assumptions are concerned with how knowledge can be created, acquired and communicated; in other words, what it means to know. Crotty (1998) posits a question that researchers must address:" is the making of meaning a subjective act essentially independent of the object or do both subjects and the object contribute to the construction of meaning?" Ontologies and epistemologies are far from clear cut definitions as one might assume from the descriptions I have chosen from the literature. Arguments are made, and seemingly contradictory positions are taken. For example, Heidegger (1962) writes about a world always already there, but he would not be considered to hold an objectivist philosophy. The researcher must develop an understanding of four concepts: epistemology, ontology, methodology, and ethics because each has a methodology and method suited to their theoretical element. It is essential to understand the theoretical underpinnings to distinguish between how these methodologies and methods relate.

This research study asks this question, **"With the introduction of BIM into the AEC work environment, what, if any, has been the impact on the social dynamics of engaged professionals in the workplace?"** The central aim of this study is to investigate the impact, if any, BIM has had, or is having, on human dynamics, collaboration and relationships defined for this study as social dynamics in the design and construction industry by interviewing a purposeful selection of industry professionals who have experienced the phenomenon and have their stories interpreted using as reference the methodologies espoused by Heidegger, Gadamer, Van Manen and Ajjawi & Higgs. Professionals who come to use a BIM process do so for different reasons. These professionals experience this differently. I will base this research study in a postpositive paradigm, with an epistemology (ontology) and theoretical perspective that will allow for the examination of the individual's experience of the impact of BIM in the workplace. It is from the study of the lived experience which can fill a knowledge gap in the industry.

3.2 Theoretical Perspective

Crotty (1998) argues that a theoretical perspective provides the researcher with a context for a chosen methodology. Guba & Lincoln (1982) discuss epistemological and methodological bases of naturalistic Inquiry and state that in the social/behavioural sciences, the class of phenomena typically addressed in inquiry has no reality in the physical sense. That is not to say that tangible objects, events, and processes do not enter into human behaviour, for example, to shape it. However, it is not these tangibles that are the subject of this research.

The author researched different philosophical perspectives to develop a research plan and chose to develop a theoretical perspective based on Crotty's (1998) four-point model,

- Epistemology,
- Theoretical Perspective,
- Methodology and
- Methods,

The research methodology developed links a constructivism epistemology with an interpretive theoretical perspective and is labelled hermeneutic phenomenology. This is an approach that uses semi-structured interviews as the research method to examine the lived experience of people; in this case, AEC professionals impacted by the introduction of BIM into the workplace.

3.2.1 Epistemology

Epistemological issues relate to the nature of knowledge and how knowledge is known. Taking an epistemological stance provides a philosophical grounding for deciding what kinds of knowledge are possible and how a researcher can ensure that they are both adequate and legitimate (Crotty, 1998). There is a range of epistemologies, and for this research, the author will outline an Objectivist Epistemology, Constructivism Epistemology, and Subjectivism Epistemology. An objectivist epistemology puts forward a position that meaning and the making of meaning exist apart from the operation of consciousness, that knowledge is in existence, and there is an objective truth to be discovered. A constructivism epistemology rejects this position as it holds forth that there is no objective truth waiting to be discovered. However, the making of meaning and truth

comes into existence in our interaction and lived experience of the world. There is no meaning without a mind (Crotty, 1998). In a subjectivist epistemology, meaning is imposed on the object by the subject, where the object does not contribute to the generation of meaning.

This research study is concerned with the lived experience, and as such cannot be as Guba & Lincoln (1982) state touched, seen, tasted, smelled, or heard, or put into statistical facts or a single reality. The author's research question leads away from positivist / objectivist epistemology and positions the research in a constructivist/interpretive epistemology.

Missing from Crotty's four elements is ontology, the nature of reality. Crotty makes an argument that ontology sits alongside epistemology. The existence of a world without a mind is conceivable, meaning without a mind is not. If the researcher intends to be involved in the research, there needs to be a heightened sense of self-awareness as it is a double-edged sword.

The research can benefit from the researcher's experience and involvement, but being human, the researcher brings with them their own beliefs as outlined in the epistemological position. In this part of Crotty's schema, the researcher states as best they can their assumptions, reflect these in the chosen methodology and develops an understanding of the effects. The researcher examines their philosophical stance against a chosen methodology.

3.3 Hermeneutic Circle and Fusion of Horizons

The hermeneutic circle is a metaphor for understanding and interpretation, which is viewed as a movement between parts (data) and whole (evolving understanding of the phenomenon), each giving meaning to the other such that understanding is circular and iterative (Ajjawi and Higgs, 2007). The meaning of a single word, for example, is recognized in reference to the whole sentence, and in return, the meaning of the whole sentence is reliant on the individual words in it (Crotty, 1998). Our horizons limit our understanding since all understanding occurs within a certain horizon, Gadamer (as cited in Langdridge, 2007). Langdridge (2007) states that by incorporating the hermeneutic circle method, the researcher moves between a part of the text and the whole of the text to establish a truth by discovering phenomena and interpreting them. Langridge (2007)

goes on to argue that Gadamer believed that we can and do gain mutual understanding and that this is through the “fusion of horizons” where we acknowledge consensus in our particular world views. Horizons are not fixed but overlapping, and they are developing all the time. The merging of horizons can result in a new, richer and more developed understanding which is greater than the previous understanding.

Both the “hermeneutic circle” and the “fusion of horizons” were employed in this research. In the analysis and subsequent interpretation of the text, the author constantly moved from the parts of the text, components of the description, to the whole of the spoken experience. In Section 4.1, the author describes in more detail the structured process used in developing each of the stage columns while referring back to the whole text to interpret meaning. In essence, this is a process of fusing the horizons of the author who is the interviewer, with the horizons of the interviewee, the participant. Ricoeur (1991) argues that appropriation is the act of capturing the meaning being expressed by a text, not necessarily through the identification of the intentions of the author, although this may be approximated through a fusion of horizons where we expand knowledge of ourselves through engagement with the other.

3.4 Hermeneutic data analysis approach

For Van Manen, there is no way to pry language and meaning apart and hence no way to do phenomenology without it being an analysis of language. This means that if one follows Van Manen's approach, one cannot escape the interpretive nature of the work (Vagle, 2014). Writing and rewriting is an iterative process that affords the author an opportunity to reflect and bring forth the essential meaning of the participant stories. Van Manen (1997) believed that writing forces an individual into a reflective attitude in which one writes themselves in a profoundly collective way. Van Manen's (1990) concern is that the researcher remains deeply committed to the phenomenon in question and that the interest in the phenomenon remains throughout the study. To avoid a loss in focus, Van Manen recommends that researchers maintain a strong and oriented approach to the phenomenon.

The author has remained committed throughout the crafting of the research question, the exploration and selection of a research method to study the phenomenon, the data

gathering and analysis process, the writing and rewriting of this study. This study's research question is, **"what, if any, has been the impact of BIM on the social dynamics of engaged professionals in the workplace"** and it has been at the forefront of data gathering and analysis. The author is committed to communicating the essence of the phenomenon from the study for others to learn from. This research is applying the concept of the Hermeneutic Circle, as described earlier. Polt (2013) describes Heidegger's hermeneutic circle as his constant return to the previous descriptions and the re-conception of these in an attempt to make them more accurate and nuanced. Van Manen (1999) also states that this means that one needs to continually measure the overall design of the study/text against the significance that the parts must play in the entire textual structure.

Transcribing the interview from the recording was the start of building a relationship with the text. At this point, the focus was on individual participants stories. The author aimed at faithfully writing down the spoken words and made a point to complete the interviews and transcription before beginning reviewing the text. The second part of this process was started when all interviews were complete and transcribed. The authors second reading involved anonymizing the text and starting to pick up on words, phrases and context that were repeated in the text. The author made notes on the side of the transcript. The author conducted fourteen interviews over a period of 8 months, transcribed them and anonymized them in preparation for an analytic process. Samples of this method are shown in chapter 4 and more extensively in appendix A.

Gadamer (cited in Giles 2008) explains how lived experiences can be understood more and more clearly by engaging with the text of the lived experiences in an interpretive circle. Ajjawi & Higgs (2007) argue the hermeneutic circle is a metaphor for understanding and interpretation, which is viewed as a movement between parts (data) and whole (evolving understanding of the phenomenon), each giving meaning to the other such that understanding is circular and iterative.

3.5 Research Methodology

The selection of a research methodology is driven by the research question. This author's research question evolved as an understanding of the phenomenon grew, and its locus was determined. The qualitative researcher has many methodologies to choose from, for

example, ethnography, narrative, phenomenological, grounded theory, and case study. It was evident from an early stage that this research would be set within a qualitative paradigm, and the developed theoretical perspective, as outlined in the previous section, guided this researcher when searching for a methodology that would be consistent with the author's epistemological stance, the research question and ultimately lead to the choice of research method and associated methodologies. The study concerns design and construction professionals who have experienced the phenomenon of BIM in the workplace. The research question is based on and reinforced by the literature review, where a possible change of practice has shown potential to be being driven by new technologies in the design and construction industry.

The philosophical stance underpinning the research stems from a constructivism/interpretive epistemology. The research question, the theoretical perspective, has led the author to choose a phenomenological methodology to address the research question and, in particular, a type of interpretive phenomenology expounded by Heidegger and refined by Van Manen and Gadamer. In the next sections, an account and description of phenomenology are given from the different philosophers' views, and how it relates to this research study and why a particular branch of phenomenology termed hermeneutic phenomenology was chosen to study the phenomenon.

3.5.1 Phenomenology

Woodruff-Smith (2008) argued that phenomenology is the study of structures of consciousness as experienced from the first-person point of view. He defined phenomenology as a philosophical movement that describes the formal structure of the objects of awareness and awareness itself in abstraction from any claims concerning existence. It seeks to find the universal nature of experience and can provide a more in-depth understanding. Phenomenology has two distinct traditions or approaches: descriptive and interpretive. In comparing phenomenology and hermeneutic phenomenology as research methodologies, similarities and differences exist that arise out of the philosophical bases of these traditions. Laverty (2003) notes that while the focus and outcomes of the research, including data collection, subject selection, and the understanding of the lived experience, may be similar, the position of the researcher, the process of data analysis, and the issues of rigour or credibility can provide striking

contrasts between these methodologies. Laverty (2003) states that phenomenological research is descriptive and focuses on the structure of experience, the organising principles that give form and meaning to the lifeworld. Sloan & Bowe (2014) state that in hermeneutic phenomenology, the researcher interprets meanings found concerning the phenomena. They analyse the text to find these meanings and allow for interpretation to build understanding. The focus is on understanding the meaning of experience by searching for themes, engaging with the data interpretively, with less emphasis on the essences that are important to descriptive phenomenology.

3.5.1.1 Husserl

Husserl, the German-born philosopher and psychologist, is known as the pioneer of phenomenology. He has described phenomenology as a descriptive science of first-person perspectives where phenomenology is supposed to be neither more nor less than a faithful description of that which appears (be it subjective acts or worldly objects), and should, as a consequence, avoid metaphysical and scientific postulates or speculations. Zahavi (2003, p.3) writes that according to Husserl, "the cardinal question facing a theory of knowledge is to establish how knowledge is possible". More generally and this is very crucial when it comes to an understanding of his early concept of phenomenology, Husserl did not want to commit himself to a specific metaphysics, be it realism or idealism (Zahavi, 2003). Instead, he wanted to address formal questions of a more Kantian flavour, particularly questions concerning the conditions of possibility for knowledge. Husserl was concerned at the loss of the human spirit with the relationship of subject/object dichotomy. For Husserl, phenomenology is a rigorous human science precisely because it investigates the way that knowledge comes into being and clarifies the assumptions upon which all human understandings are grounded. The human subject and the loss of this through the naturalistic paradigm led Husserl to develop human science to reflect the awareness of the human spirit. His methodology included bracketing, which is the resolve to set aside theories, research presuppositions, ready-made interpretations, etc., in order to reveal engaged, lived experience. The suspension of presuppositions (the epoch, or bracketing) arose historically as part of Husserl's transcendental reduction (Ashworth, 1999).

3.5.1.2 Heidegger

Heidegger was a German philosopher and seminal thinker (Capobianco, 1988) whose lifelong work focused on seeking the meaning of being. Heidegger became a junior colleague of Edmund Husserl when the latter joined the Freiburg faculty. Following World War 1, Heidegger was appointed as Husserl's assistant at the University. It is important to acknowledge this relationship as it was pivotal in forming Heidegger's philosophical and ontological position. He attempted to access “being” (Sein) using a phenomenological analysis of human existence (Dasein) concerning its temporal and historical character (Heidegger, 2008). He found some solace within the pre-Socratic tradition, perhaps seeking a purer path to the essence of being. His later criticism of western culture is rooted in the distraction that modernism employs with materialism and technology almost obliterating the connection of humans to their being. “Back to the things themselves” is his battle cry, a call for Western culture to turn away from the dead-end of nihilism and begin anew (Overgaard, 2004, p1). What is labelled as “the turn” in Heidegger's philosophical position occurred in the early 1930s and is relevant to this research. The procedure of bracketing which Ashworth (1999) proposed as the suspension of presuppositions, is essential to Husserl’s “phenomenological reduction”—the methodological procedure by which we are led from “the natural attitude,” in which we are involved in the actual world and its affairs, to “the phenomenological attitude,” in which the analysis and detached description of the content of consciousness are possible (Heidegger, 1962). LeVasseur (2003) states that Heidegger held that consciousness could not be separated from being in the world, because of this, we are unable to bracket prior conceptions and knowledge completely, we are necessarily embedded in a historical context.

Husserl’s phenomenology is a descriptive, detached analysis of consciousness. It is detaching by way of bracketing out one's suppositions to remain pure to the conscious thought. Heidegger turned away from Husserl’s view, for Heidegger the starting point of philosophy is not consciousness, but “Dasein”, he defines the German word Dasein as da "there"; sein "being" the experience of being that is particular to human beings. Phenomenology for Heidegger is not a descriptive, detached analysis of consciousness but a method of access to being.

3.5.1.3 Merleau-Ponty

Another philosopher highly influenced by Husserl was the French academic Maurice Merleau-Ponty. When speaking of his phenomenological method, Merleau-Ponty (2013) suggests that the demand for a pure description excludes equally, the procedure of analytical reflection on the one hand and that of scientific explanation on the other. Only by avoiding these tendencies, according to him as related by (Baldwin, 2016) can we rediscover, as anterior to the ideas of subject and object, the fact of one's subjectivity and the nascent object, that primordial layer at which both things and ideas come into being. The philosophy of perception is the lived bodily experience and not just a reduction of all to intentionality. Perception involves the perceiving subject in a situation, rather than positioning them as a spectator who has somehow abstracted themselves from the situation. For Merleau-Ponty, the inseparability of inner and outer ensures that a study of the perceived ends up revealing the subject perceiving. The body will draw to itself the intentional threads which bind it to its surroundings and finally will reveal to us the perceiving subject as the perceived world (Merleau-Ponty 1962, p. 453).

3.5.2 Hermeneutic Phenomenology - Van Manen, Ricoeur, Gadamer

> *"Phenomenology aims to construct an animating, evocative description of human actions, behaviours, intentions, and experiences as we meet them in the lifeworld."* (Van Manen, 1990, P 19)

Van Manen continues in the tradition of Husserl and Heidegger. He views phenomenological research as a lived experience for researchers as they attune themselves towards the ontological nature of phenomenon while learning to "see" pre-reflective, taken-for-granted, and essential understandings through the lens of their pre-understandings and prejudices (Van Manen, 1990). In judging the trustworthiness of qualitative research, Van Manen, who associates hermeneutic phenomenology as a paradigm appropriate to research having pedagogic significance, has enlisted four rigour criteria for this type of research. Considering hermeneutic phenomenology as a pedagogic practice of textuality, where doing research is to be involved in the considering of the texts that explicate the lifeworld stories of the research participants, Sloan & Bowe (2014) enlist orientation, strength, richness, and depth as the significant quality concerns. Hermeneutic phenomenology avoids method for method's sake and does not have a step

by step method or analytic requirements. The only guidelines are the recommendations for a dynamic interplay among six research activities:

- commitment to an abiding concern,
- oriented stance toward the question,
- investigating the experience as it is lived,
- describing the phenomenon through writing
- rewriting, and
- consideration of parts and whole (Kafle, 2013).

Ricoeur (1991) refers to his hermeneutic method as a "hermeneutics of suspicion" because discourse both reveals and conceals something about the nature of being. In addressing the question "who am I?" Ricoeur sets out first to understand the nature of selfhood – to understand the being whose nature it is to enquire into itself, he seeks to interpret the essential structures of our being in the world; language, freedom, guilt.

Hans Georg Gadamer was another of the Germanic / European tradition of phenomenological thinkers. He was an assistant to Heidegger at Marburg in the 1920s and was influenced by Heidegger. Gadamer's philosophical foundations lie with the Greek philosophical thought of Plato and Aristotle. His early work reflects his belief that understanding is developed from an investigation of the dialogue of the text rather than the structure within the text. Gadamer's work, in conjunction with that of Heidegger, represents a radical reworking of the idea of hermeneutics that constitutes a break with the preceding hermeneutical tradition and yet also reflects on that tradition. This is not a rejection of the importance of methodological concerns but rather an insistence on the limited role of method and the priority of understanding as a dialogic, practical, situated activity.

Hermeneutic inquiry sets out to uncover and interpret meaning from participants experiences as related in their oral texts. The researcher strives to understand the phenomenon of the study through the interpretation of these texts in essence, the act of interpretation of the texts is a constant negotiation between the researcher and the text. Friesen et al., (2012) state that hermeneutics is usually considered as the science and art of interpretation and meaning.

The author has sought in the previous sections to give the reader a background to the philosophical underpinnings for the choice of hermeneutic phenomenology as the research methodology.

3.5.3 Rigour

Guba & Lincoln (1982) propose "tests of rigour": truth, value, applicability, consistency, and neutrality. This depends partly on the adequacy of the sample, not in terms of size but in terms of its ability to supply all the information needed for a comprehensive analysis (Yardley, 2000). Smythe et al., (2008) suggest that the trustworthiness of a study is known first by researchers themselves, who test out their thinking by engaging in everyday conversations with those who share the interest or who are living the phenomenon. Tracy (2010) argues that rigour is also judged by the care and practice of data collection and analysis procedures; the study uses are sufficient, abundant, appropriate, and complex. The following are the strategies that have been used in this study:

• Theoretical constructs

• Data and time in the field

• Sample(s)

• Context(s)

• Data collection and analysis process

3.5.3.1 Theoretical constructs

A study based on a qualitative paradigm needs to be well designed and constructively aligned in terms of methodology and methods. I have provided for the reader a detailed account of the philosophical perspectives of hermeneutic phenomenology and its relevance to this study. This, in turn, is underpinned by a description of the theoretical perspective that I have brought to this study provides a context for a chosen methodology.

3.5.3.2 Data and time in the field

The participant interviews were carried out between January and August, the intervals allowed for reflective thinking on what was said. Each interview was transcribed within

a few days of taking place. Field notes were taken and added to the original transcript document. Analysis of the data began when all transcripts were gathered, anonymized, and idiosyncrasies were removed. The time intervals between each interview also gave the author the opportunity to reflect on his own participation in the interview. This is very important as the researcher themself becomes the instrument for data collection (Streubert as cited in Guerrero-Castañeda et al., 2017). The phenomenological interview is a meeting with a phenomenon that is being lived by "a" person who determines the characteristics of the phenomenon. It is not the researcher who determines it beforehand. Rather, it is the person who is allowed to bring forth this phenomenon from their consciousness and give it expression (Guerrero-Castañeda et al., 2017). The author needed to be constantly in a state of self-awareness to let the interview participant bring forth their lived experience and the time intervals between interviews allow for reflection and reflexivity here. The author became embedded in the data throughout the period of analysis, constantly thinking about the text trying to build the essential meaning. These efforts are presented in the themes discussed in chapter 5.

3.5.3.3 Samples

Samples of the text and analytical process are provided in the thesis document and give the reader a picture of the flow of the analytical process and illustrate the methodology used as detailed in Chapter 4.

3.5.3.4 Context

A context for the research with the research questions, the significance of the research phenomenon and the significance of this research thesis is given a prelude for the reader in Chapter 1.

3.5.4 Ethical Considerations

The research process is a balanced cooperative relationship between the subjects and the researcher. Generating knowledge about an individual experiential world is based on both a subject's self-knowledge and the researcher's ability to overcome his or her point of view and to understand another person (Häggman-Laitila, 1999). Langdridge (2007) states that ethics have grown in importance over recent years in the social sciences. He cites the British Psychological Society ethical guideline under four headings of Consent,

Confidentiality/Anonymity, Discomfort / Harm and Deception. TU Dublin graduate school refers research students to The European Code of Conduct for Research Integrity (ALLEA, accessed 2017). Christians (2008) emphasizes four categories as overlapping guidelines for an ethical code. These are:

- Informed Consent
- Deception
- Privacy and confidentiality
- Accuracy

3.5.4.1 Informed Consent

Landridge (2007, p.62) describes informed consent as "the most fundamental of all ethical principles". The principle of informed consent requires that prospective participants in research are provided with information about the project in which they are being invited to participate and that it is sufficiently full and accessible for their decision about whether to take part to be considered informed (Crow et al. 2006). The participants in the research described in this thesis were formally invited to participate in this research, and they were informed at this point that should when accept the invitation to participate, they would be written to with a letter that would contain information about the research, their rights as a participant including the option to withdraw at any point. They were asked if they understood the consent agreement, and if so, they were asked to sign the consent form and return it to me.

3.5.4.2 Deception

In emphasizing informed consent, social science codes of ethics uniformly oppose deception (Christians, 2008). This author has been open and transparent with the participants at all stages of the research and has faithfully transcribed their words. The author has not sought to bend or lead the participants to the point of view he might hold, but to listen to their stories as part of the conversation and attempted to be neutral in both physical expressions and with the secondary probing questions asked. These questions were framed to elicit more of the story they were telling or to open a new subject area.

3.5.4.3 Privacy and confidentiality

Christians (2008) states that confidentiality must be assured as the primary safeguard against unwanted exposure. Langdridge (2007) states that all efforts should be made to maintain confidentiality within a research team and to protect one's participants by anonymizing the information they provide when it is made public. Once the text had been transcribed from the recorded interview, the file was removed from the laptop to a secured cloud-based folder. In the second reading and edit of the text dataset, the participants were coded with an anonymous ID and all references to their name, their companies and the names of projects were removed where appropriate. The transcripts and subsequent iterations as part of my theme extraction process are all secured on a cloud-based storage facility. Samples of the anonymized transcripts and the theme generating iterations have been included for the reader.

3.5.4.4 Accuracy

Ensuring that data is accurate is a cardinal principle in social science (Christians, 2008). To the best of this authors knowledge, all descriptions, referenced material, references and figure diagrams are accurate and have been referenced.

An ethical application was submitted in January 2017 from TU Dublin's Research Ethics Committee and was granted in Nov 2017.

3.5.5 Limitations of the Research Design

The word paradigm can be used to mean either approach or design. Denzin and Lincoln (2000, p. 157) define a research paradigm as "a basic set of beliefs that guide action", dealing with first principles or the researcher's worldviews. Traditionally a gulf is seen to exist between qualitative and quantitative research with each belonging to distinctly different paradigms, Ladner 1988 cited in (Brannen, 2017). The qualitative methodology intends to understand a complex reality and the meaning of actions in a given context. On the other hand, the quantitative methodology seeks to obtain accurate and reliable measurements that allow statistical analysis (Queirós et al., 2017). This research is set within the qualitative paradigm and so carries with its criticisms of this methodology. Lincoln and Guba (1985) state from the constructivists' point of view, there are multiple constructed realities, the knower and the known are inseparable, any inquiry is value bound and subjective, and it is not possible to distinguish causes from effects. This might lead to different interpretations due to changes in the circumstances during the research.

Hammersley (2008) argues that qualitative researchers have failed to defend their work effectively against quantitative criticisms; or, to put it less combatively, they have not addressed effectively the problems to which those criticisms point. In the early battles with quantitative researchers, the qualitative inquiry was criticized in three main areas:

- For failing rigorously to operationalize concepts and thereby to document measurable differences.
- For being unable to rule out rival explanations through physical or statistical control.
- For failing to produce generalizable findings.

Qualitative researchers' responses to these criticisms have varied, but the following are the main ones:

- It is sometimes argued that qualitative work does not need to stand on its own, and if it is combined with quantitative work, it can meet the requirements that lie behind these criticisms.
- Alternatively, it may be argued that qualitative research has its own ways of documenting differences, identifying causal relations, and producing theoretical generalizations. Therefore, the strategies associated with quantitative work are not relevant to it, and the criticisms do not apply
- Finally, it is often argued that these criticisms of qualitative inquiry simply misconceive the nature of social research since they derive from a positivistic paradigm that has been discredited and superseded.

Corbin and Strauss (1998, p.11) explain that qualitative research "can refer to research about persons' lives, lived experiences, behaviours, emotions, and feelings as well as about organisational functioning, social movements, cultural phenomena, and interactions between nations". Sammel (2003) believes that understanding the lived experience offers the only possibility for change, and the researcher is required to read and extract the principles of this and apply them to the study.

In terms of this research, I have explained in Chapter 1 that the phenomenon the author wanted to study resides with the AEC professional in their workplace. It is not about the technology or process of BIM, as they are just the enablers of the phenomenon. To

discover what might be discovered and to draw meaning from it, the paradigm of qualitative research is most suitable and within that paradigm, I have chosen a version of phenomenology derived from Heidegger tempered by Gadamer's philosophical hermeneutics (Heidegger, 1962; Gadamer, 1976). Hermeneutic phenomenology is an exercise in subjectivity and inter-subjectivity, and hence, has been open to criticisms of a lack of rigour, Sandelowski (cited in Chan, 2014). This has been addressed in Section 3.5.3.

The sample size is limited by purposeful and is described in more detail in section 3.7

3.6 Research Method

3.6.0 Introduction

This chapter introduces the chosen research methodology and the methods used.

3.6.1 A Strategy for Analysis and Interpretation

The central aim of this research is to discover if there has been a shift in human dynamics as a result of the adoption of BIM in the workplace and if there has been, to discuss then the meaning of this for the industry and the community who educate these professionals. There is freedom within interpretive hermeneutic phenomenology as to the methods of collection and analysis of the data. However, the approach to data analysis adopted in this research is informed by the guidelines and frameworks developed by previous researchers.

Van Manen (1990) proposed six steps for hermeneutic phenomenological research:

- Turning to a phenomenon that seriously interests us and commits us to the world.
- Investigating experience as we live it rather than as we conceptualize it
- Reflecting on the essential themes which characterize the phenomenon
- Describing the phenomenon through the art of writing and re-writing
- Maintaining a strong and orientated (andragogical) relation to the phenomenon
- Balancing the research context by considering the parts and the whole.

3.6.1.1 Turning to a phenomenon that seriously interests us (the AEC Community) and commits us (the AEC Community) to the world.

In hermeneutic phenomenological research, the researcher lives the question by process of returning to the question or the thing itself until one begins to feel a sense of the nature of the topic being studied, Parker (cited in Munhall, 1994, p293). The subject that interests this author is Building Information Modelling. The author has been learning and teaching this subject for a decade and has glimpsed a phenomenon. The nature of this phenomenon, the author has concluded, is best researched using hermeneutic phenomenology, which to the author's knowledge has not been used to study this specific subject area before. It offers the possibility for new understandings and insights for the design and construction industry and the built environment education community. In doing this, the author is committing to the world by offering this research to this industry and the community of AEC practitioners, educators and researchers.

3.6.1.2 Investigating experience as we live it rather than as we conceptualize it

Vagle (2014) states that for Van Manen, the distinction between living experience and conceptualizing experience is not subtle and is therefore very important to understand when following his approach. What is it like to experience this phenomenon? What are all the possible facets and aspects of this phenomenon? To answer these questions, the researcher wants the participant to bring their experiences of the phenomenon.

With the interviews, starting by asking the participant to describe their current job and their working week immediately situated them in the location of the phenomenon, their workplace. This was followed up by asking them to think back five years or more and describe what had changed for them in the workplace. If they mentioned BIM in this part of their story, it was legitimate to follow up with questions as to how they felt about the changes which may have occurred after the introduction of BIM in their workplace. If not, they were asked to tell the interviewer about the current projects they were working on and if they mentioned BIM as before it was legitimate to follow up with questions relating to their experience of BIM in the workplace.

The questions and follow-up questions were designed to engage the participants in describing the interaction with BIM in the workplace, their emotions, thoughts, concerns, attitudes, working relationships with colleagues, and bring out their experiences related to the phenomenon.

3.6.1.3 Reflecting on the essential themes which characterise the phenomenon

Vagle (2014) writes on Van Manen's approach that when we craft phenomenological research, we are trying to cull meanings of things we do not typically see as we are moving in the lifeworld. Phenomenology is endeavouring to see the essence, the essential meaning of something, bringing to the fore and into focus what has been obscure. Data can be analyzed thematically in hermeneutic phenomenology, but Langdridge (2007) argues that there is a deliberate move away from a mechanical application of coding to discern meaning hermeneutically. Van Manen (1990) writes for understanding (the researcher) brings our full attention to the material at hand, engaging in a free act of seeing. To assist in analyzing to identify themes, Van Manen offers three methods of approaching the data:

- Wholistic, attend to the text as a whole
- Selective, read a text several times then underline and highlight pertinent passages and
- Detailed, look at every sentence or sentence cluster to ask what does this reveal about the phenomenon.

Iterative writing, reading, consistent and regular conversations with the author's supervisor leading to thoughtful reflection have helped in the author's journey to uncover the essential meaning of the participants lived experience of BIM in their workplace.

3.6.1.4 Describing the phenomenon through the art of writing and re-writing

For Van Manen, there is no way to pry language and meaning apart and hence no way to undertake phenomenology without it being an analysis of language. This means that if one follows Van Manen's approach, one cannot escape the interpretive nature of the work (Vagle, 2014). Writing and rewriting is an iterative process that affords the author an opportunity to reflect and bring forth the essential meaning of the participant stories. Van Manen (1997) believed writing forces an individual into a reflective attitude in which one writes themselves in a profoundly collective way.

3.6.1.5 Maintaining a strong and orientated relation to the phenomenon

Van Manen's (1990) concern is that the research remains deeply committed to the phenomenon in question and that the interest in the phenomenon remains throughout the study. To avoid a loss in focus, Van Manen recommends that researchers maintain a strong and oriented approach to the phenomenon. The author has remained committed throughout the crafting of the research question, the exploration and selection of a research method to study the phenomenon, the data gathering and analysis process, the writing and rewriting of this study. The research question, "what, if any, has been the impact of BIM on the social dynamics of engaged professionals in the workplace" has been at the forefront of data gathering and analysis. The author is committed to communicating the essential themes generated from the study for others to learn from.

3.6.1.6 Balancing the research context by considering the parts and the whole.

In this research, use is made of the concept of the Hermeneutic Circle, as described in chapter 3.3. Polt (2013) describes Heidegger's hermeneutic circle as his constant return to the previous descriptions and the re-conception of these in an attempt to make them more accurate and nuanced. Van Manen (1999) also states that this means that one needs to continually measure the overall design of the study/text against the significance that the parts must play in the entire textual structure.

Transcribing the interview from the recording was the start of building a relationship with the text. At this point, the focus was on individual participant stories. The author's concentration was aimed at faithfully writing down the spoken words, so decided to complete the interviews and transcription before beginning reviewing the text. The second part of this process was started when all interviews were complete and transcribed. The second reading involved anonymizing the text and starting to pick up on words, phrases and context that were repeated in the text. The author made notes on the side of the transcript for later reflection.

Langdridge (2007) states that by incorporating the hermeneutic circle method, the researcher moves between a part of the text and the whole of the text, to establish a truth by discovering phenomena and interpreting them. The author conducted fourteen interviews over a period of 8 months and transcribed them and anonymized them in preparation for an analytic process.

Gadamer (cited in Giles, 2008) explained how the lived experiences can be understood more and more clearly by engaging with the text of the lived experiences in an interpretive circle. Ajjawi & Higgs (2007) argue that the hermeneutic circle is a metaphor for understanding and interpretation, which is viewed as a movement between parts (data) and whole (evolving understanding of the phenomenon), each giving meaning to the other such that understanding is circular and iterative.

3.7 Research Participants: Selection and context

This section describes the selection of participants and the rationale behind a "purposeful sample" selection method. In the following sections, a context is given to the research and anonymized information on the participants to illustrate the multidiscipline nature of the design and construction industry.

3.7.1 Context for Sampling

As previously mentioned, the digitization of the design and construction industry had its beginnings in the nineteen sixties. The term Computer-Aided Design was written first in a paper by Ross et al. (1961) where he describes the objective of the Computer-Aided Design Project is to evolve a man-machine system which will permit the human designer and the computer to work together on creative design problems. Where digitization becomes relevant to this research is in the nineteen eighties with the rise of computer-aided design (CAD) applications, these, in turn, becoming commercially viable due to the affordability of personal computers (Szalapaj, 2013). Throughout the eighty's and ninety's new more powerful versions of the CAD applications responded to the growing speed and capacity of the personal computer (PC). Throughout the nineties drawing boards in architectural and engineering offices were being replaced with PCs and CAD software was replacing manual drafting. Notwithstanding the improvements in productivity, meaning more time for quality and related tasks, the overall approach, methodologies, and concepts are not dissimilar to manual draughting. A user might describe the transition as replacing the horse and cart with a car - same journey, different level of comfort, speed and amenity. It may, for new users, be a steep learning curve without expert guidance, training and support. Once the concept and processes are embraced, it offers a real step-change in how buildings are conceived, designed,

constructed and managed for a brave new world where resources become scarcer and expensive. The literature I have reviewed in chapter 2 can confirm that the introduction of BIM into the workplace is a real step-change in the industry. The research is located in Ireland, where the context is live and significant. The phenomenological interviews take place in Ireland, where the participants live and work. However, the research phenomenon is not "local"; it can be situated wherever BIM has been introduced; hence the transferability of the research phenomenon enhances it.

3.7.2 Purposeful Sampling

In hermeneutic phenomenological research, the sampling is usually purposeful as the aim is, as stated by Langdridge (2007) to recruit a sample of people such that the researcher can make claims about these people and their particular shared experience. Reece (2004) states that a purposeful sample selection method aims not to sample based on concepts that have proven theoretical relevance but to gain variation in the sample. The selected participants are all from the design and construction industry and have had an experience of BIM and the challenges associated with this technical innovation. This purposeful selection process was employed to identify individual research participants making sure to cover the main industry domains providing professional services in the design and construction industry using the following criteria:

- Suitable gender balance
- Suitable age balance
- Balance between professionals with director responsibilities and professional management/production staff
- Professional people who are involved in shaping the transition
- Those who have to follow and respond to the transition
- Location, city/rural divide
- Those who have completed formal education or training to upskill in BIM
- Those who have not had formal education or training but have experienced BIM on the job.

Participants were selected using purposeful sampling strategies. Palinkas et al., (2015) state that purposeful sampling is widely used in qualitative research for the identification and selection of information-rich cases related to the phenomenon of interest. In hermeneutic phenomenological research, the sampling is usually purposive and homogenous as the aim is to recruit a sample of people such that the researcher can make claims about these people and their particular shared experience (Landridge, 2007). This involves identifying and selecting individuals or groups of individuals that have been exposed to and have experienced the phenomenon of interest (Cresswell & Plano Clark, 2011).

All of the selected participants shown in Figure 3.0 have experienced the phenomenon. They were identified through a variety of sources where they had made public their involvement in BIM through attendance at BIM conferences, their participation in professional body BIM committees, or as registered students on postgraduate BIM-based courses and were chosen to ensure diversity of opinion and experience. The logic and power of purposeful sampling lie in selecting information-rich cases for study in depth. Information-rich cases are those from which one can learn a great deal about issues of central importance to the purpose of the inquiry, thus the term purposeful sampling. Studying information-rich cases yields insights and in-depth understanding rather than empirical generalizations (Patton, 2002).

ID	Interview Date	M/F	Age Bracket	Responcibility Level	Location	PG Edu/On Job
Participant 1	17th Jan 18	M	20/30	Senior Technical Arch	City	PG Edu
Participant 2	19th Jan 18	F	40/50	Senior Q Surveyor	City	PG Edu
Participant 3	24th Jan 18	M	30/40	Architect	City	PG Edu
Participant 4	24th Jan 18	F	30/40	Technical/BIM MEP	City	PG Edu
Participant 5	28th Feb 18	M	40/50	Construction Manager	Rural	PG Edu
Participant 6	15th March 18	F	30/40	Technical Consultant Arch	Rural	PG Edu
Participant 7	26th April 2018	F	40/50	Senior Architect	City	PG Edu
Participant 8	1st May 2018	M	50/60	Architect Principal	City	On Job
Participant 9	9th May 2018	M	50/50	Architect Director	City	On Job
Participant 10	11th May 2018	M	40/50	Engineer Manager MEP	City	PG Edu
Participant 11	18th May 2018	M	30/40	Q Surveyor	City	On Job
Participant 12	24th May 2018	M	40/50	Technical Lead Structural	City	PG Edu
Participant 13	5th July 2018	M	30/40	Architect	Rural	On Job
Participant 14	31st Aug 2018	M	30/40	Engineer Principal	Rural	On Job

Figure 3.0 Profile of Participants by gender, age, responsibility level, location and BIM Education

3.7.4 Data Collection

The primary method of data collection for this research was the semi-structured interview. The most broadly accepted method derived from hermeneutic phenomenological methodology is the qualitative interview (Van Manen, 1990). Ajjawi and Higgs (2007) state that the hermeneutic interview serves very specific purposes, first as a means of gathering narratives or stories of lived experiences and second to develop a conversational relationship with the participant about the meaning of the experience. Semi-structured interviews can provide a richness to the data as the participants are allowed to respond and elaborate on questions and probes Morse and Field (as cited in Ajjawi and Higgs, 2007). The author conducted two pilot interviews in late 2017 and had developed a set of open-ended questions to first put the participant at ease and then allow them to tell and expand on their stories. Both of these interviews were recorded using Google Hangouts video-conferencing application which facilitated replaying the interviews to examine the interview technique and reflect on the test question set. The question set was reviewed with the author's supervisor, who is an experienced interviewer.

For this study, fourteen semi-structured interviews were carried out between January and August 2018. Ethical considerations were followed, as explained previously in Chapter 3.5.4. Following the author's reflections on the pilot interviews, a decision was made where possible to conduct the interviews in person, face to face at a convenient location and time for the participant. The interviews lasted approximately 45 / 55 minutes. Each interview was recorded and transcribed using a recording microphone and an application called Mic Note which recorded voice and provided a digital notebook for field notes. Both the microphone and the Mic Note application were hosted on the authors Chromebook laptop. The question set was not given to the participants before the interview to avoid receiving pre-prepared answers and to have the freedom to prompt the participant to elaborate on the topics they brought forward. The participants were told at the start of the interview that it would be conducted in a conversational style and that there were no wrong answers. The first question was common to all and an ice breaker where they were asked to “describe their job and working week”. Each interview was transcribed within a week of occurrence. Langdridge (2007) describes the approach of

hermeneutic phenomenology as focusing on the understanding of the meaning of experiences with interpretative engagement with the data by transcribing the recordings, the author began that process.

Once the recording had been transcribed, it was removed from the Chromebook to a password encrypted cloud storage facility. Each interviewee was given an ID code, and the text was checked for references that could identify the interviewee. All references to companies, projects, and locations were anonymized, confirming the confidentiality and privacy ethical considerations described in Chapter 3.5.4.

3.8 Quality Assurance of Research

Langdridge (2007) states that qualitative research must be conducted systematically and rigorously. It is necessary to prevent the researcher's subjectivity influencing the research itself and to maximise the possibility of discovering that which was otherwise hidden in the data. Literature informs us of several approaches and criteria that can be used for this purpose (LeCompte and Goetz, 1982; Altheide and Johnson, 1994). Koch (1996) argued that the criteria selected should adhere to the methodological and philosophical assumptions on which the research is constructed. Koch (2006) further argues our situatedness as interpreters and our historicity do not constitute an obstacle. Prejudices are the conditions by which we encounter the world as we experience something. We take value positions with us into the research process (Koch, 2006). These values, rather than getting in the way of research, can make research meaningful. In the following sections, the trustworthiness, rigour and ethical conduct within this research study are discussed.

3.8.1. Trustworthiness

Simons (2009) states that in 1985, Guba and Lincoln introduced the concept of trustworthiness and suggested a parallel set of criteria to the traditional set of criteria of internal validity, external validity, reliability and objectivity. For qualitative inquiry, Guba & Lincoln (1989 p.236-43) enlist the criteria of credibility, transferability, dependability and confirmability.

3.8.1.1 Credibility

Guba & Lincoln (cited in Koch, 2006, p. 91) claim that a study is credible when it presents faithful descriptions and when coresearchers or readers confronted with the experience can recognize it. The "phenomenological nod", as suggested by Van Manen (1990, p.27) is a way of demonstrating that good phenomenological description is something that we can nod to, recognising it as an experience that we had or could have had (Dowling, 2007). Tracey (2010) refers to it as the trustworthiness, verisimilitude, and plausibility of the research findings. This is enhanced when researchers describe and interpret their experience as researchers and readers can recognize and identify with the experiences described in the study. The interviews with the participants were recorded and transcribed by the author, who endeavoured to transcribe their words, their descriptions and stories faithfully.

Credibility also reflects the author of the research, where self-awareness of the researcher is essential (Koch, 2006). Important information about the researcher should be included to enable readers to judge what Whitehead (2004, p.516) describes as "the credibility of the research in relation to intellectual rigour, professional integrity and methodological competence, and the influence of experience and background on the researcher's approach". The author has described his educational and professional background and his interest in the subject matter in chapter 1 and subsequent chapters.

3.8.1.2 Transferability

Lincoln and Guba (1985) noted that transferability is more the responsibility of the person wanting to transfer the findings to another situation or population than that of the researcher of the original study. They argued that as long as the original researcher presents sufficient descriptive data to allow comparison, he or she has addressed the problem of applicability. Sandelowski (cited in Koch, 1994) defines "fittingness" when findings can 'fit' into contexts outside the study situation and when its audience views its findings as meaningful and applicable in terms of their own experiences. The author has given a context to the research in chapter 1 which will give the reader an insight and might relate to their own experience and has described a research design in this chapter that could transfer into this subject area for other researchers to pursue.

3.8.1.3 Dependability

This definition of dependability introduces two more terms – dependable and consistent. Koch (1994) states that how a research study may be shown to be dependable, as opposed to consistent, is for its process to be audited. Sandelowski (1986) states that a study and its findings are auditable when another researcher can follow the decision trail used by the investigator in the study. In addition, another researcher could arrive at the same or comparable but not contradictory conclusions given the researcher's data, perspective and situation. Krefting (1991, p.221) describes dependability strategies in qualitative research and states "the exact methods of data gathering, analysis, and interpretation in qualitative research must be described". The research has been subject to validation annually by an internal panel with permission to progress granted each year. The author has kept chronological records of participant involvement, including invitation and acceptance to participate with a detailed explanation of the interview process and their options, the interview transcripts, field notes, iterative reflective writing. All transcripts are password protected on Google Cloud storage and are available for audit. The analytical process and the model is described and illustrated with samples in Chapter 4, making it transparent to the reader. In addition, another researcher could arrive at the same or comparable but not contradictory conclusions given the researcher's data, perspective and situation.

3.8.1.4 Confirmability

Confirmability requires one to show the way in which interpretations have been arrived at via the inquiry. For Guba & Lincoln (1989) confirmability is established when credibility, transferability and dependability are achieved. In summary, signposts indicating research decisions and influences should be present throughout the study, and the entire study should function as an inquiry audit.

3.8.2 The Role of the Researcher in Data Collection

Van Manen (1997) refers to hermeneutic alertness, which occurs in situations where researchers step back to reflect on the meanings of situations rather than accepting their pre-conceptions and interpretations at face value. The author is a lecturer in the subject area of BIM and acknowledges being embedded in the BIM community. This has the advantage of being able to understand the language generated by the BIM community, including an extensive list of acronyms without continually asking for clarification. However, as stated by Minichiello et al., (as cited in Ajjawi and Higgs, 2007) this may be

a disadvantage if researchers ascribe meanings to certain words or jargon, behaviours, and decisions, with which participants differ. Reflexivity is a significant strategy for quality control in qualitative research (Berger, 2015). Reflexivity is an awareness of the researcher's role in the practice of research and the way this is influenced by the object of research (Haynes, 2012). I have employed strategies for reflective awareness, including:

- Listening to the recordings noting how my presence or interaction as the researcher affected the process
- Discussing and evaluating responses to the research with my supervisor and selected fellow researchers
- Being aware of my assumptions and presuppositions about the subject.

These employed strategies add to the transferability of the research as outlined in Chapter 3.8.1.2

3.9 Chapter Summary

This chapter has described the author's journey in selecting a suitable research methodology and methods to answer the research question. Research paradigms are explored and discussed, leading to the development of a theoretical perspective that provides a context for the chosen methodology. The author has introduced and discussed phenomenology as a research paradigm and hermeneutic phenomenology as the chosen research methodology. This chapter also has described the research methods and the selection process of the participants. It has described the strategy for analysis and interpretation and discussed the quality assurance process for the research.

Chapter 4. Findings;

4.0 Introduction

Crotty (1998) argues that each social researcher must decide his or her framework to guide the research process, while Van Manen (1990) states the method of phenomenology and hermeneutics is that there is no fixed method. Qualitative research may be conducted in many different ways; however, as comprehensive and clarifying as these catalogues and taxonomies might be they can go out of date quickly (Miles et al., 1994).

4.1 Uncovering and Exposing the Phenomenon

As detailed in the previous chapter, hermeneutic phenomenology was the chosen research methodology; the method in regard to the interviews has been guided by the research approaches of Van Manen (1990), Gadamer (1997) and Ajjawi & Higgs (2007). Green et al., (2007) produced a four-step process for data analysis where it is stated that data analysis is a systematic and essentially taxonomic process of sorting and classifying the data that have been collected. High-quality papers demonstrate four key steps: immersion in the data, coding, creating categories, and the identification of themes. Green et al., (2007) suggest that the steps outline above are not necessarily done in a linear fashion. Data analysis starts and occurs alongside the interviews that generate the data. Data analysis is time-consuming, requiring constant movement between immersion, coding, categorizing, and creation of themes.

Another similar data analysis approach was developed by Ajjawi & Higgs (2007). They presented a design of a research approach that encompasses a research paradigm, its philosophical assumptions and framework, the methodology, and the strategies used to gather data and derive meaning from the data. This research study will take the Ajjawi & Higgs (2007) methodology and adapt it for this research and conduct the data analysis through 4 stages; this model is presented in Figure 4.0. Ajjawi & Higgs used nVivo software to code their data. The author investigated the nVivo application and completed two courses learning how to use it but made a conscious decision not to employ the application for coding arguing that it lacked subtlety required for an interpretative research methodology.

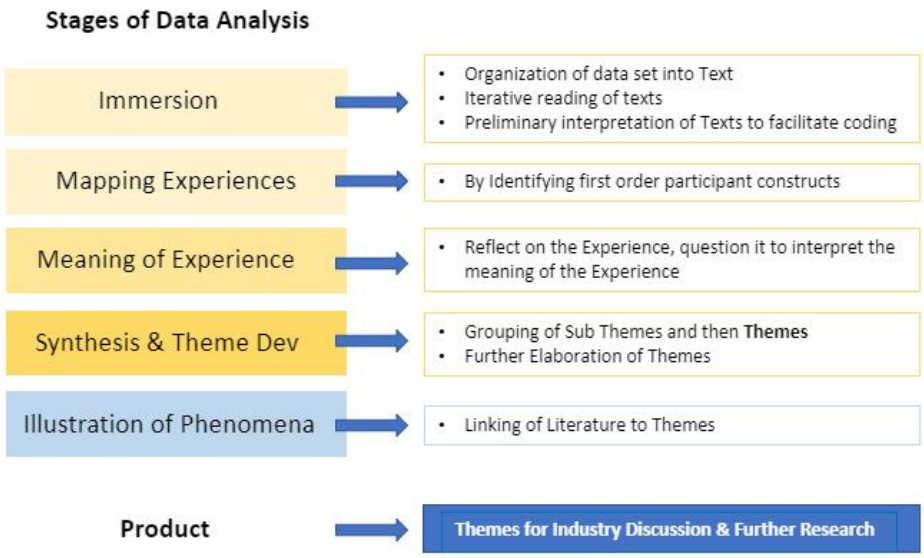


Figure 4.0: From Ajjawi & Higgs, 2007, Authors adapted model for data analysis.

4.2 Stage 1; Immersion

The first stage in this process is Immersion in the data. The Cambridge dictionary defines the word "immerse" as to become wholly involved in something (Dictionary.Cambridge.org, June 2020). There is no shying away from the fact that data analysis requires the time-consuming process of immersion (Green et al., 2007). Ajjawi and Higgs (2007) outline three steps in the stage:

- Organizing the data set into texts
- Iterative reading of texts – Van Manen's Detailed Reading Approach
- Preliminary interpretation of texts to enable coding.

4.2.1 Organizing the data set into text-based documents

To start to become "immersed" in the data, the author first transcribed the text from each recording for each interview. This was done soon after the interview had taken place while it was still fresh in the memory. The transcription is a faithful recording of the spoken word and when this was completed, the editing process started. The author set in motion a process to organise and keep safe the interview data. The first step carried out was to

make a digital copy of the original transcribed documents and store it in a secure location, in this case, on a cloud-based file storage facility. In the next part of the process the author work on the set of transcribed documents set up in a folder named Stage 1 and begin to remove personal names, company names and other text that might identify the participant and while doing this edit the author also removed “emm”, “agh”, “basically” and other prepositions. When the edited documents were finished Stage 1 editing, they were given an anonymizing identification tag and this ID tag was stored in the authors master research design document.

Examples of this stage 1 process are available to view in Appendix A.

4.2.2 Iterative reading of texts

The author then employed Van Manen’s (1990) detailed reading approach as described in chapter 3.6 by reading and re-reading the texts, in effect examining every word, sentence or cluster of sentences with time allowed to set the transcribed text aside to reflect on what had been said. Green et al., (2007) argue that repeated reading and re-reading of interview transcripts and contextual data and listening to recordings of the interviews are, therefore, the first step in the analysis.

4.2.3 Preliminary interpretation of texts to enable coding

The process continued by re-reading parts and making side notes on the text pages enables a growing familiarization with the text. When this exercise was completed, the entire set of transcripts was be copied and moved to a secure location to a folder labelled Stage 2.

4.3 Stage 2; Mapping Experiences

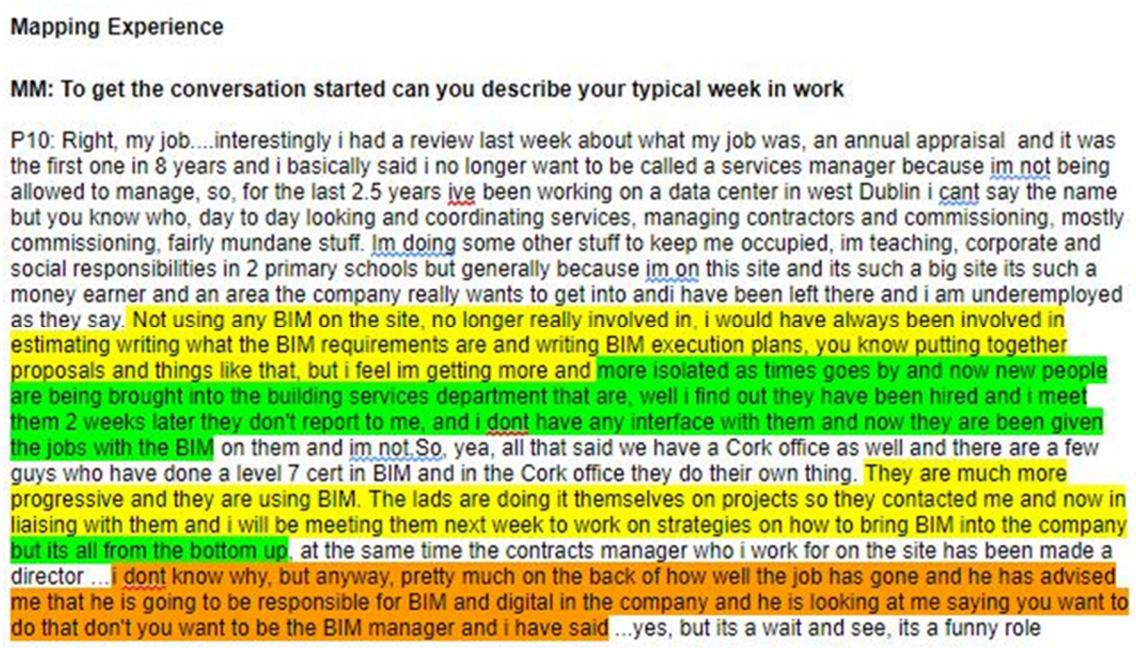
The author was now in a position to pick out words, sentences or cluster of sentences that had value and merited further examination. This was achieved by using the highlighter pen option in digital format. The author also started to use the strikeout tool to discard parts of the text that did not relate to the participant's direct experience or back into the research question.

4.3.1 Begin Manual Coding

Stage two of data analysis is manual coding; that is, the process of examining and organizing the information contained in each interview and the whole dataset. Green et

al., (2007) states that this forces the researcher to begin to make judgements and tag blocks of transcripts. Titchen and McIntyre (as cited in Ajjawi and Higgs, 2007) identify first-order "participant" constructs as participants' experiences expressed in their own words or phrases, which capture the precise detail of what the person is saying. Hycner (1985) describes this as delineating units of general meaning and being close to the literal data.

The author began this first-order coding as per the adapted Ajjawi & Higgs methodology in Figure 4.0 by examining the text in greater detail and selecting text that related to the participant's work-related experience and when found, highlighting it with colour. The author continued to read and highlight words, sentences and passages of text that were appropriate, continually asking the question, what is the participant saying and how does what is being said relate to the research question and, what, if any, has been the impact of BIM on the social dynamics of professionals in the workplace. The colour coding of words and sentences served as a method to start early stage filtering of the text.



Mapping Experience

MM: To get the conversation started can you describe your typical week in work

P10: Right, my job....interestingly i had a review last week about what my job was, an annual appraisal and it was the first one in 8 years and i basically said i no longer want to be called a services manager because im not being allowed to manage, so, for the last 2.5 years ive been working on a data center in west Dublin i cant say the name but you know who, day to day looking and coordinating services, managing contractors and commissioning, mostly commissioning, fairly mundane stuff. Im doing some other stuff to keep me occupied, im teaching, corporate and social responsibilities in 2 primary schools but generally because im on this site and its such a big site its such a money earner and an area the company really wants to get into andi have been left there and i am underemployed as they say. Not using any BIM on the site, no longer really involved in, i would have always been involved in estimating writing what the BIM requirements are and writing BIM execution plans, you know putting together proposals and things like that, but i feel im getting more and more isolated as times goes by and now new people are being brought into the building services department that are, well i find out they have been hired and i meet them 2 weeks later they don't report to me, and i dont have any interface with them and now they are been given the jobs with the BIM on them and im not.So, yea, all that said we have a Cork office as well and there are a few guys who have done a level 7 cert in BIM and in the Cork office they do their own thing. They are much more progressive and they are using BIM. The lads are doing it themselves on projects so they contacted me and now in liaising with them and i will be meeting them next week to work on strategies on how to bring BIM into the company but its all from the bottom up, at the same time the contracts manager who i work for on the site has been made a director ...I dont know why, but anyway, pretty much on the back of how well the job has gone and he has advised me that he is going to be responsible for BIM and digital in the company and he is looking at me saying you want to do that don't you want to be the BIM manager and i have said ...yes, but its a wait and see, its a funny role

Figure 4.1: Example of highlight words, sentences and passages of text that were appropriate.

4.4 Stage 3, Meaning of Experience's

When the author finished the second iteration of the examination of the text to highlight experiences relating to the phenomenon, a copy of the edited set of documents was created and placed into a new folder on the cloud storage labelled as Stage 3. The author then recommenced the analytical process by deleting sections of strikeout text; this had the effect of condensing the written word. The author then edited each new copy of the stage 3 text by adding a text box in the right-hand side margin and labelled this, Meaning of Experience, shown in figure 4.2. Ajjawi and Higgs (2007) outline two steps in stage 3 and state that second-order constructs are then generated using the researchers' theoretical and personal knowledge; these are abstractions of the first order (experience) constructs. The author followed this process using one step by;

- Reflecting on the experience, questioning it, interpreting the meaning of the second-order constructs coded to experience. (Ajjawi and Higgs, 2007)

This involves the process of reading and re-reading the condensed text and reflecting on the initial single words, phrases or whole paragraphs highlighted previously to see if they still hold value against the updated reading of the texts. In systematically making sense of a whole dataset, the author moved back and forth through the processes employing the "hermeneutic circle" and the "fusion of horizons" as described in chapter 3.2. Green et al. (2007) argue that the analytical process must engage in a constant process of 'testing the fit' as new data is integrated into the analysis. The author picked out new insights and commonalities between the different sets of text and copied them into the "Meaning of Experience" column.

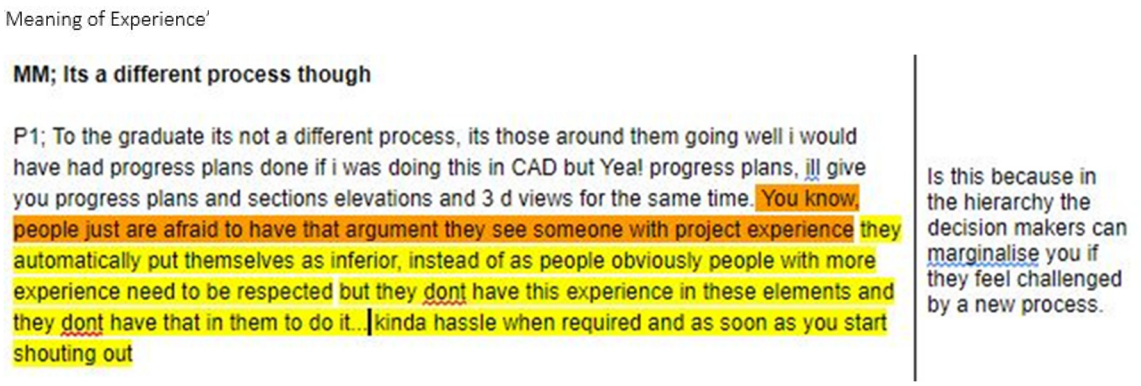


Figure 4.2: New insights and commonalities are placed in the “Meaning of Experience” column

4.5 Stage 4; Synthesis and Theme Development

Phenomenological themes may be understood as structures of experience and offer a thick description of the phenomena (Ajjawi and Higgs, 2007). Braun and Clarke (2019) state that themes are conceptualized as patterns of shared meaning across data items, underpinned or united by a central concept, which are essential to the understanding of a phenomenon and are relevant to the research question. In this adapted Ajjawi and Higgs (2007) model, there is more than one step in stage 4.

- Developing sub-themes

4.5.1 Developing Sub Themes

When Stage 3 Meaning of Experience part of the process is completed, the set of documents was again copied into a new folder named Stage 4a Sub Theme Development. The author added a second text column to the right margin of Meaning of Experience column, and this was labelled Sub Theme, shown in figure 4.3. The author now started the stage 4 process by further distilling the body text to develop Sub Themes. The author removed other text that was not holding relevance to the research question and the developing sub-themes, further concentrating the text. The emerging sub-themes were cross-checked against the other texts to highlight shared meaning within the participant's text but also across the other participant's text to highlight shared meaning. The author colour coded portions of sub-theme text which had the effect of visually bringing together emerging patterns over the fourteen transcripts.

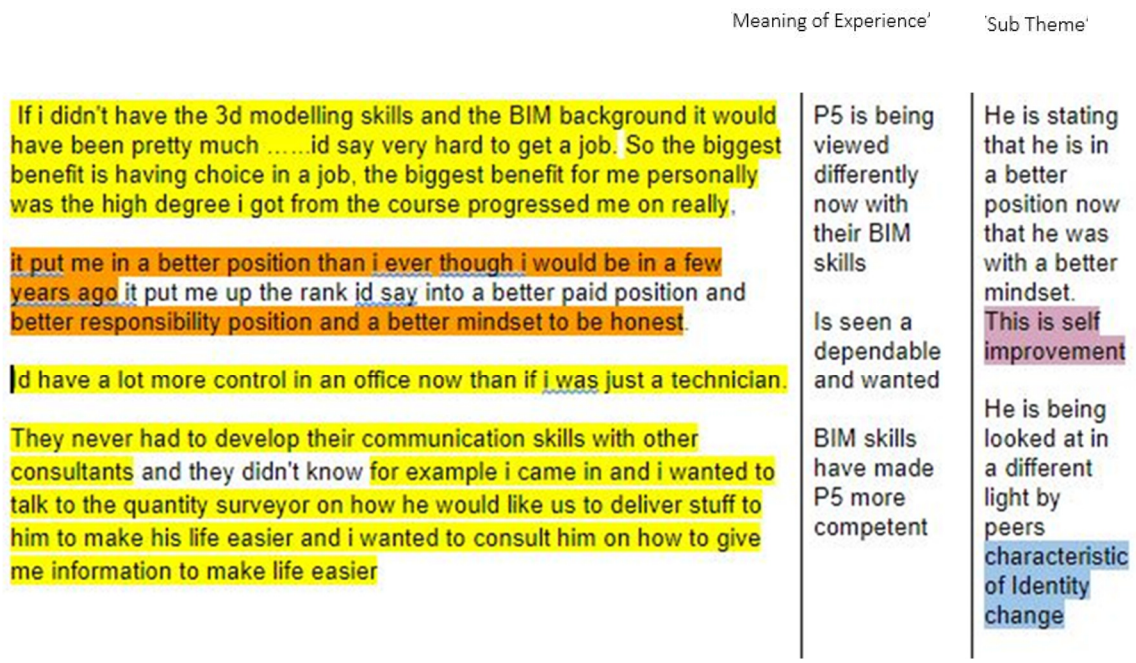
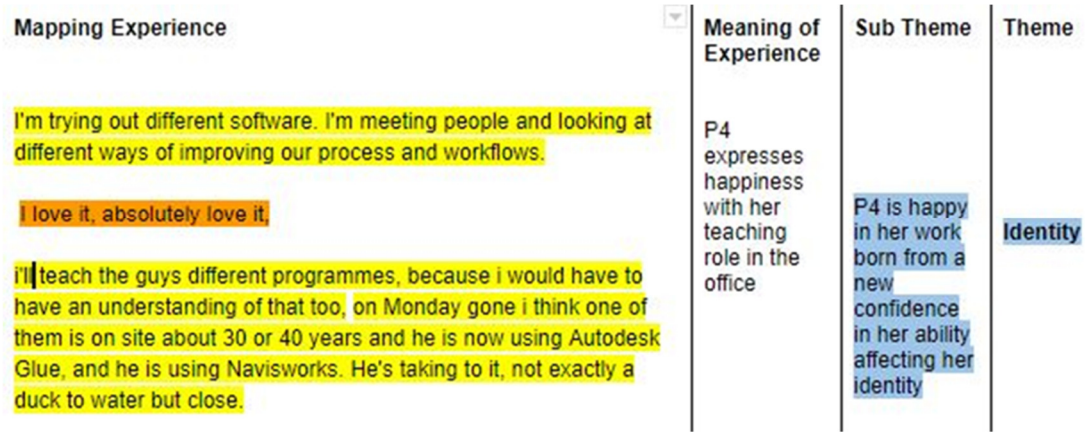


Figure 4.3: A second text column to the right margin of "Meaning of Experience" column, and this was labelled "Sub Theme."

4.5.2 Developing Themes

The final part of this adapted analytical process was to repeat once more the copying of the Stage 4a colour coded document set into a new folder labelled Stage 4b Themes. The author again following the outlined process, created a new text column to the right of the Sub Themes column and labelled these Themes, shown in figure 4.4. Green et al. (2007) state analytic categories (themes) are 'saturated' when there is sufficient information for the experience to be seen as coherent and explicable, for example, in showing that a group of research participants act in the same way because of shared values or life experiences. The generation of themes requires moving beyond the iterative condensed description of the previous two columns into the interpretation of the text and its meaning linking this to social theory and addressing the human dynamics of the research question.



Mapping Experience	Meaning of Experience	Sub Theme	Theme
I'm trying out different software. I'm meeting people and looking at different ways of improving our process and workflows. I love it, absolutely love it, i'll teach the guys different programmes, because i would have to have an understanding of that too, on Monday gone i think one of them is on site about 30 or 40 years and he is now using Autodesk Glue, and he is using Navisworks. He's taking to it, not exactly a duck to water but close.	P4 expresses happiness with her teaching role in the office	P4 is happy in her work born from a new confidence in her ability affecting her identity	Identity

Figure 4.4: new text column to the right of the "Sub Themes" column and labelled this "Themes."

This part of the process resulted in the identification of 4 themes to describe the impact of BIM on the social dynamics of the workplace, which are now presented in the next section. The research design took a hermeneutic phenomenological approach, and the findings of this research are presented in Figure 4.5.

Figure 4.5 shows the authors thought process working through the stages of data analysis, immersion by way of engaging with the text, mapping the experiences, deriving meaning from the experiences leading to synthesis and theme development. Column 1, named Iteration 1, is an example of the authors first attempt at positioning words, sentences and paragraphs of text using a code as a descriptor. These, however, on reflection, were not phenomenological themes and did not serve to bring forth meaning. Column 1 did serve a purpose as the first run at manual coding, and much was learned from this.

Column 2, named Iteration 2, is headed as "meaning of experience". The author was becoming more and more familiar with the text and was drawing more meaning from the parts to the whole and the correlation between the texts pick out more specific words and sentences for further reflection.

Column 3 named Iteration 3 is evidence that the author was now developing a deeper understanding of the text and this led to the first interpretations of the true meaning. This is expressed in the sub themes.

Column 4 named Iteration 4 shows the culmination of the author's thoughts leading to the themes by way of hermeneutic circle and fusion of horizons as detailed in section 3.3 The themes have emerged and the process is detailed in Chapter 4 and discussed in Chapter 5.

A Hermeneutic Phenomenological Study into the impact of BIM on the Social Dynamics of the AEC professional in the Workplace			
Iteration one	**Iteration two**	**Iteration three**	**Iteration four**
Mapping experience	**Meaning of Experience**	**Synthesis and Sub Theme Development**	**Synthesis and Theme Development**
BIM Fiction	**Personal perspectives**	**Sub Theme 1: Personal Role changes**	**Theme 1: Identity**
Exaggerated Knowledge Claims	different options on technology	frustration	Identity has surfaced as a theme from the analysis How the professional looks at themselves and their relationship with others, how that has changed their workplace forever Its personal its not empirical
Pseudo BIM	lack of understanding	made me feel young again	Motifs gathered around Identity
	unwilling to change	not left behind	1/ who you are, 2/ the way you think about yourself, 3/ the way you are viewed by the world 4/ the characteristics that define you.
		ability to progress a career	Professionals experience anxiety about their identity
		Happier in myself	
		information sharing happens when you are confident in your own identity	

BIM Finesse	**Confidence building**	**Sub Theme 2; Enablement**	**Theme 2; Empowerment**
New Knowledge Confidence	upskilling education	seeking new responsibilities	Empowerment has surfaced from the analysis and is reflected in the professional by way of new confidence, new abilities, but also dissatisfaction with the current job, current ways of transacting business, causing disarrangement
Network Knowledge Sharing	Technology master	moving jobs	Motifs gathered around Empowerment
	wanting responsibility	meeting new professionals	1/ organisational culture
	not getting left behind	knowledge sharing	2/ hierarchy
	opportunity		3/ relationships
	some see opportunity some see the same thing as a challenge		4/ relationship disruption
BIM Friction	**Disruption**	**Sub Theme 3: Disarrangement**	**Theme 3; Disarrangement**
Technology Disruption	don't want to have to upskill	to throw into disorder	Disarrangement has surfaced as a theme caused by the introduction of BIM and the effect of this on the professional is, frustration, conflict, isolation, rejection
New Knowledge Disruption	Its ok as it is	shaking up the current order	Motifs gathered around Disarrangement
	Frustrated to bring in new knowledge	challenge to hierarchy	is the workplace and relationships in the workplace put under strain
		conflict with middle management	

BIM Fracture	**New Technologies**	**Sub Theme 4: New Practice from new process**	**Theme 4; Collaborative Practice**
Hierarchy Holdback	middle managers preventing progress	Information sharing	Collaborative practice has surfaced as a theme and its effect is tied into the 3 other themes where new interpersonal skills are required for social collaborative working causing loss of identity, for some, improved identity for others, empowerment for some, disenfranchise for others and disarrangement for all.
Legacy Process	This is the way we have always done it	Delivering more in shorter space of time	Motifs gathered around Collaborative Practice
	Too expensive too much time to learn		1/ Identity in Collaborative Practice
			2/ Empowerment in Collaborative Practice
			3/Disarrangement in Collaborative Practice
			4/ Trust
			5/ Relationships

Figure 4.5 Progression chart showing the development of Themes, Sub Themes and Motifs

4.6 Emerging theme description

Four themes have emerged from the analysis. These are:

- Identity
- Empowerment
- Disarrangement
- Collaborative Practice

The first theme to come forward is termed **"Identity"**; it is necessary to frame this theme in terms of its use in this research. Fearon (1999) in his paper "What is Identity (as we now use the word)" picks out fourteen definitions of Identity from academic literature, from suggestive glosses to some somewhat complicated and opaque formulations. Fearon argues that identity is presently used in two linked senses, which may be termed "social" and "personal."

> *"As we use it now, an "identity" refers to either (a) a social category, defined by membership rules and allegedly characteristic attributes or expected behaviours, or (b) socially distinguishing features that a person takes special pride in or views as unchangeable but socially consequential (or (a) and (b) at once)".* (Fearon, 1999, p.38)

In this case, it is necessary to narrow down the meaning applied to the theme "Identity" while accepting many other definitions. The author has given a breakdown of the participants in chapter 3.7 of this document. All of the selected participants shown in Fig 3.0 have in one way or another experienced the influence of BIM in their workplace. They are all AEC professionals and are identified by their educational qualifications (personal identity) and their workplace (social identity). Fearon's definition is focused on in the

analysis of the presented texts because it is in the workplace where the effects of BIM can be identified.

The second theme to come forward is **"Empowerment"**; Rowlands (1995) states that the meaning of `empowerment can be seen to relate to the user's interpretation of power. In the context of the conventional definition, empowerment must be about bringing people who are outside the decision-making process into it. The acquisition of new knowledge and new digital skills presented the participants with new opportunities allowing them to progress into new positions where they became sought after or the go-to people in the decision-making process in their existing or new workplace.

The third theme to emerge came about due to experiences related to the first and second themes. For every action, there is a reaction, and for this case, the theme labelled **"Disarrangement"**; is defined as a condition where an orderly system has been disrupted (Vocabulary.com, accessed 2021). It came forth as a placeholder theme to gather the experiences from the knock-on effect of new knowledge and new skill development and how this challenged existing workplace hierarchy and management systems in the workplace. It was used to describe experiences of isolation, frustration and conflict.

The fourth theme to present itself is **"Collaborative Practice"**; The related experiences identified BIM and digital technologies as a platform for transforming work practices, which could improve productivity and foster new professional relations in the workplace. For this study, the cause and effect of collaborative practice can be tied into the three other themes of identity, empowerment and disarrangement.

4.7 Summary

This Chapter has provided an account of the strategies and procedures used in the analysis and interpretation of the participants' accounts of their workplace to identify themes by working the text, highlighting words, sentences, phrases or statements that reveal something about the phenomenon. The selected words, phrases and sentences were examined, reflected upon and questioned within the broader perspective of the study. This was an iterative process conducted in this study over a period of one year. This research has used a methodology developed using a combination of procedures outlined by (Van

Manen, 1997) and a modified model for analysis developed by (Ajjawi & Higgs, 2007) detailed in chapter 4.1. Four themes emerged from this analysis. In chapter 5, the themes are discussed and connected to existing knowledge relating back to the research question.

Chapter 5. Discussion

5.0 Introduction;

In this section, each theme will be discussed and connected to existing knowledge from published literature and provide a theoretical basis for the key findings discussed in chapter 6. No one theme is more significant than the other. The reader may recognise elements from their own lived experience from the transcripts and interpretations. However, it is the interplay between the four main themes that draw out a fuller understanding and can allow the author and reader to derive meaning from answering the research question, "with the introduction of BIM into the AEC Workplace, what, if any, has been the impact on the social dynamics of engaged professionals in the workplace".

5.1 Theme 1: Identity

The role of one's identity has come to the fore strongly in the hermeneutic analysis of the text. What is identity, and does identity matter? Jenkins (2014) asks this question, in order to begin to think about this, we must decide what we mean by "identity". Jenkins defines identity as the human capacity to know who is who; this involves knowing who you are, knowing who others are, them knowing who you are, us knowing who they think you are and so on. It's a multi-dimensional classification or mapping of the human world. Lamb & Davidson (2005) state that increasingly, information and communication technology uses are transforming professional activities and interactions in ways that challenge traditional assumptions about professional identity. The identity of the AEC professional is discussed in the following sections.

5.1.1 Evidence of a shift in the identity of the AEC Professional affected by BIM in the workplace.

The participants' stories all describe situations and experiences where their knowledge of BIM has affected their relationships; these are relationships with colleagues from their own perception of themselves and from the perspective of colleagues in their workplace.

P10 tells us

> *(BIM) has certainly empowered me. I was able to turn around to them to say I will be the BIM manager and at the kick-off of the BIM coordination meeting I will set up the CDE, I said how I wanted things done, so we took back control.*

P10 has gained confidence with his knowledge of BIM and had the confidence to "take charge" of a meeting in which BIM matters are discussed. Bloomfield and McLean (1996) describe how new information systems are implicated in the "empowerment" of health care workers, whereby their professional identity has shifted from a group primarily involved in the direct care of patients to one concerned with both direct health care and the management of information related to health care. P10 professional identity shifted when his company was challenged over control of the process; he was able to use his knowledge to set up systems of knowledge management, knowing how he wanted things done. P10 took advantage of this situation to demonstrate to his employer his applied knowledge, showing his confidence and abilities.

P6 tells us

> *BIM has given me an opportunity to specialise in a new area in the construction industry.*
>
> *It has meant that I have become a specialist and now a consultant now in an area of architectural technology. It has allowed me to harvest my experience as an architectural technologist to be able to be the best at the game in terms of Building Information Modelling,*
>
> *I took the opportunity to become involved in BIM initially thru using the software, but then that gave me an edge over other ATs*

P6 has forged a new identity on top of her existing to give her the edge over others and the confidence to strike out on her own as a consultant. As traditional roles and skills are challenged by increasing reliance and trust in ICT systems, professionals can experience anxiety about their identity (Lamb & Davidson, 2005).

P4 tells us she is happy now in her work,

> *I am trying out different software. I am meeting people and looking at different ways of improving our process and workflows. I love it, absolutely love it,*
>
> *I teach the guys different programmes because I would have to have an understanding of that too, on Monday gone I think one of them is on-site about 30*

or 40 years and he is now using Autodesk Glue, and he is using Navisworks. He is taking to it, not exactly a duck to water but close.

There are six site guys who two years ago would not have been using email, now they are basically looking at the model thru Glue on their tablets, and they go to the site.

P4 is telling us that she absolutely loves her role in her workplace, she is referring to her work which now includes passing on her knowledge to older, more experienced colleagues in her job. She has developed confidence in her ability, her knowledge and her social communication skills. Her view of herself is reflected in these new qualities and is a shift in her identity.

P12 relates to us how he made use of an opportunity at work for self-development.

We had an opportunity to develop BIM, and when (named person) who is our boss came to me and said this is where we need to go. So he gave us the go-ahead to do BIM, and that helped my development from a work sense, its made it way more interesting, It opened my eyes to education again in a way I have never seen before, a whole new way of education which I have never seen, an understanding I had never come across so going to college and then applying that to my work is just amazing.

It's given me in the last eight years the initiative to me "an RC detailer" the time to develop, and that became a driver for this for everybody, and it has changed my role,

Well, I tell you it was definitely a new lease of life for me,

P12 provides more evidence of his identity shift, telling us how his return to education opened his eyes and expanded his horizons. His work is now way more interesting than it was before. A shift in identity can be made by an alignment with new technology and practice this has caused some of the participants to move from their traditional community, leaving it behind to join a new community, described by Bruffee (1999) as re-accultration. The reasons for the shift from one community to another and the resulting change to their professional identity are shown by participants who related their stories of:

- Not wanting to get left behind,

P7 tells us that her office made a commitment to start all new jobs using the Revit application,

> *From now on everything is in Revit, never mind the BIM part, Revit is our drawing tool, but most people are using, most consultants want to use it .laugh...its made me young again.....laugh.... Seriously, doing that, I wouldn't like to be in a position where I hadn't jumped on board.*
>
> *the directors have made the decision that everybody coming into the office should be skilled up unless they were a particularly fabulous designer, but ideally, the would be able to use Revit and jump on a team, its got to the reality that in our room anyway and in other rooms if you were not able to use it there would be nothing for you to do. It's like cutting your hand off, and it's like going into an office saying I can't draw because I have no hands, you know you have to be conversant in it,*

For P7, the choice was obvious to get on board or be left behind in her workplace. One can detect a hesitancy at first, perhaps a fear of the unknown but the outcome of her decision to upskill surprised her as well stating, it has made me young again, a shift in her professional identity.

- Wanting to improve employment prospects.

P5 tells us that his job prospects improved because of his skills in BIM

> *It was very easy to find ….well not finding a job but it was very easy to apply for a lot of jobs and to narrow down and pick a job that suited me best with my BIM If I didn't have the 3d modelling skills and the BIM background it would have been pretty much ……id say very hard to get a job.*
>
> *So the biggest benefit has a choice in a job, the biggest benefit for me personally was the high degree I got from the course progressed me on really, it put me in a better position than I ever thought I would be in a few years ago, It put me up the rank id say into a better-paid position and better responsibility position and a better mindset to be honest.*

He is showing confidence in himself now being able to pick a job that suited him best; also, he can shoot for a better-paid position with more responsibility. He is expecting to be viewed in the new light of his upskilling showing a shift in his identity in how he expects others are looking at him.

- Wanting something new

P2 finds herself wanting to introduce BIM into a public service technical department. She states she has come up against resistance, but her enthusiasm is still strong.

> *I gravitate towards the ones who want to progress really well and as I am rolling out a load of free seminars and everywhere they're getting really excited about it and getting interested in it. I've rolled out 2 "BIM for Beginners" much to my surprise there were ...and when I looked at it afterwards it was more than beginners, to be honest, but it was fascinating for them, and they came away with their heads buzzing.*

P2 wants to show her colleagues the benefits of adopting and embedding BIM in their workplace practice. She is saying that she will work with colleagues who want to progress and does not have much time for those who don't want to change. P2 wants change, because she has become aware of better technology solutions through her upskilling in BIM, this is a measure of the shift in her identity.

- Wanting to improve the industry they work in,

P6 takes pride in her work and wants to improve this industry she works in

> *It's about improving the way we do things in the construction industry so to be able to delve further into that industry I did a masters in building information modelling and management that opened up for me an opportunity for me to get into the strategy side of things in implementation, change management even, new mindsets and working with people.*

P6 made a decision to validate her BIM knowledge and improve her professional skill set as a commitment to improving the industry. She is saying that she wants to be in a position to influence others by getting into the strategic decision-making zone. Her desire to make

the industry better has caused a shift in her identity, causing her to look at her role in the design and construction industry from a managerial perspective.

5.2.2 What are the implications of a shift in the Identity of an AEC professional?

In his book titled Social Identity, Jenkins (2004, p.17-18) suggests that the world as constructed and experienced by humans can be best understood as three distinct 'orders':

> • *the individual order: is the human world as made up of embodied individuals, and what-goes-on-in-their-heads;*
>
> • *the interaction order: is the human world as constituted in relationships between individuals, in what-goes-on-between-people; and*
>
> • *the institutional order: is the human world of pattern and organisation, of established-ways-of-doing-things.*

This is a way of looking at a complex but unified phenomenon, the human world, and viewing the same observable realities – humans and their works – from different points of view, paying attention to different stuff: embodied individuals, interaction, and institutions, respectively (Jenkins, 2004).

5.2.2.1 The Individual Order

Moving from a traditional workplace community to this other new BIM-based community can cause a shift in an AEC professional's identity. Bruffee (1999) argues that we experience and learn indirect social exchange, with other individual's perspectives and opinions introducing us to new and deeper ways of seeing something. Some of the participants have been exposed to new and deeper ways of seeing themselves and their role in the industry through post-graduate education arising from a personal desire to improve or change their position in the workplace. This has manifest itself in some of the participant's stories where they have less tolerance now towards the traditional tools and process, the colleagues who still hold on to these and those colleagues who show resistance to change.

P1 gives us a description of how he is thinking in this excerpt:

The younger people, without being ageist, it is yea the younger people get it quicker. It is strange, some in the office have a fear of it, you know yourself you do something in Revit you move a wall, and you get a pop up with 40 warnings, you've spoiled this, un-joined this, you've deleted this, and you're kinda going O...its grand I'm changing the whole building here anyway so...it will be fine, whereas other people get this and they freeze...o god, what will I do,...it just says "warning", but it scares them. I know I do and the other lads from college just steam into it.....

P1 has opinions on colleagues and how different personalities react to a technology problem, these are his ideas demonstrating Jenkins description of the Individual Order, and what goes on in their heads. How people have seen the world and what goes on in it helps form their identity, and when this is challenged by new experience and a new understanding, it will cause a shift in the professional's identity which will manifest in the workplace.

P 5 relates how his colleagues now see him in a different light.

Well, I have changed from being an engineer or technician, and I have now become a BIM person or BIM Manager. They see it more as a hindrance. The 2D lads are still doing 2D, and they are in a mindset where they would instead sort it out on-site with their foremen.

At the moment I am the only one leading it in this office. So, it's challenging. I used not to be confident when I came from a 2d background. They definitely see me as the man who knows all about the BIM. They do like the fact.

P5 tells us he has changed, and this change is confirmed to him by the way his colleagues see him as the man who knows all about BIM and how they like having that in their workplace. He is forging new relationships from a different starting point in his professional career. Individuals are unique and variable, but selfhood is thoroughly socially constructed: in the processes of primary and subsequent socialisation, and in the ongoing interaction during which individuals define and redefine themselves and others throughout their lives (Jenkins, 2014).

5.2.2.2 The Interaction Order

A person's understanding of their identity, how one is seen by others, one's perception of how they are seen by others are challenging to their identity. Some of these challenges can be caused by a shift in the dynamics in the workplace.

P6 relates her experience of attempting to implement a directive from the executive management of her firm,

> *It was probably something that was the hardest part of developing my career into this area of specialism, so one of the biggest difficulties I had in implementing BIM in my (firm) was "middle management" and the conflict I had with colleagues at middle management they were comfortable in what they were doing they did not want to shake things up they did not want to change the way they did things and BIM really pushed them outside their boundaries, and also they did not know about BIM they thought BIM was Revit so trying to educate them they did not want to listen, they did not want to learn, whereas the executive committee was really open to BIM and what BIM could do, and the modellers on the ground they really wanted to push their boundaries, but it was the middle management that didn't want to change things, they didn't want to allow the project teams to develop in the whole BIM area,*

P6, in trying to implement change comes up against a barrier in what she terms as middle management, established professionals who wield decision making power, who are comfortable in their positions and do not want change, became adversarial towards P6. Their attitude to new innovation, the potential shift to the established hierarchy and one's place in that hierarchy, coupled with the challenge of new knowledge has the potential to isolate P6 in the workplace, challenging her professional and personal identity relating to the interaction order as described by (Jenkins, 2004).

5.2.2.3 The Institutional Order

What is identity, and to be more specific, what is a work identity? Clarke, Brown, & Hailey (2009) state that work identities are contingent and perpetual works in progress, the fragile outcomes of a continuing dialectic between structure and agency. What is more, while identities are achieved rather than ascribed, such identities may not always be of our own choosing. Weick (as cited in Nach & Lejeune, 2009) states that identities

are lenses through which people make sense of the world. People construct their identities from a wide array of interdependent social resources such as ethnicity, workplace and education (Nach & Lejeune, 2009).

P8 relates what a new experience for him is:

> *People are sharing that information, and that is a whole new way of working, and that is you know, hey we found this little thing called dynamo, and it is saving us hours doing this, it has made us quicker, and then we share it. That sharing of information is a whole new thing for me, and we did all this, so we stick it up on the blog then someone else goes that is great but have you tried this ....you suddenly realise let not try to hide this anymore we will share it with everyone because we are all doing the same thing and it will go quicker and faster if we share the information.*
>
> *Certainly, all of the guys that part of that whole Revit culture of share and share because I think that everybody realizes that we have something great here and we have only hit the tip of the iceberg let us all try and make it with our best efforts.*
>
> *For me, it's a whole new culture. Kind of like this whole Facebook thing,*

Institutions are among the more important contexts within which identification becomes consequential. Institutions are established patterns of practice, recognized as such by actors, which have force as the way things are done (Jenkins, 2004). P8 has had a shift in his identity and now subscribes to the culture of sharing of knowledge which is bound up within the BIM community.

5.2 Theme 2: Empowerment

Empowerment has surfaced from the analysis and is reflected in the professional by way of new confidence and new abilities. However, empowerment also has a reaction to this action described as; dissatisfaction with the current job, current ways of transacting business, causing disarrangement as described in the third theme. Maeroff (as cited in Edwards, Green, & Lyons, 2002) states that (teacher) empowerment consists of three elements, improved status, increased knowledge and access to decision making. These three elements are worth taking into the discussion of empowerment as reflected in the stories from the participants.

5.2.1 Improved Status.

P12 tells us of his change of role and the development of his standing in his workplace.

> *We had an opportunity to develop BIM, and when (named person) who is our boss came to me and said this is where we need to go. So he gave us the go-ahead to do BIM, and that helped my development from a work sense, its made it way more interesting.*
>
> *It is given me in the last eight years the initiative to me "an RC detailer" the time to develop, and that became a driver for this for everybody, and it has changed my role.*
>
> *I still work as a draftsman, but now I have a role in IT which I would never have had before. I have I suppose to become the go-to man for all Autodesk products because no one else would support them at the time because they were very much Bentley at the time and now it is gone to the stage where they are more Autodesk, and no one took up the role. So I took up the role of Autodesk support.*

P12 tells us he took it upon himself to upskill in BIM technologies and process, hoping to create a new career opening for himself and his opportunity came calling when his boss came to him to discuss and plan out the firms approach to implementing BIM. His manager sought him out because of his new knowledge and skills; his colleagues seek him out to provide support on their technology problems. P12 states that his job as a draughtsman has been added to with a managerial and support role improving his status in his workplace. This has all added to P12's status in his workplace, and this reflects in a new attitude to work.

> *But you know I enjoy going into work now. I look forward to it, I go in and enjoy it, it's brilliant, eight years ago we were doing mundane tasks I would wake up going O God,....no I'm up, and my wife is looking at me, and I'm saying I enjoy my work …you can't come home moaning that you don't enjoy your work. I think that's all because it all a challenge a learning challenge and if there's no challenge there it's boring.*

P12 relishes his work he looks forward to it, and this has even been noted by as he explained by his wife, he has a new enthusiasm for work that is a vast improvement on where he was before. P12 has been empowered by his upskilling efforts.

5.2.2 Increased Knowledge

P3 is now a joint director of his own architectural design practice. He was convinced by a colleague to get into BIM before he set up his own practice.

> *It was really the downturn that gave me the opportunity I think there were a lot of people on the course who were in the same position, the target was those who were unemployed, and I would say that the people who did go on the course did really benefit from it.*

As his knowledge of BIM was increasing, he started to spread the word in his workplace, this at the time was a large multidisciplinary service provider.

> *It was very simple lunchtime forum where you would get 50/60 people, and you would cover the people in (named firm) over time, so that gave me power and gave me I suppose the knowledge to go and do that and again without being an expert I had enough knowledge to say look this is what is it about, this is how we do it and these are the steps…*

P3's growing knowledge of BIM technologies and process put him in a position of power which he used later to springboard himself into a consultant's role with the firm.

> *I've not really thought about that .....am I happier....I suppose when you see the benefits, yes definitely, but with it comes the challenges of a/ keeping yourself educated and b/ up to the speed of things.*

P3 is happier now with his increased knowledge; it has put him into a position where he has used it as the anchor in setting up his own business, he has been empowered by his increased knowledge.

5.2.3 Access to Decision Making.

P1 has extensive BIM knowledge and experience gained over years at being at the forefront of embedding BIM in his firm. He describes his role like this:

> *It is kind of an un-quantifiable role, you know it is, some people come to you with all the problems, some people don't come to you at all unless they have a problem, you're kind of, there no official sort of, no official BIM person as such in the office its just muck in.*

His knowledge and problem-solving abilities while not officially recognised or perhaps labelled is sought after by directors and managers in the firm.

> *.i suppose it's given me more seniority or something people come to me with ...not just people below me but people above me with questions like at every stage of a project can people do this or what's involved ... I get dragged into office workgroups for policy and that kind of stuff, Well at the minute we're writing the BIM manual for the office there is a new ISO 9001 brought in new flow, it used to be all test-based work procedures but now its flow charts, graphic flow charts, easier for people. Its a graphic industry easier for people than reading text, we're in the middle of writing the documents for all various things...I'm on the BIM one, the CAD one, the Inspections one.*

P1 has direct access to decision making for the firm. His requested involvement in setting standards for the practice will have a direct effect on all who work there. He is empowered in terms of his access to decision making.

5.3 Theme 3: Disarrangement

Disarrangement has surfaced as a theme caused by the introduction of BIM into the workplace. Disarrange is defined by Merriam-Webster as "to disturb the arrangement or order of" (Merriam-Webster, n.d). Deutsch (2011) addresses what he defines as the number one problem of BIM implementation in the workplace as being not the technology nor the business value proposition nor even the return on investment (ROI), but rather people. As discussed in chapter 5.2, there are examples of AEC professionals in the industry who expressed how they felt empowered by BIM knowledge; they also report that this has caused difficulties for both them and their work colleagues. Some have expressed a feeling of frustration, isolation, fear of missing out (FOMO) and actual

conflict. BIM is a relatively recent innovation, and innovation, as described by Van de Ven (1986) is the development and implementation of new ideas by people who over time engage in transactions with others within an institutional order. It is these transactions with others that are of interest to this study

5.3.1 Frustration

P10 has upskilled in BIM and finds himself ahead of the others in decision making roles in the company. He has, however, been drawn into situations where the management know he has knowledge useful to them to show clients they are BIM compliant. P10 becomes frustrated when he is left out.

> *I got an email to say, we went to an interview, and we were asked a question in the interview about BIM, can you answer that question, knowing that (named person) was involved in that project I discussed it with him because it is quite a complicated question even between myself and himself we were mulling over how to answer it, so I arranged a meeting with the guy who asked the question with myself and (named person) to find out… they had (already) answered the question, I don't know how but they have gotten themselves in a right mess, So they didn't allow for BIM on the job even though they knew it was there, so the people with the knowledge are at the bottom and the people making the decisions are at the top, and they are not informed so trying to.*

There are several interpretations one can take from this extract, and perhaps the questioner was looking for a quick answer, thinking there was a quick answer to be had. P10 with his knowledge, spotted that this was a complex question and he needed to seek a second opinion but the questioner decided either just not to wait or to ignore his colleague. The questioner may have been challenged by P10's knowledge and in the hierarchical organisation of this firm P10 surmised that he did not want to be put into a weakened position so decided to provide his own solution, leaving P10 bewildered and frustrated that his knowledge and efforts were ignored.

> *It's a bit frustrating, I think some people have done stuff, and they think sure it will be grand.*

They are ignoring the most qualified person in BIM in the company.

P10 wants to progress his career with this company but by upskilling he found himself rather than being lauded and appreciated, left frustrated and ignored.

5.3.2 Isolation

P1 gives us an example of how a professional can find themselves isolated in a busy office:

> *Directors hire the new staff, and he has a client who says I want this in Revit so they get a graduate technologist in and they have Revit. So, you're the Revit person you can sit there siloed essentially. They're working in Revit and the BEPs and EIRs everything is there. Its a BIM project but... it's not because it's not collaborative; you're siloed. You're getting your instructions from different people who are testing layouts in CAD and they're basically using you as a monkey a BIMpanzee, and you're just modelling up off somebody else's drawings.*

P1 is expressing sympathy with the graduate technologist who has been hired for his BIM skills so a director can say he has BIM capabilities in their team, but their working process has not changed, and the new recruit is isolated because of their BIM skillset. P1 knows what's going on here and understands that the graduate is not in a position where they can stand up to those whom they see having more experience even if they feel the more experienced colleague is wrong.

> *To the graduate, it's not a different process, its those around them going well I would have had progress plans done if I was doing this in CAD, but Yea! progress plans, ill give you progress plans sections elevations and 3D views for the same time. You know, people just are afraid to have that argument they see someone with project experience they automatically put themselves as inferior, instead of as people obviously people with more experience need to be respected, but they don't have this experience in these elements, and they don't have that in them to do it.*

P1 sees a power play happening here within the hierarchy of the office team. The junior member is finding themselves isolated as a result of their skillset in BIM because the rest

of the team has not adopted or upskilled in BIM and this is reinforced by the ambivalent attitude coming from the director and leader of the team.

P10 has found himself in a similar situation; he is the most qualified in BIM in the firm but finds himself isolated because of it.

> *I think some people have done stuff and they think sure it will be grand. The guy who has been made the director responsible for digital and technology spent some time in the BIM room in (named company) and now thinks he knows all there is to know, but I know even at this stage that I don't know it all, and they are ignoring the most qualified person in BIM in the company.*

P10 finds his situation "strange" and "frustrating". The company are making moves into BIM, but he is being ignored and isolated.

> *Not using any BIM on the site, no longer really involved in, I would have always been involved in estimating writing what the BIM requirements are and writing BIM execution plans, you know putting together proposals and things like that, but I feel I'm getting more and more isolated as times goes by and now new people are being brought into the building services department that are, well I find out they have been hired and I meet them two weeks later they don't report to me, and I don't have any interface with them, and now they are being given the jobs with the BIM on them, and I'm not.*

P10 is seeing himself as the victim of kingdom building within the company and is possibly seen as a threat to others who are seeking to move up the management ladder.

> *I don't know why the Dublin office is so …there are little kingdoms being grown, so yea, maybe I know too much, maybe they think I know too much, maybe I'm too honest. You can take that (named client) job in town I worked on the tender for that, I, we got the BIM execution plan, I got the price and went out and put it all together did the post-contract BEP and submitted it back, and then I was just cut out of it and moved not on the job, not informing the job.*

P10 suggests that "maybe I know too much" and "may they think I know too much" this is indicating that P10 knowledge and skillset of BIM is a threat to others and their way of dealing with it is to take his knowledge and then cut him out of the job. Useful but a threat

to their own careers and leaving P10 in a difficult and frustrating position of feeling used for the advancement of others.

5.3.3 Fear of Missing Out

P13 is a director of a busy provincial-based architectural practice. Their process is 2D CAD-based with design and technical staff having their set roles in the office structure. P13 is aware of BIM, but they have not made any inroads to implementing BIM into their office process.

> *I suppose you know we haven't moved over to BIM yet, there is an awareness of it and there is an awareness of it now by the bigger clients like (named client) or Department of Education work, and we are going to have to go there in time. Nobody here has any training in it, and we need to look at bringing on board someone who is skilled and proficient in it.*

P13 expresses a fear that their larger clients could very easily start asking for their project to be designed using BIM and that he could lose out and become small fry in their industry.

> *Well, I've not looked at it in any great detail other than we know it's coming it going to be a big change. Our fear is, and I suppose we are open to change, I can remember in 95 when the drawing office moved from drawing boards to computers that was a big change, but it was one that was embraced within the office so, our fear is that if we don't move over that we will become small fry and we won't be able to do …we are not looking to take over the world here, but we would like to continue to work with the clients we all ready have, and even as well we are seeing it with some of the larger clients on jobs we are tendering for its a competency that you have to show that you have*

He knows it's coming and that it is going to be a big change, but he does not know the scale of the change as he is comparing it to the move off the drawing boards to digital drafting. He is fearful that this will impact on the business and that he is being driven to this by factors outside of his control. He has a process that works and has worked for 23 years, but now this is being challenged.

I think its kind of comfort, a false comfort you can take all the jobs we are working on are using Autocad and they're all going very well, and you know we have had Autocad in the office here now since 95 that's 23 years.

Yes, we have almost become stuck in a rut with the process of production that we have I would recognize that it's not ideal,

P13 knows there is uncertainty ahead, new challenges to meet being driven by external forces. What is motivating him is a fear of missing out as opposed to seeing the benefits BIM can bring to the office process, the empowerment of his staff and the improvement of the industry for the client's benefit.

5.3.4 Conflict

P6 tells us of her difficulties in implementing BIM in a large company where a hierarchy of management exists around an embedded traditional design and construction process.

So one of the biggest difficulties I had in implementing BIM in my (firm) was "middle management" and the conflict I had with colleagues at middle management

BIM really pushed them outside their boundaries and also they did not know about BIM they thought BIM was Revit so trying to educate them they did not want to listen, they did not want to learn.

It was the middle management that didn't want to change things; they did not want to allow the project teams to develop in the whole BIM area.

So it was actually very adversarial to deal with those people because they just did not want to engage and yes I made some enemies.

From trying to do that because when you're being encouraged from top-down and bottom-up are really asking, can we do this you're like the hero for the executive and the project teams so people come to you rather than the middle management and that raises more conflict as well.

She has had to deal with conflict because she is challenging the established process and those who are in charge of that process. She refers to top-down this being the senior

management who have instructed her to implement BIM in the company and bottom-up, these being technical production staff who are benefitting from the new approach. Each of these groups are coming to her for help and decision making and bypassing their line managers. This is a source of conflict, and as she states, there was a lot of difficulty with that. The social dynamics of this workplace have been disarranged by the implementation of BIM as expressed by P6, her relating stories of conflict in her workplace.

5.4 Theme 4: Collaborative Practice

Collaborative practice has surfaced as a theme in this research. In the design and construction industry there needs to be a level of cooperation or collaboration with others to get the job done however successive reports on the industry, (Latham 1998; Egan, 2002; Farmer, 2016) have highlighted that collaboration has been an area of weakness in the industry. The UK Government Construction Strategy 2011 (GCS, 2011) specifically identified technology as a solution to public sector asset procurement and management. It identified BIM and digital technologies as being key to transforming work practices, which was necessary to improve productivity. For this study, cause and effect of collaborative practice can be tied into the three other themes of identity, empowerment and disarrangement. Collaborative design is an activity that requires the participation of individuals for sharing information and organizing design tasks and resources (Chiu, 2002).

5.4.1 Identity in collaborative practice

Deutsch (2011) highlights the number one problem of BIM implementation is not technology nor business value propositions but rather behavioural, temperamental, emotional and mental attributes. He goes on to state that many design professionals and their firms when considering BIM, do not consider people - the social impacts, benefits and challenges brought on and about by this relatively new technology currently being introduced into the workplace P7 has experience of working on large projects and states

> *"There is a major problem with BIM in the sense that it's brilliant if you are on the same page and producing the same information at the same time but, if you're not, it's torture not to be dramatic about it."*

Being "on the same page" refers in this case to the behavioural attitude of the project stakeholders. Having even one actor out of sync or just not at the same technological level can put a serious dent in the workplace workflow. The ability to collaborate and work productively in teams, historically subjects felt better left to psychologists and operations, will be the most critical skillset design professionals will need to master if they are to survive the current professional, economic, social and technical challenges (Deutsch, 2011). BIM supports the sharing and integration of information and collaboration, and this is a direct challenge to the identity of the AEC professional where sharing information and resources is not something that comes easy in a design and construction industry that has its roots in a division of intellectual effort over technical know-how going back over 500 years. To achieve effective collaboration, there needs to be what is referred to in the literature as a change of mindset or culture change (Rowlinson et al. 2010; Babič & Rebolj, 2016). P6 tells of her own understanding of BIM collaboration:

> *My own personal belief is that a task team or a task force is one of the best ways to execute a BIM project., but it has to be the entire team, it has to be the project manager, the project engineer, the architect, the modeller, the QS, the project planner, all working together in that environment,*
>
> *The people side is getting the right people on the team that are going to engage in that environment. You don't want the negative people who don't trust anybody or that…those middle management people they are of no benefit to that process, and whether their mindset has changed or whether you just move on you want to work with people who will engage in that process,*

The "right people" on this team are those professionals open to the sharing of information and tasks to achieve a common goal.

P6 identifies herself as a team player:

> *Absolutely a team player...but I don't suffer fools either, so if everybody is not playing for the team I won't stand for that, I'm organised and good at organizing. I feel passionate about the industry.*

P8's professional identity has changed because of the sharing culture he has found that surrounds the BIM community,

People are sharing that information, and that's a whole new way of working, and that's you know, hey we found this little thing called dynamo and it is saving us hours doing this, it has made us quicker, and then we share it. That sharing of information is a whole new thing for me, and we did all this, so we stick it up on the blog then someone else goes that is great but have you tried this ....you suddenly realise let not try to hide this anymore we will share it with everyone because we are all doing the same thing and it will go quicker and faster if we share the information.

He is now working differently to the way he did before, and his attitude is different from before.

Certainly, all of the guys that part of that whole Revit culture of share and share because I think that everybody realizes that we have something great here and we have only hit the tip of the iceberg, let's all try and make it with our best efforts. We participate in all the lectures and conferences, and in as it were a smaller network that's a huge thing for us learning and sharing that's the way we work here.

P8 embracement of BIM as his office digital platform for collaboration has given him a new attitude toward the way he organises his office,

We have gone away from the whole hierarchy of boss's associate's directors everybody sits at the table, and that's a great atmosphere for encouraging design, encouraging participation, encouraging enthusiasm as much as anything.

He has moved away from the hierarchical management structure to a more collaborative roundtable structure. His collaborative platform has shifted his identity as an owner and a professional.

5.4.2 Empowerment in collaborative practice

Collaborative practice based on BIM technologies and process opens up new avenues for the AEC professional. P5 shows this when he tells us of his interaction with other professionals:

I'd have been able to deal with outside consultants and use their models and work with them far better than the person who was in charge in the company because it wasn't their fault really they had that job, but I had the chance to go back to college whereas they developed their BIM skill in the job but in a surrounding where they have just to deal with the same people in the office around them. They never had to develop their communication skills with other consultants, and they didn't know for example I came in, and I wanted to talk to the quantity surveyor on how he would like us to deliver stuff to him to make his life easier and I wanted to consult him on how to give me information to make life easier

P5 has found empowerment in his collaborative abilities. He is telling us that upskilling from postgraduate education has put him into a position where he can work with outside consultants better than those in his workplace.

P1 shows us how he was able to use his BIM knowledge to effect in a collaborative setting:

We did the schools project that was a level 2 project and there was a collaboration between ourselves and the engineers ...it wasn't...the suite of documents provided was loose, and because of fee issues I was able to wriggle out of doing some of the .....we read the documents, so we saw what we had to do and didn't, so we said well we're not doing that they (the contractor) wanted us basically take full responsibility for a full COBie to drop your responsible to commission the building so why would we do that, we are the architect, go thru your document here, they didn't like that.

He has the confidence to challenge the contractor's interpretation of the BIM contract documents saving himself and his employer from an amount of extra work.

But it gives you confidence that you can go into a meeting with a contractor and review a gnat chart and spot that the critical path is off that he is in breach of clause x in the contract and pick out such and such in the tender doc.

P1's knowledge of BIM orientated process and contractual matters has empowered him in his workplace.

5.4.3 Disarrangement in collaborative practice

All the motifs surrounding both identity and empowerment themes hold the possibility to be magnified in a collaborative setting which can lead to a successful endeavor or can lead to disarrangement in the process, the project and in the company.

P10 has experienced disarrangement within the collaborative practice in his workplace.

> *We really need a BIM manager because even just the name because if there is BIM on that tender, you can say ring and ask him, whereas at the moment they don't know whom to ring and ask so they don't ring anybody so yea its really me being on the bottom trying to inform people, It's a bit frustrating, I think some people have done stuff, and they think sure it will be grand. The guy who has been made the director responsible for digital and technology spent some time in the BIM room in (named company) and now thinks he knows all there is to know, but I know even at this stage that I don't know it all, and they're ignoring the most qualified person in BIM in the company yea so its....but you know I've almost gone past that.*

P10 has resigned himself to being ignored despite have the knowledge the company needs. He is caught up in a competitive management system where knowledge is taken and guarded and not shared unless it benefits the informer. This is a cooperative system as opposed to a collaborative system, and the cooperative system is one where a colleague or external professional will work with you but in order to achieve their own goal, the collaborative system is where you work together to achieve a shared goal by sharing available information. P10 is frustrated finding himself caught up in a cooperative management hierarchy system.

P2 has had to deal with an embedded domain-based hierarchy in her attempts to introduce BIM.

> *I always enjoy challenges, so I do actually enjoy it, I've enjoyed rolling it out, but sometimes we meet even with the Architects upstairs ...o god give me patience....so of them are for it but now that,...when this becomes a mandate there is no way around it, you either get on board, or you don't ...so a lot of them are accepting it. Actually, it is growing a momentum big time, and it really is growing now, I find people are coming to me rather than me trying to reach people like in here*

initially I was trying to figure out the corporate structure. I was trying to find in the corporate structure who do I have to ...hit for want of a better word, but I didn't know their significance necessarily was, but now I've got the right people anyway

P2 has another example of domain-based hierarchy disarrangement:

It is starting to happen, but it's very slowly starting to happen big time, but our issue has always been IT, they won't play ball with us, couldn't have it, somebody must have talked to our IT guy because he appeared and that was wonderful, but I'm looking at his body language, and I'm thinking it does not agree with what you're saying.

The dynamics in P2's workplace is being made visible here with reluctant participation from one domain department and active resistance by another domain department, all leading to a disarrangement in collaborative practice.

5.5 Summary

The four themes and their related motifs have been presented and discussed in this chapter. The themes are interconnected and have the advantage to give the reader four different but connected perspectives on the research question. Each theme has been discussed and connected to existing knowledge from published literature. Direct quotations from the interviewees are used to highlight the lived experience and are presented under each of the themes. The themes emerged from the analysis described in chapter 3 and explained in chapter 4. The author as researcher, is an active participant in the study, being embedded in BIM as both an educator and practitioner. To separate the interviewees lived experience from the authors lived experience is a difficult one. (Clandinin and Connelly cited in White, 2003) note the way that participants talk with us, tell us something about how we are storied. That is, as much as the researcher tells the stories of the participants, so too do the participants story the researcher.

The author did recognise many of the experiences as related by the participants, some of these were from the authors own lived experience, but also some of the stories were recognised from previously published literature. The purposeful sample of participants

crossing the age, gender, seniority, urban/rural mix provided a rich seam of lived experiences added to the authors own journey of discovery, confirmation and reflexivity.

Chapter 6. Conclusion

6.0 Introduction

New technologies are changing the workplace at lightning speed - or so conventional wisdom goes. In practice, digital transformation can be painstakingly slow, often because it takes workers much longer than expected to master new skills (Weber, 2020). This research set out to examine **"what, if any, has been the impact (of BIM) on the social dynamics of engaged professionals in the workplace"** through analyzing their lived experience. Two pilot interviews were conducted to help refine the interview process. After these fourteen AEC, professional participants were interviewed. This was a purposeful sample of professionals across the design and construction domains, with gender and level of responsibility balance in the makeup. The resulting spoken word data sets were transcribed, read, reread and analyzed using a method described in chapter 3. This was designed to distil and produce themes and associated motifs. This analytical process resulted in four themes emerging; Identity, Empowerment, Disarrangement and Collaborative Practice.

The hermeneutic interpretive analysis method allowed the author to go back to the research question with a newer understanding of the phenomenon being studied after reading and analyzing the participants' lived experiences. With this new understanding, the author was in a better position to address the themes and their motifs through further discussion and enriched these with published literature references on the specific topic.

New knowledge has been generated specifically on the human social dynamic of this digital transformation in the AEC workplace which will contribute to research by adding to the sum of knowledge on the subject matter of social dynamics of engaged professionals in the workplace affected by BIM. This final chapter will review the implications of this research for skills and competencies arising from working in a BIM-based design/construction environment and implications skills/competencies that can be embedded into design and construction education. The chapter will outline the limitations of the research and discuss future research options.

6.1 Implications for Industry; skills and competencies arising from working in a BIM-based design and construction environment.

The impacts of BIM on organisational structure and construction companies' day-to-day business operations are extensive as well as intensive (Wu & Issa, 2014a). The resistance to change in organisations is most challenging when top management and senior personnel refuse to adopt new practices but would rather stay in their "comfort zone", which typically occurs in the course of new technology insertion and intellectual transition (Eastman et al., 2011). Examining the analysis of the interview participants' lived experience and listening to their stories by reading and re-reading the transcripts, the author has gained an insight into new skills and competencies required to work in a BIM-based workplace. It is possible to divide these new skills and competencies into sections. Bruffee (1999) who has written powerfully on the subject of collaboration, talks about foundational and non-foundational knowledge generation theories. These are two different ways of thinking about knowledge. Foundational refers to learning as cognition. The cognitive understanding of knowledge is foundational because it assumes that there is a theory, a structure, beneath knowledge on which all knowledge is built, so it is applied and explicit. Non-foundational understanding of knowledge is an alternative to this traditional cognitive idea. It asserts that people construct knowledge from a variety of “languages” available to us. The knowledge is not absolute; it is local and ever-changing, building up layer upon layer and is always reconstructing your knowledge. The school of thought called, non-foundational social construction, would believe that knowledge is a community project, interesting in terms of collaboration where the language is one constructed, owned and spoken by that community.

This is so prevalent in this age of instant and global communication that communities of collaborators are already all around us. Internet-based gaming is an organic growing community to which there is a new language of developing knowledge. BIM training can be viewed as foundational knowledge. It develops basic understanding and skillsets in the application. This is necessary before an AEC professional can effectively collaborate with other members of the wider AEC community. Foundational knowledge does not interfere with the creative thought process. It becomes the spark that ignites the questioning and so commences a round of collaborative non-foundational knowledge-making. It is this sharing and questioning where foundational knowledge stop’s and non-foundational constructs take over.

Moving and changing from foundational to non-foundational education is a process that (Bruffee 1999) calls re-acculturation. He defines this as a complex and painful process that involves the practitioner giving up, modifying or reconstructing the language, values, knowledge from the community they come from and become fluent instead in the language and so on of another community. This community is new, and the fear of the unknown can drive professionals back into their comfort zone so that collaboration gets distilled and loses out to cooperation. Cooperation is a failsafe but in essence, a failure because no new knowledge is being generated just old knowledge regurgitated.

6.1.1 Learning to BIM

Foundational BIM knowledge would cover discipline-specific software skills and knowledge of associated processes. Developing mastery over a BIM creator application is a difficult task and is cited as one of the barriers to adoption (Cunningham, McClements, & McKane, 2015). A common mistake in the industry is the comparisons made between the transition from pen, paper and drawing board to the mouse and screen, i.e., drafting to CAD being similar to transitioning from CAD to BIM. The shift from hand to CAD in the 1980s represented an incremental rather than step-change in work practices. The means of inputting the brain to hand information morphed from manual drafting to digital media, but the output remained substantially the same, primarily paper-based drawings. (Harty, Kouider, & Paterson, 2015). P1 shares a story of a colleague telling him

> *"I would have had progress plans done if I was doing this with (2d) CAD, P1 tells him progress plans !!, Ill give you progress plans, sections, elevations and 3d views for the same time".*

Foundational skills, in this case, is the applied learning of application techniques to create a digital building information model. The shift from CAD to BIM is a paradigm change, it's a move from representation to simulation, and that entails drawing heavily on your knowledge of technical design in order to build a building digitally first. In CAD building elements are represented by lines and geometric shapes, in BIM, the elements hold specifications (Khosrowshahi, 2017). Therefore the first implication for Industry is recognition that employees need to be trained in the foundational skills of BIM.

6.1.2 Learning to Work Collaboratively in the Cloud

One way to make sense of the conversational nature of networked computers is to understand them too in this way, as conversational artefacts (Bruffee, 1999). There is a synergy between BIM, (the technological platform that facilitates collaboration), collaboration (the social interaction between professionals) and knowledge generation. Rorty (2009) explains how we understand knowledge when we understand the social justification of belief. Justification, in this case, is achieved through knowledge - community - constituting - conversations. While this can happen in the localized workplace, it becomes broader and more powerful when it is extended into multidisciplinary interaction facilitated by cloud-based technologies.

P8 knows the value of "knowledge - community - constituting - conversations", he states,

> *"The more you go and listen to what people are doing, and you go and tell people what you are doing, the more lightly it is that they will tell you what they are doing, we are all travelling in the same direction you know, let's not fall over each other, let's share it. Certainly, all of the guys that are part of that Revit culture of sharing share because I think that everybody realises that we have something great here and we have only hit the tip of the iceberg. We participate in all lectures and conferences, and as it were a smaller network, that's a huge thing for our learning and sharing, that's the way we work here".*

Hence, industry also needs to recognise the impact of collaborative practice and to make efforts to train their professional staff in the ways of working to achieve shared multidisciplinary goals.

6.1.3 Soft Skills for Collaboration

Soft skills have become a crucial and increasingly sought after quality for careers in the corporate world, irrespective of the sector (John, 2009). Employers need employees who have adequate technical skills but who also have soft skills. These soft skills include communication skills, ability to work across generations, problem-solving skills, conflict resolution, mindset, attitude and control when working with other professionals, an understanding of BIM etiquette. They will need interpersonal skills, team player skills, ethics, creativity, and ability to value diversity, responsiveness, and a willingness to

change all lead to the path of a collaborative professional. The shift from an industrial economy to an information society and an office economy means that many jobs now place emphasis on integrity, communication, and flexibility (Zehr, 1998). Irrespective of the professional qualification and apart from the domain knowledge, today's professionals need to possess a high Soft Skills quotient in order to succeed in this competitive era (John, 2009). Hard skills contribute to only 15% of one's success, while the remaining 85% is made by soft skill (Watts & Watts, 2008).

P1 relates a story highlighting his interpersonal skills,

> *" I'd know the majority of people in the office because I'm up and down to them when they need help. I'd know most people in the office, new people in the office get told to come and see me or I get told to go to them to give them a rundown on where the template is. It's no official thing, but I'm not going to leave someone struggling if I can help them and it's invariably at my own expense going up and down cause I have to stay late at my own work".*

P14 describes a situation,

> *"I had this experience in New Zealand where I had this guy next to me, email me...you know he's sitting next to me, and I really took exception to that. How can you build trust if that's happening I'm not just covering my backside because I know when the wheels come off, we are not in it together, it's going to be me on my own and so that changes how people work".*

Soft skills are character traits, attitudes, and behaviours—rather than technical aptitude or knowledge. Soft skills are the intangible, nontechnical, personality-specific skills that determine one's strengths as a leader, facilitator, mediator, and negotiator (Robles, 2012). True collaboration, interdependency, and mutual support amongst team members and work toward common team goals emerges in many BIM-based projects, allowing highly innovative building solutions rather than just efficient and similar results as in traditional approaches (Grilo & Jardim-Goncalves, 2010). Building on the lived experiences of P1 and P14 highlights that successful introduction of BIM requires industry to recognise the importance of interpersonal skills and to challenge their current hierarchal structure,

communication strategy, team meetings ethos, to enhance opportunities for staff to develop their communication skills, and learn to work with true collaboration.

6.2 Implications for Education; skills and competencies to be embedded into design and construction education.

Bruffee (1999) argues that college and university teachers have been taught to think about what they know and how they know it drives the way they teach it. He states that teachers can change the way they teach only by changing what they think about, what they know and about how they know it. A digital transformation directly challenges industry and education, changes occur as a result of innovation through new technologies. Deutsch (2011) argues that tradition is a powerful force, almost as powerful as the technologies and processes that seek to overcome it. Education in the built environment subjects is as diverse as the domains themselves. There are pockets of educators responding to the challenge of BIM and embedding learning outcomes into their courses (McAuley et al., 2020). However, others who are not responding to the challenge seek comfort in what they have always done on the foundation of what and how they were taught. This is not to say that what has been taught is not valuable, but when education moves from foundational knowledge into non-foundational knowledge creation, the choice of direction becomes directly relevant to graduate attributes and industry needs. All indicators in the design and construction industry point to a move towards collaborative practice. Graduates will need their technical skills (foundational knowledge), but employers are seeking more than just this. Those soft interpersonal skills are now highly desired but can be missing from the undergraduate education experience.

P5 gives us an example of this

> *"They (his workplace colleagues) never had to develop their communication skills with other consultants, they didn't know, for example, when I came in, I wanted to talk to the quantity surveyor on how he would like us to deliver stuff to him and make his life easier. I got shot down straight away from the "BIM Manager".*

P7 gives us another example. "

> *"So, it's that kind of lack of management and engagement between the contractor and sub-contractor. The sub-contractor not caring what information they were*

given and what other people were doing and their time and programme, so what we found was they just stall and will give you whatever will get them over the line".

P10 relates another example of short-sighted ambition.

"I'd be in favour of giving responsibility to people, but immediately these people start to build because they want to get to the next level, so their agenda is to get to the mainboard, so each director there does not seem to be a company ethos, it's siloed, very much siloed, and I think in that sense BIM doesn't really appeal to them because you have to be open with the design team you have you be open with the client".

There is much literature covering the integration of BIM into 3rd level education across the main creator and consumer domains in the built environment (McAuley et al., 2020). There is a lot less literature covering the teaching of the soft skills necessary to achieve the full value of BIM collaboration. This offers opportunities for program designers to embed new competencies into modules to reflect these changes and for researchers to report on the outcomes.

6.2.1 Teaching BIM

BIM modules embedded in a course curriculum will bring challenges to a lecturer's identity, students can become empowered as their knowledge of BIM increases, and this can lead to disarrangement in the teaching and learning environment. Becerik-Gerber et al., (2011a, p.9) argue "BIM prompts students to ask questions about structures, material assemblies and detailing that requires the instructors to be relatively more agile in their ability to respond". The students' visual connection to the 3D model prompts these type of questions in a more concise way, and questions can be framed using 3D screenshots to get to the problem quicker with more understanding. However, in built-environment literature, a reader will see many references to education silos, these tend to be proliferated in colleges, schools and departments. The individual lecturer who knows their subject well might not be inclined to open themselves to areas where they are not experts and consequently have to rely on a colleague's subject area expertise. They may experience frustration in terms of not understanding the BIM application and new

process. Educators can exist themselves in silos in terms of their own practice and follow a pattern by which they teach the way they were taught, leading to conflict and challenge from technological innovation.

Students too have expectations coming to college; they come from an education system which is predominantly traditional in its teaching and learning where the teacher stands in front of the class and delivers knowledge. Students are expected to listen, note take, revise and rote learn in many but not all cases. Teaching BIM can be different in the sense that the student not only builds a digital model, but they build a visual relationship with the artefact itself. As in any relationship, there are highs and lows. BIM acts as a conduit for other learning, construction technique, material properties, measurement, services systems, so there are many actors involved and all come with their own perspectives.

Teachers will be affected by this digital transformation happening in the design and construction industry, and they will have to acknowledge change not only in the way they teach and what they teach but also be aware that students will learn differently. Re-acculturation is required to develop collaborative modules to suit industry needs.

6.2.2 Teaching Collaboration

(Zehr 1998; Holtom & Bowen 2007) argue that one of the main challenges of soft skills training faced by educators is that we still have not figured out how to teach soft skills, nor have we figured out how to assess them and capture the impact of such programs on learners. It's a legitimate question to ask if current methods of teaching and learning in undergraduate education are suitable to develop a collaborative skillset. Methods of teaching and learning tend to be down to the individual lecturer and their ideas of imparting knowledge is perhaps the way, as has been stated by Bruffee, it was imparted to them.

P1 has made some observations of some professional colleagues.

> *Yea, it's physiological like, some people are sort of, they have no confidence in their ability, It's very much a personality thing I think. I haven't figured out why or what. I've noticed with people who are, and you see it, the kind of people who call for that kind of help are also very standoffish at social settings in the canteen, they don't engage, there kinda shy, no it's a confidence thing.*

Also

> *"Yea, it's physiological, they have the degree, so they have the ability they met the minimum requirements to get the qualification, so they obviously have the ability to do the job, but they don't see themselves as having that ability, you know it's really strange".*

P6 talks about new values emerging, one of honesty,

> *Honesty, to be able to collaborate and get the most out of BIM process their needs to be that trust and rapport with the team, with the client, you will get that if people are open and honest and not the traditional adversarial, I'm not going to share with you because you might use it to your benefit and not to mine, so being open, honest, willing to share, I think that's critical to the success of BIM.*

P7 also mentions the importance of trusting relationships;

> *I think it, in terms of relationships with the consultants, you need to trust who you are working with and have a good relationship and be very clear about expectations. All that has to be much more closely looked at when you are getting into a job. That's a good thing because the potential to fall depending on who you are with, all for one and one for all !!.*

Design and construction students need to learn how to work in a team setting, utilizing a brief that has soft skills as learning outcomes that can be assessed. Ed & Ed (2000) argue that learning is an active, constructive process that is inherently social. In collaborative learning situations, students create something new with information and ideas. They further argue that collaborative learning brings about the intellectual synergy of multiple minds coming to bear on a problem by engaging them to gather, share and develop collective insight (Vassigh et al., 2014). Nicolae Nistor, English, & Wheeler (2003) state that this mutual exploration, meaning-making, and feedback often leads to a better understanding on the part of students and to the creation of new understandings for all of us.

6.2.3 Teaching to Work Collaboratively in the Cloud

More and more design and construction work will be uploaded or downloaded from remote cloud-based services. However, perhaps more strikingly, the bigger innovation will be the collaborative work that is carried out in real-time using cloud services from remote locations. Different collaboration attitudes and various personalities of professionals stimulate various relationships. These relationships may create either a positive or negative influence on the final project outcomes. Collaboration on the organisational level would capture these interactions and, based on the research output, people can assess the influence to project performance from these interactions (Lu et al., 2013).

Technology is at the core of BIM, and this cloud-based technology has only become mainstream in college education in the last decade. It holds great potential for teaching and learning but will not reach its full potential unless it is fully supported and utilised by a collaborative team of lecturers and students.

6.2.4 BIM and Computer-Supported Collaborative Learning.

The full potential of BIM can be realised by considering knowledge, technology and relationships. Many researchers focus on the discussion of BIM technology. Few researchers address the importance of the collaborative process of BIM implementation (Lu et al., 2013). In lifelong education, collaborative learning is a key paradigm in informal learning (e.g. sharing knowledge among communities of practices) but has been somewhat underutilized in corporate training, (Dillenbourg, Järvelä, & Fischer, 2009). Computer-Supported Collaborative Learning (CSCL) is the field concerned with how Information and Communication Technology (ICT) might support learning in groups (co-located and distributed). This field is well explored and researched by (Kreijns & Kirschner, 2004; Dillenbourg et al., 2009; Ludvigsen & Mørch, 2010). CSCL emerged in response to skills that are important in a knowledge-based society. These skills are not easily taught through memorizing and fact-finding using textbooks, which are prevailing methods for learning basic skills. In fact, finding, for example, the goal of the activity is most often invisible to students, and the focus tends to be on tasks (Hewitt, 2013).

Dillenbourg & Fischer, (2007, p1) state,

The evolution of research on computer-supported collaborative learning (CSCL) can be depicted as being divided into three ages. In the first age (1990–1995), CSCL emerges after the neglect of collaborative learning in educational technology for more than 20 years. These first years led to the understanding that collaborative learning results from the effort necessary for co-construction of a shared understanding of the field and that productive social interactions can be engineered by careful design of CSCL environments.

The second age (1995–2005) is characterized by the growth of a scientific community (it acquired its own conference cycle, book series, society and journal). This community developed some engineering expertise for the whole life cycle of social interactions: the design of environments and activities, their real-time analysis and their later utilization by the environment.

The third age (since 2005) will probably be characterized by the disappearance of CSCL as a distinct pedagogical approach. Instead, collaborative activities are becoming integrated within comprehensive environments that include non-collaborative activities stretching over the digital and physical spaces and in which the teacher orchestrates multiple activities with multiple tools.

We are possibly looking at the fourth age of CSCL not foreseen by Dillenboug and his colleagues, whereby the cloud-based BIM applications provide a collaborative platform for a new version of computer-supported collaborative learning.

6.3 Limitations of the Research

There are limitations within this research that need to be made clear to the reader. The choice of Hermeneutic Phenomenology as the research methodology was purposeful. The author felt it was best suited to examine the research question and the phenomenon of BIM in the design and construction professionals' workplace. This methodology has been largely used in the social sciences and nursing profession and not in the built environment. A question will always arise over the "validity" of this type of interpretative research. Yardley (2000) highlights four broad topics that qualitative researchers should be concerned about,

- sensitivity to context,

- commitment and rigour,
- transparency and coherence, and
- impact and importance,

The author has demonstrated sensitivity to context by consistently referring to published literature by weaving strands of contextual knowledge to inform the reader on the subject matter and has developed a knowledge of philosophy from its origins through its development in the modern world in order to position himself in this world by developing an epistemology on how knowledge can be created, acquired and communicated, in other words, what it means to know. The author has been embedded in the subject matter and importantly needed to carry in all times a self-awareness that notions of bias, self-prejudice and pre-assumption could colour the interpretative writing. This is the double-edged sword of hermeneutic phenomenology research and must be actively managed.

In terms of commitment and rigour, the author has described and demonstrated the analytical research process, including hand transcribing the interview texts as a method of connecting to what was being said. The author has demonstrated commitment by publishing papers on the subject matter and presenting at conferences over the last seven years and has grown in a personal capacity as a researcher in the field of building information modelling. The author has designed modules and courses and delivered BIM education at both undergraduate and postgraduate levels.

The findings have been presented to the reader with transparency, coherence and honesty and are open to constructive criticism on the findings and welcome this as a vital part of the research process.

Crotty (1998) argues that findings in an interpretive study are not generalizable as there is no singular way of seeing things and no universal truth. Conclusions have not been drawn as conclusions can close the conversation, the author wants this work as a platform to open a dialogue on the impact of BIM on the social dynamics of engaged professionals in the workplace. Yardley (2000) states that the final criterion is the impact of the research on the industry. The impact may be delayed and indirect, but it should have some impact (Landridge, 2007). This research will be made accessible to the industry and academic community through the Arrow database.

There was a purposeful selection of participants for this research. All were involved in one form or another with the subject matter. They crossed design and construction domains, levels of responsibility, gender and age divide.

The author acknowledges that the participants were all from Ireland, and in this case, the research might be deemed national rather than international but the author is confident that readers from other countries will recognise many elements of the lived experience and the themes presented. The efforts to standardise BIM are happening. The publication of the ISO 19650 suite in 2020 is a foundational document that will cross international boundaries and in doing so will this research will be valuable to individuals and organisations who will undergo this digital transformation.

6.4 Final Word and Opportunities for Further Research

It has been stated in numerous reports referred to in the author's literature review that the design and construction industry needs to become more efficient so that there is less waste both in terms of materials and human endeavour, it needs to change the way it does its business, this is commonly referred to or understood as culture change. As referenced previously, digital technologies and associated process's backed by internationally agreed standards are continuing to improve performance options. The next innovation in the AEC industry is the move to cloud-based services but as yet perhaps the industry is not responding in the way that it could. Culture change is slow-moving phenomenon and as has been discovered in this thesis, a reason for this lies with the people who work in the industry and the people who design and teach students looking to enter the professions.

Foundational knowledge learning in BIM is well catered for in 3rd level universities and Institutes of Technology. Perhaps what is problematic is non-foundational knowledge learning expressed as cross-domain dialogue, interdisciplinary projects, multidisciplinary modules. These are still very few and far between in higher education and consequently, many AEC programs are not currently reflecting industry workplace. The real value of multidisciplinary education modules is reflected in the social skills necessary to partake in these endeavours. Referred to as soft skills, listening, trust-building, respect for oneself and work colleagues, empathy have all come to the fore in various ways within this research under the themes of identity, empowerment, disarrangement and collaborative

practice. These soft skills are equally necessary, along with those domain-based foundational skills that are applied to the use of technology.

BIM is now the core technology in a cloud-based platform to facilitate collaboration. This has the potential to be the new location where professionals will work. These professionals will need to build trust with each other so that the project will succeed and where new knowledge can be generated from the social dynamics involved. The skills needed are best positioned to start within built environment education where opportunities can be made for non-foundational learning.

The next ten years in the design and construction industry here in Ireland and within the UK and EU will see a new generation of digitally skilled professionals emerge into the workforce whose workplace will not be fixed in the way the previous generations were. Work will be more mobile, and new technological innovations will add and drive the current digital transformation further. What won't change is that people will be at the heart of that too and the themes of identity, empowerment, disarrangement and collaborative practice will hold relevance into the future. This thesis will contribute to the research community and lay down the foundations of this future research with a methodology and method with its focus on professional people working in the industry. This research has brought to the fore themes that will contribute to the discourse surrounding an industry that is changing and for educators that will need to change to produce graduates fit for industry.

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Appendix A

Formatted transcript – Beginning of Immersion

Extract from Participant 10;

Interview with Participant 10 11 May 18

MM: To get the conversation started can you describe your typical week in work

P10: Right, my job....interestingly I had a review last week about what my job was, an annual appraisal and it was the first one in 8 years, and I basically said I no longer want to be called a services manager because I'm not being allowed to manage, so, for the last 2.5 years I've been working on a data centre in west Dublin I can't say the name, but you know who, day to day looking and coordinating services, managing contractors and commissioning mostly commissioning, fairly mundane stuff. I'm doing some other stuff to keep me occupied, I'm teaching, corporate and social responsibilities in 2 primary schools but generally, because I'm on this site and it's such a big site its such a money earner and an area the company really wants to get into and have been left there, and I am underemployed as they say. Not using any BIM on the site, no longer really involved in, I would have always been involved in estimating writing what the BIM requirements are and writing BIM execution plans, you know putting together proposals and things like that, but I feel I'm getting more and more isolated as times goes by and now new people are being brought into the building services department that are, well I find out they have been hired and I meet them two weeks later they don't report to me, and I don't have any interface with them, and now they have been given the jobs with the BIM on them, and I'm not. So, yea, all that said we have a Cork office as well and there are a few guys who have done a level 7 cert in BIM and in the Cork office they do their own thing. They are much more progressive, and they are using BIM. The lads are doing it themselves on projects, so they contacted me and now in liaising with them, and I will be meeting them next week to work on strategies on how to bring BIM into the company, but it's all from the bottom up, at the same time the contracts manager whom I work for on the site has been made a director … I don't know why, but anyway, pretty much on the back of how well the job has gone and he has advised me that he is going to be responsible for BIM and digital in the company and he is looking at me saying you want to do that don't you want to be the BIM manager and I have said ...yes, but its a wait and see, its a funny role

MM: What do you mean by a bottom-up initiative?

P10: For example in a recent job a job for a pharma company on the border of Dublin and Meath I got an email to say, we went to an interview, and we were asked a question in the interview about BIM can you answer that question, knowing that (named person) was involved in that project I discussed it with him because it's quite a complicated question even between myself and himself we were mulling over how to answer it, so I arranged a meeting with the guy who asked the question with myself and (named person) to find out they had answered the question, I don't know how but they have

gotten themselves in a right mess, So they didn't allow for BIM on the job even though they knew it was there, so the people with the knowledge are at the bottom and the people making the decisions are at the top, and they are not informed so trying to....there seems to be a fear of BIM …

I'll ignore it, and sure we get on all right so I'm trying to really I was talking to someone the other day we really need a BIM manager because even just the name because if there is BIM on that tender, you can say ring and ask him, whereas at the moment they don't know who to ring and ask so they don't ring anybody so yea its really me being on the bottom trying to inform people, It's a bit frustrating, I think some people have done stuff, and they think sure it will be grand. The guy who has been made the director responsible for digital and technology spent some time in the BIM room in (named company) and now thinks he knows all there is to know, but I know even at this stage that I don't know it all, and they're ignoring the most qualified person in BIM in the company yea so its....but you know I've almost gone past that. When I started the course four years ago, two years later I had a qualification was very frustrated but still was doing a bit of BIM at the time now I've gone thru that pain barrier and I'm almost no longer frustrated, but I am at a crossroads do I or don't I stay with them. In the appraisal, it was suggested that if you want to do BIM, perhaps you should go elsewhere to do BIM. My response was that the whole industry is going that way, why would the company say that, why would you say that, if you want to do BIM go elsewhere you're going to be doing BIM, but,....there is history there, but it was an interesting comment.

Stage 1 Immersion; … First Read – selecting paragraphs, sentences and words of relevance.

Interview with Participant 10 11 May 18

"With the introduction of BIM into the AEC workplace environment, what, if any, has been the impact on the social dynamics of engaged professionals?"
get at the experiences here and the effects of BIM, this should be the focus, then examine how this experience is related to human dynamics

Mapping Experience

MM: To get the conversation started can you describe your typical week in work

P10: Right, my job....interestingly I had a review last week about what my job was, an annual appraisal and it was the first one in 8 years, and I basically said I no longer want to be called a services manager because I'm not being allowed to manage, so, for the last 2.5 years I've been working on a data centre in west Dublin I can't say the name but you know who, day to day looking and coordinating services, managing contractors and commissioning mostly commissioning, fairly mundane stuff. I'm doing some other stuff to keep me occupied, I'm teaching, corporate and social responsibilities in 2 primary schools but generally, because I'm on this site and it's such a big site its such a money earner and an area the company really wants to get into and have been left there, and I am underemployed as they say. Not using any BIM on the site, no longer really involved in, I would have always been involved in

estimating writing what the BIM requirements are and writing BIM execution plans, you know putting together proposals and things like that, but I feel I'm getting more and more isolated as times goes by and now new people are being brought into the building services department that are, well I find out they have been hired and I meet them two weeks later they don't report to me, and I don't have any interface with them, and now they have been given the jobs with the BIM on them, and I'm not. So, yea, all that said we have a Cork office as well and there are a few guys who have done a level 7 cert in BIM and in the Cork office they do their own thing. They are much more progressive, and they are using BIM. The lads are doing it themselves on projects, so they contacted me and now in liaising with them, and I will be meeting them next week to work on strategies on how to bring BIM into the company, but it's all from the bottom up, at the same time the contracts manager who I work for on the site has been made a director … I don't know why, but anyway, pretty much on the back of how well the job has gone and he has advised me that he is going to be responsible for BIM and digital in the company and he is looking at me saying you want to do that don't you want to be the BIM manager and I have said ...yes, but its a wait and see, its a funny role

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would you say that, if you want to do BIM go elsewhere, your going to be doing BIM, but,....there is history there, but it was an interesting comment

Stage 2 Understanding; Mapping Experience

Interview with Participant 10 11 May 18

"With the introduction of BIM into the AEC workplace environment, what, if any, has been the impact on the social dynamics of engaged professionals?"

Mapping Experience **MM: To get the conversation started can you describe your typical week in work** P10: Right, my job....interestingly I had a review last week about what my job was, an annual appraisal and it was the first one in 8 years, and I basically said I no longer want to be called a services manager because I'm not being allowed to manage, so, for the last 2.5 years I've been working on a data centre in west Dublin I cant say the name, but you know who, day to day looking and coordinating services, managing contractors and commissioning mostly commissioning, fairly mundane stuff. I'm doing some other stuff to keep me occupied, I'm teaching, corporate and social responsibilities in 2 primary schools but generally, because I'm on this site and it's such a big site its such a money earner and an area the company really wants to get into and have been left there, and I am underemployed as they say. Not using any BIM on the site, no longer really involved in, I would have always been involved in estimating writing what the BIM requirements are and writing BIM execution plans, you know putting together proposals and things like that, but I feel I'm getting more and more isolated as times goes by and now new people are being brought into the building services department that are, well I find out they have been hired and I meet them two weeks later they don't report to me, and I dont have any interface with them, and now they have been given the jobs with the BIM on them, and I'm not. So, yea, all that said we have a Cork office as well and there are a few guys who have done a level 7 cert in BIM and in the Cork office they do their own thing. They are much more progressive, and they are using BIM. The lads are doing it themselves on projects, so they contacted me and now in liaising with them, and I will be meeting them next week to work on strategies on how to bring BIM into the company, but it's all	Meaning of Experience P10 is BIM qualified but is not using his BIM skills in his current position. Is he expressing a feeling of isolation and rejection? Because he knows there is BIM work going on in the firm This is a very interesting

from the bottom up, at the same time the contracts manager who I work for on the site has been made a director … I dont know why, but anyway, pretty much on the back of how well the job has gone and he has advised me that he is going to be responsible for BIM and digital in the company and he is looking at me saying you want to do that don't you want to be the BIM manager and I have said ...yes, but its a wait and see, its a funny role **MM: What do you mean by a bottom-up initiative?** P10: For example in a recent job a job for a pharma company on the border of Dublin and Meath I got an e mail to say, we went to an interview and we were asked a question in the interview about BIM can you answer that question, knowing that (named person) was involved in that project I discussed it with him because its quite a complicated question even between myself and himself we were mulling over how to answer it, so I arranged a meeting with the guy who asked the question with myself and (named person) to find out they had answered the question, i don't know how but they have gotten themselves in a right mess, So they didnt allow for BIM on the job even though they knew it was there, so the people with the knowledge are at the bottom and the people making the decisions are at the top and they are not informed so trying to....there seems to be a fear of BIM …ill ignore it and sure we get on alright so im trying to really i was talking to someone the other day we really need a BIM manager because even just the name because if there is BIM on that tender you can say ring and ask him, whereas at the moment they don't know who to ring and ask so they don't ring anybody so yea its really me being on the bottom trying to inform people, Its a bit frustrating, I think some people have done stuff and they think sure it will be grand. The guy who has been made the director responsible for digital and technology spent some time in the BIM room in (named company) and now thinks he knows all there is to know, but I know even at this stage that I dont know it all, and they're ignoring the most qualified person in BIM in the company yea so its....but you know I've almost gone past that. When I started the course four years ago, two years later I had a qualification was very frustrated but still was doing a bit of BIM at the time now I've gone thru that pain barrier and I'm almost no longer frustrated, but I am at a crossroads do I or don't I stay with them. In the appraisal, it was suggested that if you want to do BIM, perhaps you should go elsewhere to do BIM. My response was that the whole industry is going that way, why would the company say that, why would you say that, if you want to do BIM go elsewhere, your going to be doing BIM, but,....there is history there, but it was an interesting comment	anecdote ..P10 was asked a BIM-based question but was then ignored and subsequently found out the Q had been answered badly He is frustrated, and this is another side of changing identity it has disarranged his previous position To the point that he is considering different career options P11s company were way behind his development, and this has caused conflict with his colleagues

Stage 3 Abstraction; Meaning of Experience

Interview with Participant 10 11 May 18

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get at the experiences here and the effects of BIM, this should be the focus, then examine how this experience is related to human dynamics

Mapping Experience	Meaning of Experience	Sub Theme emergence
. Not using any BIM on the site, no longer really involved in, I would have always been involved in estimating writing what the BIM requirements are and writing BIM execution plans, you know putting together proposals and things like that, but I feel I'm getting more and more isolated as times goes by and now new people are being brought into the building services department that are, well I find out they have been hired and I meet them two weeks later they don't report to me, and I dont have any interface with them, and now they have been given the jobs with the BIM They are much more progressive, and they are using BIM. The lads are doing it themselves on projects, so they contacted me and now in liaising with them, and I will be meeting them next week to work on strategies on how to bring BIM into the company but it's all from the bottom up, I dont know why, but anyway, pretty much on the back of how well the job has gone and he has advised me that he is going to be responsible for BIM and digital in the company and he is looking at me saying you want to do that don't you want to be the BIM manager and I have said I got an email to say, we went to an interview, and we were asked a question in the interview about BIM can you answer that question,	P10 is BIM qualified but is not using his BIM skills in his current position. Is he expressing a feeling of isolation and rejection? Because he knows there is BIM work going on in the firm This is a very interesting anecdote ..P10 was asked a BIM-based question but was then ignored and subsequently found out the Q had been answered badly	P10 is expressing another side of empowerment. He is seen as a challenge to his employers who are not ready for change and is being isolated. Empowerment and disarrangement Utter frustration at being asked a BIM question then not being allowed answer it A challenge to the identity of managers here by the

so I arranged a meeting with the guy who asked the question with myself and (named person) to find out they had answered the question, I don't know how but they have gotten themselves in a right mess, So they didn't allow for BIM on the job even though they knew it was there, so the people with the knowledge are at the bottom, and the people making the decisions are at the top, and they are not informed so trying to....there seems to be a fear of BIM … ill ignore it, and sure we get on all right whereas at the moment they don't know who to ring and ask so they don't ring anybody so yea it's really me being on the bottom trying to inform people, Its a bit frustrating, I think some people have done stuff, and they think sure it will be grand. The guy who has been made the director responsible for digital and technology spent some time in the BIM room in (named company) and now thinks he knows all there is to know, but I know even at this stage that I dont know it all, they're ignoring the most qualified person in BIM in the company yea so its....but you know I've almost gone past that. I'm almost no longer frustrated, but I am at a crossroads do I or don't I stay with them. In the appraisal, it was suggested that if you want to do BIM, perhaps you should go elsewhere to do BIM. When I asked or suggested that I was going to do a masters in BIM, I was asked why I would do that? What's in it for the company, what's it going to cost them, that happened initially at the very start, and it happened again this time, so I decided to pay the fees myself,	He is frustrated, and this is another side of changing identity it has disarranged his previous position To the point that he is considering different career options P11s company were way behind his development, and this has caused conflict with his colleagues It's almost like they want his skills and image but do not want to embrace the change and challenge that comes with BIM adoption. Evidence of the disarrangement with this firm and the feeling of isolation felt by P1	empowered P10 He can see the mistakes before the management know they are mistakes but is isolated Empowerment has caused conflict with colleagues Head in the sand attitudes major disruption on the way disarrangement in collaborative practice

.i have hit a glass ceiling there I don't see myself progressing to director level its a BIM job, and what's the first thing they do, they reach out and say who can help us here?		

Stage 4 Theme; Theme Development

Interview with Participant 10 11 May 18

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Mapping Experience	Meaning of Experience	Sub-theme	Theme
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any interface with them, and now they have been given the jobs with the BIM They are much more progressive, and they are using BIM. The lads are doing it themselves on projects, so they contacted me and now in liaising with them, and I will be meeting them next week to work on strategies on how to bring BIM into the company but it's all from the bottom up, I dont know why, but anyway, pretty much on the back of how well the job has gone and he has advised me that he is going to be responsible for BIM and digital in the company and he is looking at me saying you want to do that don't you want to be the BIM manager and I have said I got an email to say, we went to an interview, and we were asked a question in the interview about BIM can you answer that question,	out the Q had been answered badly He is frustrated, and this is another side of changing identity it has disarranged his previous position To the point that he is considering different career options P11s company were way behind his development, and this has caused conflict with his colleagues It's almost like they want his skills and image but do not want to embrace the change and challenge that comes with BIM adoption. Evidence of the disarrangement with this firm and the feeling of isolation felt by P10 P10 has experienced actual resistance to BIM from management	A challenge to the identity of managers here by the empowered P10 He can see the mistakes before the management know they are mistakes but is isolated Empowerment has caused conflict with colleagues Head in the sand attitudes major disruption on the way disarrangement in collaborative practice Resistance here has it's a basis in the	Disarrangement And Identity Identity Empowerment Collaborative Practice

so I arranged a meeting with the guy who asked the question with myself and (named person) to find out they had answered the question, I don't know how but they have gotten themselves in a right mess, So they didn't allow for BIM on the job even though they knew it was there, so the people with the knowledge are at the bottom, and the people making the decisions are at the top, and they are not informed so trying to....there seems to be a fear of BIM … ill ignore it, and sure we get on all right whereas at the moment they don't know who to ring and ask so they don't ring anybody so yea it's really me being on the bottom trying to inform people, Its a bit frustrating, I think some people have done stuff, and they think sure it will be grand. The guy who has been made the director responsible for digital and technology spent	He feels like he is a treat to the middle management Hierarchy in the firm can mean that employees lose their identity being subject to the will of the section manager Interesting comment showing management using BIM as an excuse for failing and probably those associated with it. P10 highlighting a problem he sees with the management understanding of BIM all leading to frustration P10 highlighting a problem he sees with the management understanding of BIM all leading to frustration But P10 is feeling empowered a shift in his identity knowing he is in a good place because	hierarchical setup of the organisation Yet P10 is threatened by new hires who are being given BIM duties	

some time in the BIM room in (named company) and now thinks he knows all there is to know, but I know even at this stage that I dont know it all, they're ignoring the most qualified person in BIM in the company yea so its....but you know I've almost gone past that. I'm almost no longer frustrated, but I am at a crossroads do I or don't I stay with them.			