Doctoral Thesis

BUILDING INFORMATION MODELLING (BIM) AND THE UK QUANTITY SURVEYING ORGANISATION: A FRAMEWORK FOR VALUE CREATION.

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by

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Abstract

This thesis delivers a significant contribution to knowledge through the construction of a validated framework, that supports value creation for the QS organisation, when adopting and implementing BIM. It also reports on the current misconceptions in terms of the threat posed by Building Information Modelling (BIM) to the QS profession. This research has found that the QS role will evolve and transform with the opportunities that BIM presents, and will survive as consequence of value creation. The thesis identified 9 critical success factors, 5 success factors specific to BIM and 4 success factors specific to the organisation, all of which contributed towards the development of the framework. The study was conducted by adopting a mixed methods design by extracting knowledge from the literature review to inform the semi structured interviews, the results of which informed the design of the questionnaires and finally all results informed the development of the framework which was finally validated via a focus group. The major findings of this research were threefold. Firstly, from a theoretical perspective it was found that a unified understanding of BIM definition aligning the perceptions of the individual QS with those of the organisation, was the foundation from which to develop the framework. It was found to be of far more significance than most theorist purport, as the adoption process requires systemic transformation at all levels within the organisation, based on a unified vison. This stems from individual and organisational perceptions of BIM, which in turn go back to definition. Secondly, the research identified that the BIM barriers reported by the theorists are not the dominant barrier to implementation, but it is more specifically the lack of understanding of the benefits of BIM to the individual, that restrict adoption. Finally, the research has provided the QS organisation with a holistic overview of the key critical success factors necessary to support BIM level maturity and ultimately value creation.

Keywords: BIM, QS, framework, perceptions, critical success factors, definition, benefits, maturity, value creation.

I would like to dedicate this thesis to my wonderful family without whom I would never have completed this challenge at such a late stage in my career.

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Finally, I would like to thank my friends and family who have taken on many of my responsibilities to support me in my research. My friends have provided me with positivity and reassurance and it is their friendship that I look forward to enjoying once again. It is, however, my family to whom I owe the greatest debt and gratitude: my mother, my children and not least my husband Colin whose unconditional love, support and understanding has enabled me to successfully complete this thesis.

1. Introduction to the research

1.1. Introduction

This chapter provides an overview of the research problem and a rationale for its study. The background to the problem is defined and the aims and objectives of the study are introduced. The scope and the delimitations of the research will be considered along with its contribution to knowledge. The final section of this chapter outlines the structure of the thesis.

1.2. Background and rationale

The UK construction industry is of massive significance to the UK economy (Construction Industry Training Board, 2016). In August 2016, construction output represented 5.9% of GDP, (Office for National Statistics, 2016), in 2014 this was valued at £103 Billion and comprised 2.1 million jobs, 6.2% of the UK jobs total (House of Commons, 2015). The construction industry has been subject to much Government scrutiny as numerous reports Latham,1994; Egan,1998; Woolstenholme et al, 2009 etc, seek to create efficiencies and improve performance. The industry is now facing one of its biggest challenges in recent times, to further reduce costs, time and carbon, whilst simultaneously adding value. The Government Construction Strategy 2016-20 (2016) sets this challenge, as it seeks to further increase construction productivity, which it forecasts will "create efficiency savings of 1.7 billion over the course of this parliament" (Infrastructure and Projects Authority, 2016, p.2). The principal objectives of the strategy are to improve the capability of central government as a construction client, by increasing the use of digital technology, including BIM (Building Information Modelling) Level 2, deploying collaborative procurement techniques and driving through whole life approaches to cost and carbon reduction. Central government is the largest single construction client, with over 25% of total construction output being from the public sector (House of Commons, 2015). Hence the impact of these objectives will have far reaching consequences on the industry stakeholders, not least the role of the Quantity Surveyor (QS).

Construction industry change has caused the QS profession to reflect on their role and question the future of their profession. Many would argue that the QS has responded to the issues raised, and evolved and adapted to reflect the current environmental and economic constraints, to provide a more efficient and effective service to the construction client (Nkado and Meyer, 2001, Ashworth and Hogg, 2007). Frei, (2010), agrees that the role of the QS has seen significant change over the last decade, but argues that the very existence of the profession is now threatened. The same study suggests, that, if it is to survive, the profession would need to undergo extensive transformation, in order to remain relevant. BIM is seen as the current threat to the QS (Mathews, 2011). Thomas, (2012), questions the relevance of the current QS and purports that the implementation of BIM across the industry will result in major changes to the QS profession, with BIM redefining the role and working practices of its stakeholders (Pittard and Sell, 2015).

The QS has survived many challenges over the years, why does BIM now present such a threat to its very existence? BIM can provide both opportunity and challenge to the QS profession (Smith, 2014). BIM technologies allow for the automatic generation of quantities, which some in the profession, see as a threat to the service offered by the QS, believing other stakeholders may take on this role (Saunders, 2013). Whilst others argue that BIM is not simply a technology, but a new way of working, requiring a new approach to project procurement and delivery (RICS, 2012). The QS must embrace BIM and resist decline and become a key player in a BIM enabled environment (Mitchell, 2012, Muzvimwe, 2011) as “the true value of the future Quantity Surveyor will be their construction wisdom, their ability to factor in project specific peculiarities, and add real value, rather than their ability to count building parts” (Mamphey,2016, p1).

The QS must therefore understand the benefits of BIM to their role, for which a plethora of literature exists, (Stanley and Thurnell, 2014; Gouicher and Thurairajah, 2013; Boon and Prigg, 2012; Sattineni and Bradford, 2011; Byland and Magnusson, 2011; Shen and Issa, 2010; Olatinji, Sher and

Ogunsemi, 2010; Matipa et al 2010; Boon, 2009; Popov et al, 2008). However, Sackey, (2014) argues, some of these identified benefits are not validated and that whilst the promise of reward for those that have implemented BIM successfully may be great, the journey to success may be long. BIM benefits must be understood and must be seen to create value to the QS organisation, if they are to be validated and, the QS role is to survive.

Many theorists argue, that it is the knowledge associated with BIM implementation that can create value. The underlying assumption being that if knowledge is managed, you can create and appropriate more value (Fosstenløkken, 2015). Knowledge assets are becoming increasingly important as development and deployment of “knowledge asset” can fuel organisational value creation dynamics (Giovanni, 2011). Furthermore, Egbu, (2004) argued, that innovation is a vital proponent of success, and an organisation’s capacity to innovate, depends upon the knowledge and expertise possessed by its staff.

If BIM is innovation and success is survival, then how can the QS organisation manage BIM knowledge and ultimately create value? BIM knowledge is held within individuals and this knowledge must be captured, transferred and stored by the organisation. A learning organisation is an organisation made up of employees skilled at creating, acquiring and transferring knowledge, (Senge,1990). Pedler et al. (1996) argue that a learning organisation facilitates the learning of employees and in so doing, transforms itself and its perspective. Learning organisation are skilled at creating, acquiring and transferring knowledge (Garvin, 1993). Lowe and Skitmore, (2007) argued that the learning environment within QS organisations is perceived to be supportive in terms of human support but to a lesser extent, in working practices. Concluding, that learning takes place on an informal basis as opposed to being formally driven and supported by management.

BIM implementation requires change. Egbu (2004) asserts that “competitive advantage and financial success are bound up with industry dynamics, it is necessary to place strategic change in competitive context and identify what kinds of changes lead to strategic innovation, and when these changes result in benefits for the organisation." p 309. Therefore, how the QS organisation manages that change is crucial to innovation and, ultimately value creation. Many factors have been identified as influencing successful business process change, including strong leadership, empowerment of employees, clear open communication channels, strategic vision, motivated organizational actors, organizational structure and inter-departmental interaction and culture (Sikdar and Payyazhi, 2014). Change must be managed effectively as Succar (2005) warns that not all approaches to BIM implementation have been successful, as the barriers to implementation are numerous. Hence, it is recognised that the awareness of the barriers and benefits of BIM is conditional upon appropriate implementation of BIM at an organisational level.

Recent research on BIM focuses on developing frameworks for BIM implementation and adoption generically across the construction sector: (Succar and Kassem, 2015, Kaseem et al, 2015, Ahmad et al, 2012, Jung and Joo, 2011, Succar, 2009, Krygiel and Nies, 2008); with less coverage on how BIM implementation can be used to support organisational objectives by the changing of work practices and process (Lindblad and Vass, 2015). An understanding of BIM realisation and readiness of organisations to implement BIM should be based on a proper understanding of the current state of the organisations' maturity and readiness to accept and implement BIM (Khosrowshahi and Arayici, 2012).

1.3. The research problem

This research considers the QS organisation and the progress they have made when implementing BIM within their organisations. Consideration is given to establishing the benefits and barriers of BIM to both the QS role and to the organisation; establishing a common set of benefits capable of delivering successful implementation. The organisational characteristics and organisational learning are considered to establish the key prerequisites to value creation, in order to create a fit for purpose organisation capable of sustaining the BIM revolution. In addition, recent research has identified the critical success factors for the QS firm (Frei et al, 2013) identifying threats and challenges that face the profession. This research is to consider the critical success factors, specific to organisations offering QS services in a BIM environment, in order to develop a framework to support value creation.

Hence the overarching question guiding this research is:

Can the QS role survive, and, if so can the organisation respond to the challenges set by BIM- enabled construction in the UK and create value to its processes and services?

1.4. Aims and objectives of the study

The overall research aim of this study is to develop a framework for the UK QS organisation that will support value creation when adopting and implementing BIM.

To achieve the aim, the following objectives have been formed:

1. To assimilate the existing literature and theories on BIM implementation and organisational development to provide a comprehensive academic basis for the framework of value creation through BIM.
2. To establish the critical success factors of BIM to the QS that will identify the opportunities and challenges to the quantity surveying organisation when adopting and implementing BIM;
3. To determine the implication of organisation BIM learning in creating and adding value to the quantity surveying organisation.
4. To determine the organisational changes needed to accommodate BIM in a quantity surveying organisation to support the value proposition of BIM.
5. To develop and validate a framework of value creation for a

quantity surveying organisation when adopting and implementing BIM.

Figure 1.1 below demonstrates the rationalisation of the research aim and its objectives.

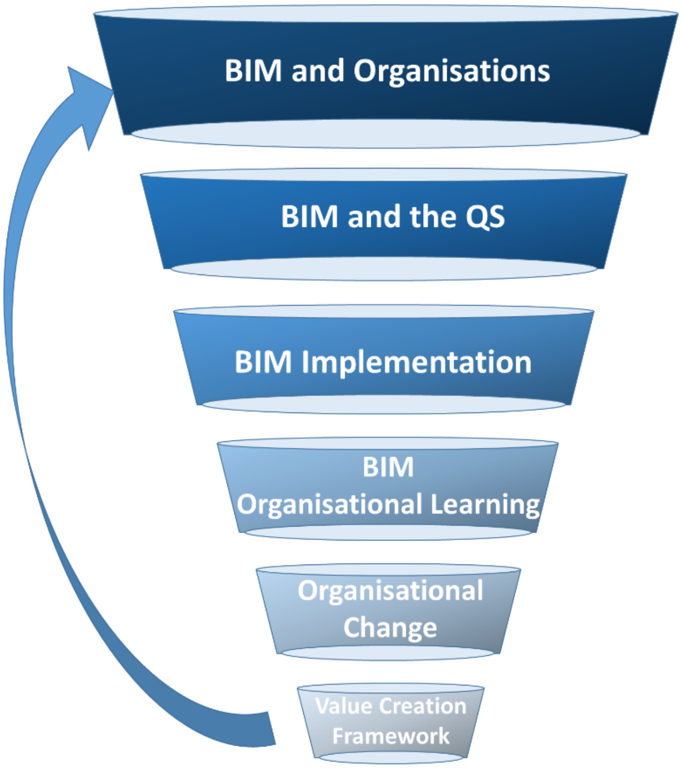


Figure 1-1: Rationalisation of the objectives to achieve the research aim.

1.5. Research methods adopted for this study

A pragmatic research philosophy is adopted by this study which suggests that there are singular and multiple realities that are open to empirical inquiry, positioning itself toward solving practical problems in the ‘‘real world’’ (Creswell et al, 2007, pp. 20-28; Dewey, 1925; Rorty, 1999). The research approach adopted in this study to support the philosophy is an abductive approach, where the theory is different to the reality. This approach is best suited for new research topics with little literature in its actual context (i.e. QS organisations survival frameworks) but with a wealth of information in another context (i.e. BIM) (Saunders et al, 2012).

The research starts with an inductive approach by going back to the literature review and extracting knowledge in order to identify themes which then inform the questions used in the semi structured exploratory interviews. A deductive approach is then taken in the design of the questionnaires and, finally, it is validated via a focus group adopting inductive and deductive logic.

1.6. Key Findings

This research has identified critical success factors (CSF's) which will support the QS organisation in responding positively to the challenge of BIM. A total of 9 factors were identified, 5 factors being specific to BIM and 4 to the organisation. It is these critical success factors that constitute the structure of the validated framework:

- BIM maturity
- BIM definition
- BIM benefits
- BIM barriers
- BIM adoption
- Business planning
- Organisational characteristics
- Organisational learning
- Change management

1.7. Contribution to body of knowledge

This research contribution to knowledge is in two parts comprising; theoretical and practical.

Theoretical contribution

The research proposed

- As BIM definition evolves BIM maturity increases.
- It is the lack of understanding and clarity of the benefits of BIM to the individual QS that is the barrier to successful BIM implementation.
- New evidence and insights and contributed to the current knowledge in the academic field of BIM implementation, with the development of the framework

Practical contributions

- The thesis has provided a framework that enables organisations to recognise the key critical success factors necessary to support BIM level maturity.
- It provides a clear understanding of BIM as a change process and provides support to QS organisations wishing to implement BIM
- The thesis has identified the practical importance of the creation of a learning environment to support BIM maturity.
- It is identified that it is the lack of understanding and clarity of the benefits of BIM to the individual QS that is the barrier to successful BIM implementation.
- Other construction industry BIM stakeholders can utilise this contribution to knowledge
- Finally, the study provides a better understanding of the current prominence of BIM implementation in QS organisations based on their BIM maturity level.

1.8. Structure of the thesis.

Chapter 1 Introduction to the research

This chapter outlined the research problem, detailed its aims and objectives and provided a background to its study and an overview of the research methodology. It provided a brief summary of the key findings and the research contribution to knowledge.

Chapter 2 The construction industry, BIM and the evolving role of the QS

This chapter critically reviews the literature related to this research and provides a background to the construction industry and its problems, and, reviews the industry reports commissioned to confront these challenges. In addition, the evolving role of the QS is examined and the timeline of associated professional reports reviewed. The chapter includes an evaluation of BIM and its implications for the industry, but more specifically for the QS, identifying the critical success factors associated with BIM implementation.

Chapter 3 Organisational growth strategies

This chapter critically reviews the literature related to this research and examines organisational theory and its implications for innovation and organisational growth and survival. Consideration is also given to knowledge management and organisational learning. Change management is finally discussed and organisational change, as it relates to organisation growth and value creation.

Chapter 4 The use of frameworks in the context of BIM

This chapter critically reviews the literature related to this research and examines the purpose and development of frameworks and, framework specific to BIM. In addition, it draws themes from the reviewed literature in chapters 2, 3 and 4 and identifies the gap in the literature.

Chapter 5 Research methodology

This chapter presents and develops the research methodology. It discusses the research philosophy, methodological choices and approaches and provides a comprehensive justification for the approach and methods adopted for this research. It discusses the proposed research samples and the proposed organisation of collecting data along with methods of synthesis and analysis. Finally, this chapter presents its journey of ethical compliance.

Chapter 6 Findings - interviews

This chapter presents the data from the exploratory interviews undertaken with BIM experts, QS consultants(CQS) and contractors QS's(COQS), the purpose of which is to gather a depth and breadth of information to inform and supplement the questionnaires by identifying the themes to be further considered by the survey.

Chapter 7 Findings – questionnaires

This chapter presents the collected data from the questionnaires targeted at the QS, the evidence of statistical analysis and a summary of its findings. The purpose of this is to provide an in depth understanding of BIM implementation within QS organisations and to identify the existence of any correlations between the themes that would support the development of the framework

Chapter 8 Discussion and Framework development

This chapter presents the discussion of findings and the basis for the framework development. It considers the relevance of the findings from which it develops a framework for QS organisational survival. The discussion considers the themes identified by the interviews and the survey and rationalises the relevant importance of each towards the development of the framework.

Chapter 9 Conclusions and recommendations

This chapter offers conclusions and recommendations of this research. It summarises the achievement of the research aims and its objectives, justifying its conclusions and contribution to knowledge in this field. Finally, it offers recommendations for further research.

2. The construction industry, BIM and the evolving role of the QS

2.1. Introduction

The literature review is undertaken in 3 stages and presented in 3 chapters, in order to create a comprehensive understanding of the available knowledge for this research. Each chapter considers opinions and ideologies, theories and frameworks in order to formulate conclusions and to identify a unique perspective from which to direct this research.

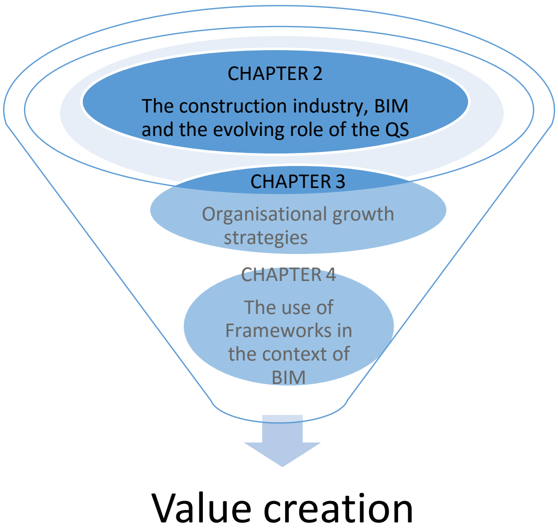


Figure 2-1 The structure of the literature review

The relationship between each stage of the review is illustrated in Figure 2.1. above. The review reflects initially on the Construction industry, the Quantity Surveyor (QS) and Building Information Modelling (BIM) in order to assess the impact of BIM on the QS in terms of the perceived challenges and opportunities. Secondly, the review reflects on organisation management in terms of organisational survival, growth, organisational learning and change management. Finally, consideration is given to frameworks, particularly in the context of BIM as they relate to the construction industry and current gaps in the research area identified as moving from organisational survival to that of opportunity and value creation.

2.2. The UK Construction Scene

The UK construction industry is of huge significance to the UK economy (Construction Industry Training Board, 2016). In August 2016, construction output represented 5.9% of GDP, (Office for National Statistics, 2016), in 2014 this was valued at £103 Billion and comprised 2.1 million jobs, 6.2% of the UK jobs total (House of Commons, 2015).

Furthermore, it is one of the largest employers in the UK comprising an estimated 300,000 firms employed in various roles (BIS, 2013). These numbers are likely to increase as the industry is predicted to continue to grow. The output of the industry is predicted to increase into 2019 with the Construction Products Association (CPA, 2016) forecasting construction output growth of approximately 4% over the next three years (Schouten, 2016). As illustrated in Figure 2.2.

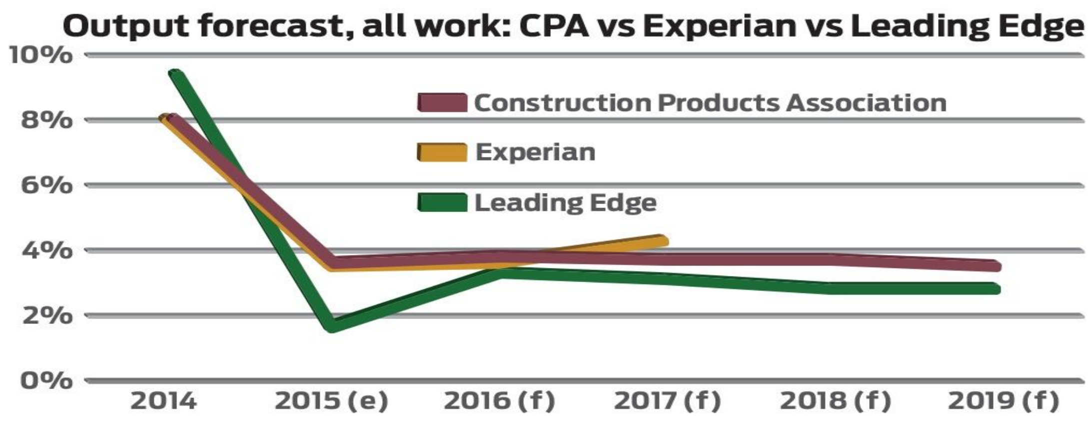


Figure 2-2: Construction Output Forecast 2016-2019

Source: Schouten, 2016

2.2.1. The characteristics of the UK construction industry

The construction sector comprises a wide range of products, services and technologies. The contracting and the service sectors work within the fields of building, building engineering, civil engineering and heavy and industrial engineering as identified in Figure 2.3 (UK Construction, 2013).

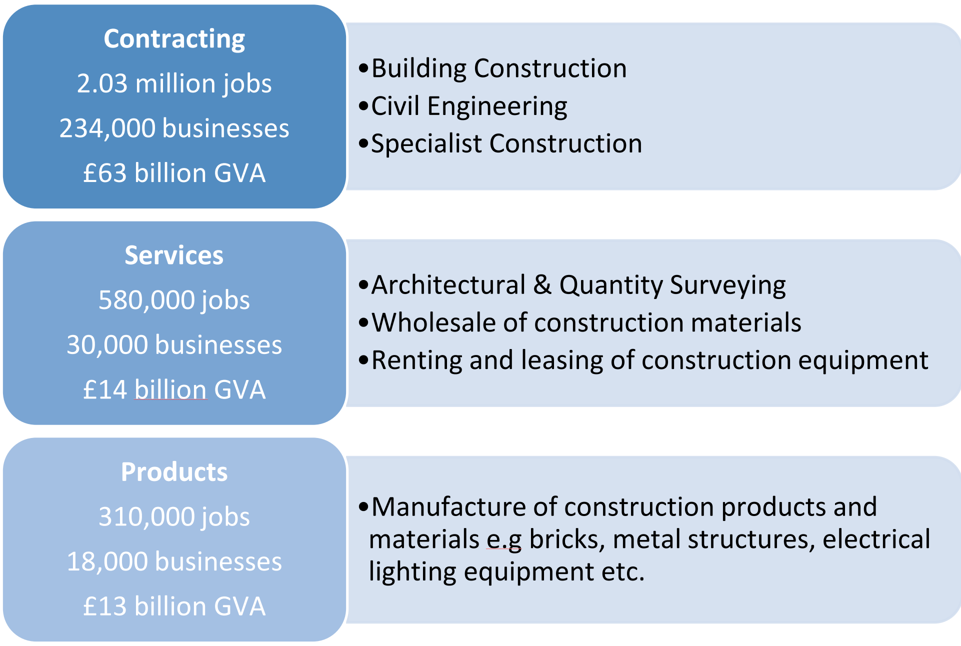


Figure 2-3: Composition of the UK Construction Sector.

Source (UK Construction 2013)

One of the services provided to the construction industry is that delivered by the QS. The QS is employed by both the contracting organisation and organisations offering consultancy services. In 2013, 16,000 UK-based firms alone, specialising in architecture and quantity surveying services, accounted for approximately £4.2 billion in gross value added (ONS, 2013). The value of the QS to this industry cannot therefore be overlooked.

2.2.2. The evolutionary development of the UK construction industry and the QS

BIM is set to challenge existing work procedures and practice's in the construction industry (Kerosuo et al, 2015) and may bring into question the very survival of the QS role itself (Olatunji et al, 2010). How the QS evolves and rises to the challenge set by BIM is the subject of this research. Evolution is not new to the industry. Numerous construction reports all demand change, from the Simon Report 1944 to the more recent Farmers Review 2016 challenge, the construction industry to modify its performance and to reconsider its mode of operation. The embryonic nature of the construction industry is also reflected in QS focused reports that demand changes in the QS role to support the recovery of the construction industry. The UK construction industry has been subject to much criticism, having consistently failed to deliver on its responsibilities over the last 70 years. The industry has suffered from excessive costs, suboptimal building quality and time delays and adversarial and conflict ridden relationships between the various parties (Duncan, 2011). During this time numerous government reports have been commissioned to promote improvements in productivity and predictability as identified in Figure 2.4.

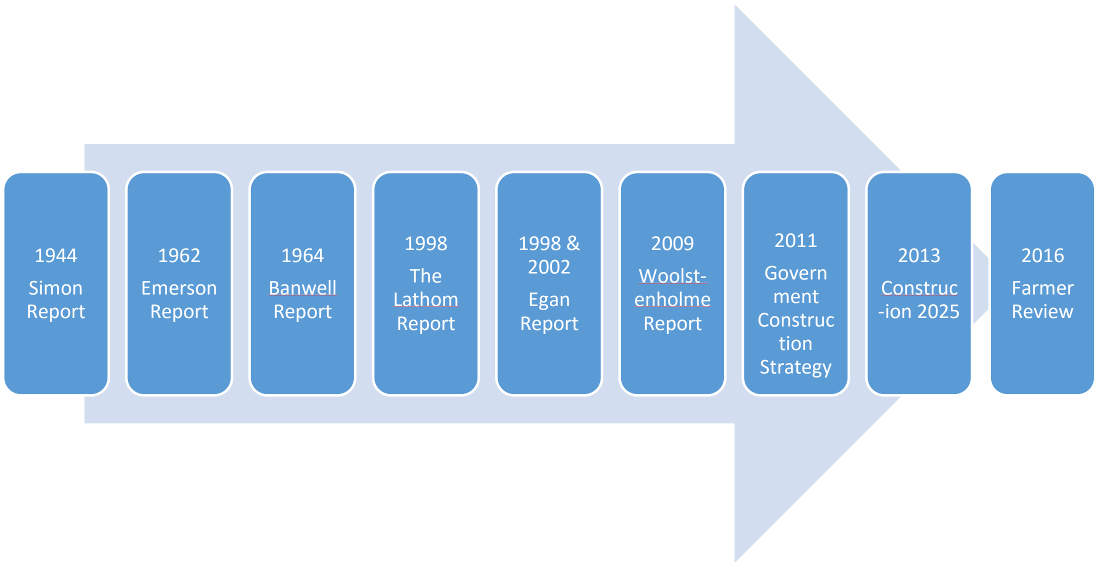


Figure 2-4: Major reports impacting the UK Construction Industry

Predictability, particularly as it pertains to cost, is the responsibility of the QS and as such the QS role too, has been subject to much scrutiny. The QS professional body, the Royal Institution of Chartered Surveyors (RICS), in parallel to the construction industry wide reports has reflected on its own performance, presented reports and proposed evolutionary developments to respond to these challenges. The embryonic nature of the construction industry demands changes of those stakeholders working within it, the QS being no exception. The reports are identified in Figure 2.5.

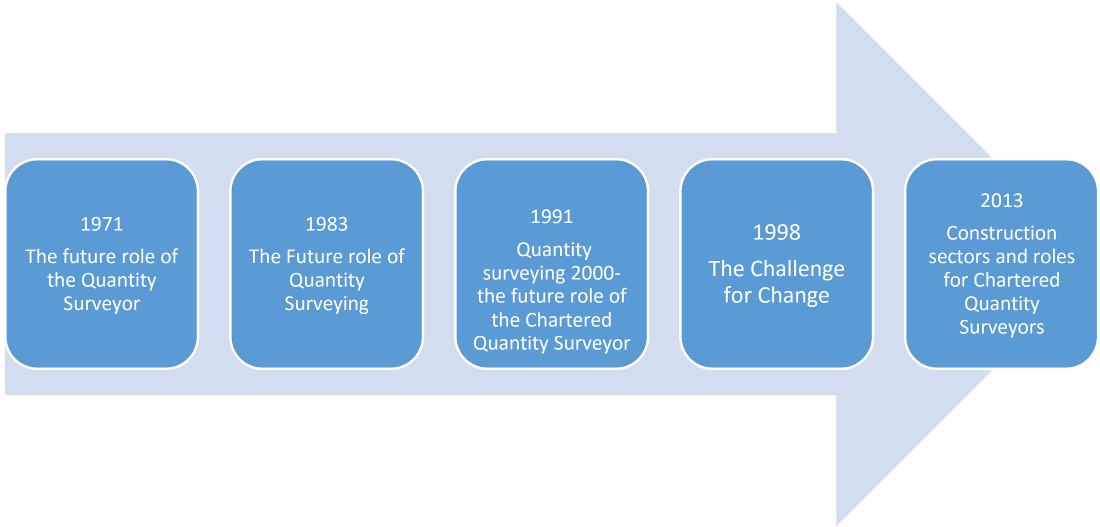


Figure 2-5 Major QS reports published by the RICS.

An overview of these reports will be provided in the next section to identify how the industry and more especially the QS prepares to respond to the numerous industry challenges.

2.3. An historical overview of UK Construction reports

From 1944 onwards, the Government has repeatedly commissioned reports to reflect on its practice, make recommendations and ultimately improve its outputs. The many and detailed reports commenced with Simon (1944), ‘Placing and Management of Building Contracts’ which was concerned with organising the reconstruction of the UK after the Second World War with the objective of increasing productivity and matching the demand and supply, to ensure the reconstruction of a war torn country. Interestingly this report instigated the debate on how the construction process should be organised rather than formulating solutions (Hillebrandt 2008). Emmerson (1962), followed, ‘Survey of problems before the Construction Industry’. He argued that the problems the industry faced were not of its own making it was the repetitive “boom and bust” cycle that inhibited productivity (Moodley and Preece 2008). It did however act as a catalyst for the much more influential Banwell (1964), ‘The Placing and Management of Contracts for Building and Civil Engineering’. This report identified similar issues as its predecessors: mismanagement of process and contractual issues and proposed a more flexible approach in contractual procedures, ultimately recommending changes in the appointment of contractors. These recommendations did not come with targets or means of measurement, but nevertheless these changes were supported by the Professional Bodies of the Royal Institute of Chartered Architects (RIBA) and the Royal Institution of Chartered Surveyors (RICS).

It was to be a further 30 years before the next report was commissioned by a still failing industry with Latham (1994), the main aim of which was to encourage Government backed reforms, reduce litigation and improve productivity and performance by encouraging clients, designers and contractors to change the way in which they operate and instigate cultural transformation from within the industry (Cahill and Puybaraud 2008). The Construction Act, which deals with contractual issues in relation to litigation and payments, is something for which this report is probably best remembered. Targets were the focus for Egan (1998); encouraging radical reform which relied on innovation of cultural change, innovation of product and process development, innovation in projects and business and innovation in continuous improvement and adding value. This report is synonymous with the introduction of the Key Drivers for change, target setting and the introduction of Key Performance Indicators (KPI) as a means of measuring achievements (Murray 2008).

Four years later followed Egan (2002), which this time focussed on the rationale that major long-term benefits could be gained from integrated team working, based on strategic partnering, transferring knowledge and expertise more effectively from one project to the next. This led to developments in new forms of contracts, more especially the New Engineering Contract (NEC) which supported a less adversarial approach to construction. Egan’s 1998 targets resulted in little change to the industry and ”were to be the subject of scrutiny in the next report to analyse the troubled industry, Woolstenholme (2009). The report considered the industry progress since Egan was to define the improvement agenda for the next decade. It concluded that whilst some improvements had been made, the industry had failed to achieve Egan’s targets. Improvements could be seen in safety and profitability but all other areas resulted in annual improvement of less than 3%. The barriers to improvement were identified as “business models based on short term cycles, a fragmented industry, poor integration in the supply chain, and a lack of strategic commitment at senior management and Government levels. The review also set out a future agenda for UK construction, including some quick fixes, and identified one of the greatest challenges for the sector as being the delivery of a built environment that supports the creation of a low carbon economy” (Constructing Excellence, 2015).

In contrast to previous reports, the driver for the Government Construction Strategy (2011) was to respond to austerity and to stimulate growth by enabling more to be constructed within the reduced publically available funds. This time the report not only called for change but identified the Government as a key player in securing better value for money and improving the performance of the industry. As a major client of the construction industry responsible for 40% of total construction spend (Cabinet office, 2011) it called “for a profound change in the relationship between public authorities and the construction industry to ensure the Government consistently gets a good deal and the country gets the social and economic infrastructure it needs for the long-term.”(Cabinet Office, 2011, p 3). The focus was to be on public procurement by implementing a detailed programme of measures by Government based on value for money, standards and cost benchmarking to reduce costs by up to 20% by the end of parliament. The phased roll-out of BIM, with fully-collaborative 3D BIM on all centrally-procured construction contracts by 2016 was at its core. 52.9% of public sector clients made some changes in response to the strategy with 5% making significant changes to their practices (Gardner, 2013). BIM adoption was more successful with 38% of public sector clients adopting BIM on one of their projects (Gardner, 2013).

Building on the key themes of the 2011 strategy is the Construction 2025 strategy (2013). This later strategy, provides a long term global vision of the industry, complete with new industry targets. These targets challenge the industry once more to reconsider its performance and once again to consider strategies to reduce costs (including whole life costs), reduce project delivery time and reduce carbon emissions, as shown in Figure 2.6.

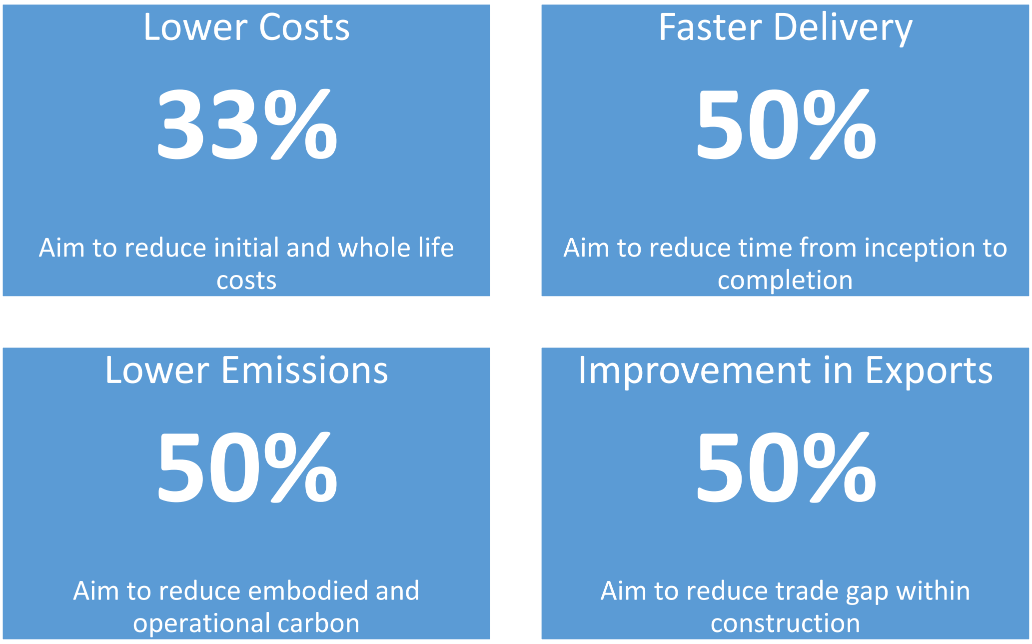


Figure 2-6 Construction 2025 targets

Source: Adapted from Construction 2025 Strategy

The vision now is for construction to be at “the heart of our future, low carbon, resource efficient, modern and globally competitive economy” (Department for Business, Innovation and Skills, 2013, p.31) and is dependent on having a skilled, motivated and diverse workforce. Greater emphasis being on new technologies, digital design and sustainable solutions in order to improve productivity and drive down costs. Construction 2025 aims to achieve further savings, of up to 33% by 2025, through the increased use of BIM and greater efficiency in the supply chain. BIM once again is seen as instrumental in supporting the achievements of these targets as the UK government drives its adoption.

Finally, the Farmer Review of the UK Construction Labour Model 2016 entitled “Modernise or die” identifies a construction industry that faces “inexorable decline” unless the problems identified in previous reports are addressed. Farmer, (2016) said: “The construction industry is in dire need of change. With digital technology advancements pushing ahead in almost every other industry and with the construction labour pool coming under serious pressure, the time has come for action. The construction industry doesn’t have the impetus needed for this change; it requires external action to initiate change.” This report calls on the Government to push forward change in the industry and to create the conditions prerequisite to support the construction sectors modernisation.

How will the construction industry respond to change, is death inevitable? Can the QS modernise, transform and evolve? The next section will consider the evolution of the QS and review its response to change.

2.4. The Quantity Surveyor and the Construction Industry

The obsession with scrutinising performance and gazing towards the future is not confined to the Construction Industry per se as the QS profession too reflect on performance, consider the needs of industry and change their role accordingly. In 1971 the RICS defined the role of the quantity surveyor as being associated with measurement and valuation (Nkado and Meyer, 2001). Nowadays this role has diversified to such an extent that the quantity surveyor must develop a range of knowledge and understanding to satisfy the needs of a plethora of different employers and their roles. Ashworth and Hogg (2007), argued that their skills have been enhanced to meet current needs in relation to cost management of a construction project. Just what triggered these changes is the subject of review in the next section.

2.4.1. The evolving role of the QS

The first report to consider the QS was the 1971 RICS report*, The Future Role of the Quantity Surveyor.* This identified that the key competence of the QS was that of measurement, the role principally concerned the production of Bills of Quantities (BQ), that the QS was appointed by the patronage of the architect and that the QS predominately worked under a competitive single stage selective tendering system (Duncan, 2011.p.7). The report identified that clients were becoming better informed, design and build projects were rare but gave no indication about how the QS could prepare for the challenges ahead.

The traditional QS duties were identified by Ashworth et al (2013, p.9) as being:

- Single rate estimating
- Cost planning
- Procurement advice
- Measurement and quantification
- Documentation preparation, especially BQ’s
- Cost control during construction
- Interim valuations and payments
- Financial statements
- Final accounts preparation and agreement
- Settlement of contractual claims

The architect would be appointed by the client and they would recommend a QS who, in turn, would be appointed by the client. Fee scales were strictly adhered to and the role of the QS clear. Initial cost was provided to the client by approximate single price estimating and if they were happy with this the QS would go on to produce the BQ. The BQ would then form the basis of the tender and used to administer payments for the project, typically valuations and final accounts. In the 1960’s, cost planning was introduced to help maintain budgets and added to the list of duties that the QS could charge a fee for (Ashworth et al, 2013, p.8). Two distinct QS roles evolved, one working on behalf of the client and employed as a consultant (CQS), and the other working on behalf of the contractor (COQS) and both working together to administer and agree payments on the project.

The 1983 RICS report, *“The Future Role of Quantity Surveying”,* further clarified the role of the QS, placing greater emphasis on the consultancy role and defined the role of the QS as being about

“ensuring that the resources of the construction industry are utilised to the best advantage of society by providing inter alia the financial management for projects and a cost consultancy service to the client and designer during the whole construction process. The distinctive competence of the QS is a skill in measurement and valuation in the fields of construction in order that such work can be described and the cost and price can be forecasted, analysed, planned , controlled and accounted for” (RICS, 1983).

Furthermore, this report identified a change in work sectors, as new work decreased, whilst maintenance and refurbishment along with energy conservation increased. It recognised that the focus of the industry was set to change and that energy conservation was to be a focus for the future. In addition, further recognition was given to the changing role of the QS with greater emphasis now on project management functions as much more focus was being placed on the needs of the construction client. This report considered the commercial pressure of working within a multi-disciplinary environment and discussed the benefits of the client being offered services from a multi-disciplinary team, which, would offer a design and management service. Consideration was also given to procurement, as, design and build was seen as a challenge to the QS, and it emphasised the need for the QS to remain as an independent cost manager moving away from the traditional consultants or contractors QS as previously identified. Even the very basis of the QS role as a producer of Bills of Quantities (BQ’s) was questioned, BQ’s coming under fire as the need for a more streamlined abbreviated document to be used for management and control purposes was deemed necessary.

Total costs became the focus of attention for the QS. Public clients at this time were only interested in capital cost as opposed to life cycle costs, but as running and staffing costs were set to rise it was now seen as essential that the QS’s should have a greater expertise in relation to economic analysis. It was at this point that the real importance of life cycle costing started to emerge. However, more concern was given to the calculation of fees for the service rather than the quality of service provided. Technology was seen as the final challenge to the QS profession at that time. It encouraged QS's to be competent in the use of technology, but had no clear strategy as to the way forward with the technology. It discussed word processing and data base information retrieval systems as being capable of producing quantitative data and ultimately, improve the scope and efficiency of the services offered by the QS. However, it did not realise the ultimate potential technology had to offer the profession.

It recognised that

"many QS's are likely to be employed in large multi – disciplinary firms and practices capable of designing and managing major construction projects or in organisations developing and monitoring the management systems, data bases and information systems used by the profession" (RICS,1983, p.14).

For the first time the QS felt threatened as the very survival of the conventional Consultant Quantity Surveyor (CQS) practices were questioned. The RICS sought to identify the characteristics of organisations that would survive as being those that adopt technology to gather information in the management of construction projects (RICS,1983). These characteristics would prove to be of profound importance to the QS organisation as it came to terms with many of the challenges and targets besieging its very existence in the future.

Change was not restricted to the CQS as change would affect the Contractors Quantity Surveyor (COQS), particularly as they related to:

- Procurement routes which sought to divert the responsibilities of the QS to other members of the design team.
- Project management as it pertained to the knowledge offered to the client in relation to decision making when matching project and client needs.
- The development and extension of life cycle costs.

- Information technology.

It is important to remember that this report preceded Latham (1994) by more than ten years, yet it recognised the importance of focussing on the needs of the client and identified key drivers for change in terms of procurement, management skills, lifecycle costing and of course information technology.

Indeed, there was to be another QS report that would precede Latham (1994) entitled *"Quantity Surveying 2000- the future role of the Chartered Quantity Surveyors (1991)"* which considered the changing context of demand for the QS and its preparation to respond to the needs of an ever changing environment. This time it looked to the COQS and identified the changing nature of contracting, particularly the rise in specialist subcontractors and the move by contractors to design and management. Whilst this was seen as a potential game changer for the industry it was not seen as a threat to the QS profession, but more of a change in relationships, especially with that of the client. The function undertaken by the QS would not change. It was more about managing the relationship with the client and the ability to meet the client requirements more effectively than anything to do with survival. The emphasis on management was also identified as changing the industry context, but, as many practices also offered project management services, the QS saw themselves as key contenders in this role "with their unique expertise in their understanding of construction costs which is vital to successful project management" (RICS, 1991, p.19).

The recognition of changes in procurement and the need to manage risk, particularly with Construction Management procurement, was identified and warned "They need not advocate any single procurement method, but they must become experienced in all of them (RICS,1991, p.22). Clients' needs were to be prioritised and the QS advised to consider their services in terms of value added to the client's business, with the provision of independent procurement advice alongside the management and organisation of procurement being seen as adding this value. Another value added service is that of early cost advice and this report sought to improve the accuracy of cost estimates despite the challenges of uncertainty surrounding client's projects and also the uncertain economy. This early cost advice, however, should identify "a proper balance between project cost and value to maximise client benefit" (RICS,1991, p.24). The profession was encouraged to get involved with value management by way of offering services including investment appraisal and life cycle costing and also assessments on the analysis of building quality, function, efficiency and environmental impact.

This report concluded that QS's were well positioned to provide total facilities management from cradle to grave and once again advised the profession to assemble information, but this time in relation to premises management, in particular maintenance needs and costs. Overall, this report responded positive to change and emphasised adding value, by better information management and greater collaboration.

1998 saw the next publication from the RICS *"The Challenge for Change"* This time the emphasis was driven by "information technology, where quantity generation is a low cost activity and the client base is demanding that surveyors demonstrate added value" (Duncan, 2011, p.7). This was the first reported incidence of wholesale change to organisations which offered QS services, with many of the small and medium practices of the 1960-1990's disappearing, as result of the conglomeration of many, to form large multi-disciplinary practices. Furthermore, in complete contradiction to previous reports it now recognised that the line between the CQS and the COQS would blur as a result of advancements in procurement methods. This was to be the final report by the QS division by the RICS, as the RICS itself changed and adapted its structure to satisfy the wider global economy. The QS division being subsumed into "Construction" one of three new pathways established by the RICS.

It was a further 15 years before the QS role was once again interrogated and in 2013 the RICS, in its entirety, published an information paper entitled *"Construction sectors and roles for chartered quantity surveyors".* This information paper looked at the structure and background to the industry, the impact of Government reports, the role of clients and the briefing process and the supply chain. It then went on to consider the role of the QS and identified that QS's were being used in an assortment of client supporting roles including:

- Quantity Surveying:
  - demand (client) side
  - supply (contractor/subcontractor) side
  - public sector
  - civil engineering; and
  - energy (oil and gas)
- development management
- employer's agent
- project manager
- project monitoring.

In contrast to "*Challenge for change"* (1998) which discussed a fuzziness of QS roles this report went back to the traditional view of clear delineation between the two: demand (client, CQS) and supply (contracting, COQS). The key functions of the CQS, were identified as advising the client on:

- design economics and cost planning
- whole life costing
- procurement and tendering
- contract administration; and
- commercial management.

In contrast the key functions of the COQS were identified as advising the contractor on:

- commercial management of construction projects including financial processes, profitability, project cash flows and cost value reconciliation.

The demand side was then divided into 5 work stages as identified in Figure 2.7 during the construction process and the QS role applicable to each of these stages acknowledged.

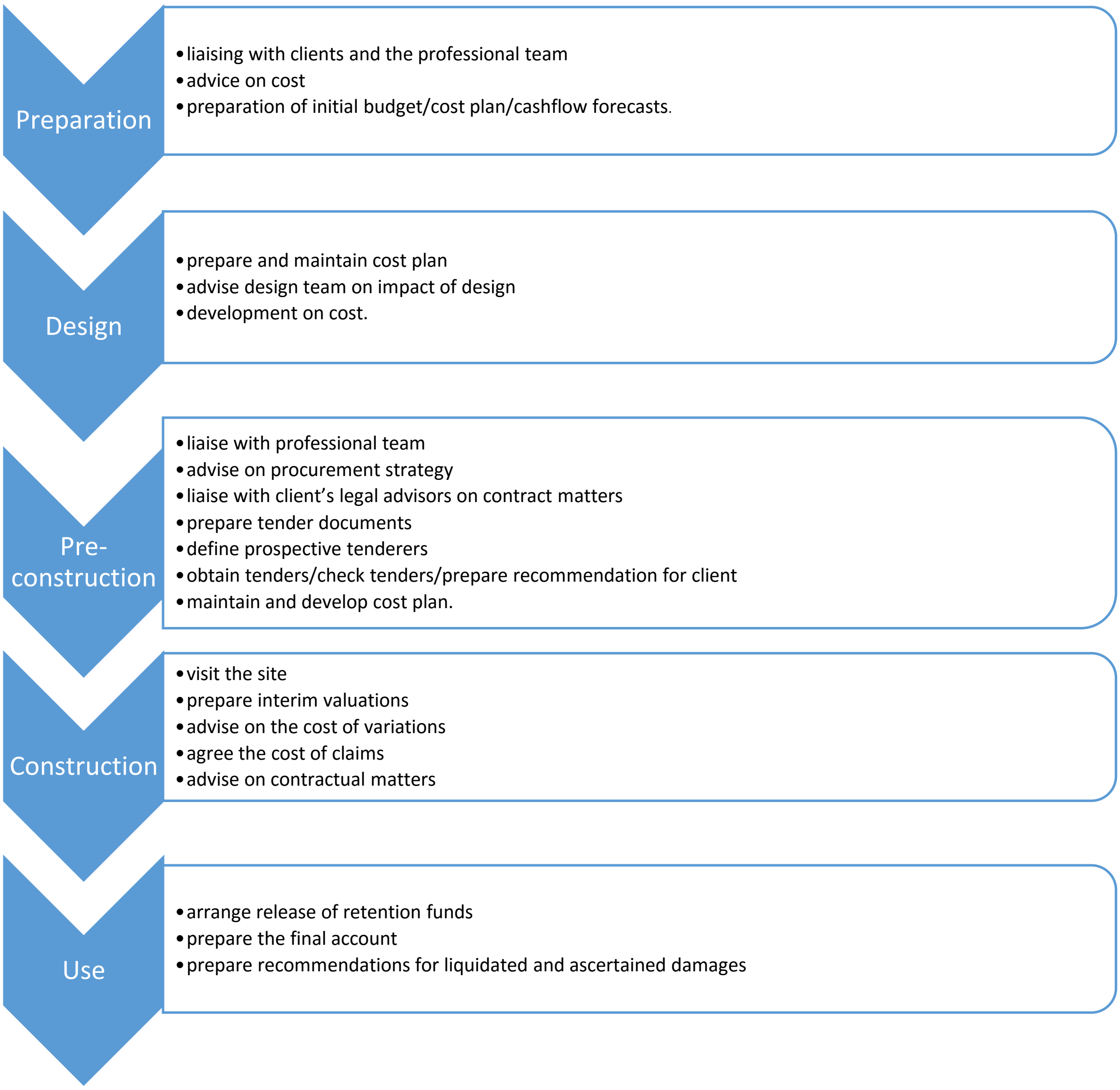


Figure 2-7 Demand side QS services over project life cycle..

Source: Adapted from RICS, 2013.

In addition to the above duties the report identified supplementary activities as optional additions, to be adopted if required by the client and if the project dictated. These are identified in Figure 2.8. They were not however seen as core requisites of the QS service to the client. Surprisingly this is at odds with both the Government Strategy 2011 and Construction 2025, particularly as it relates to life cycle calculations. If the efficiency of 33% in costs is to be achieved, then life cycle calculations should be a core service offered to the client at design stage not supplementary.

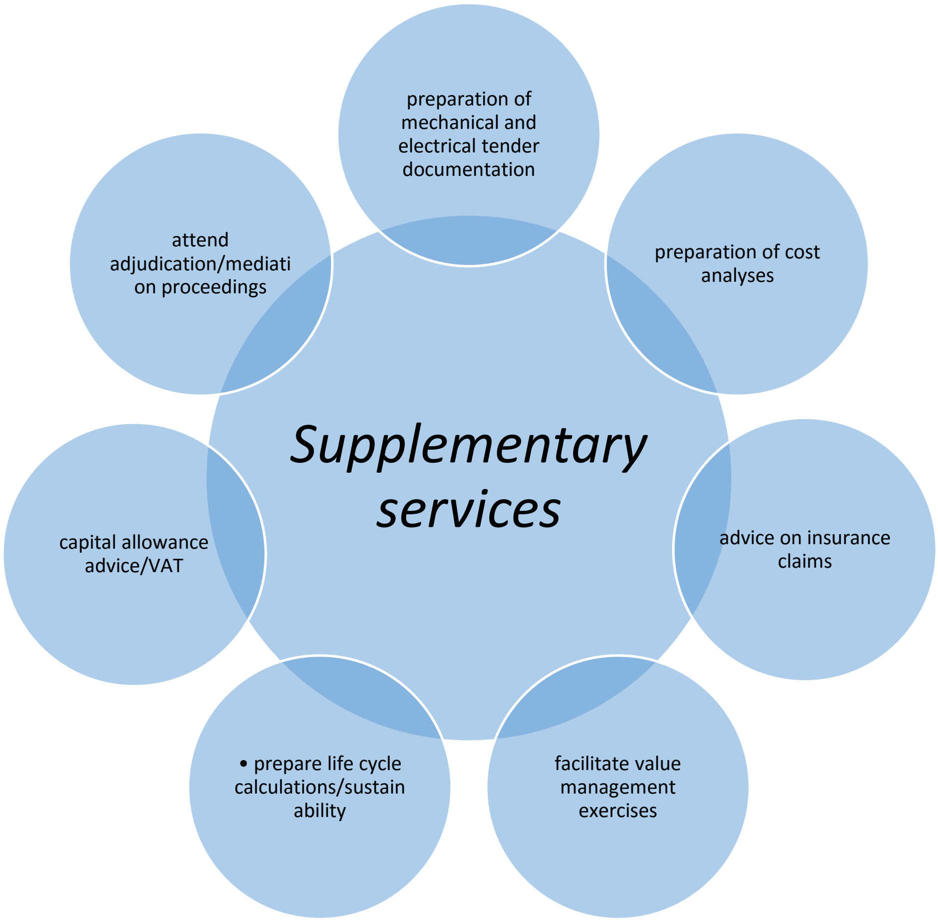


Figure 2-8 Supplementary QS services.

Source: Adapted from RICS, 2013.

The report continued to discuss the involvement of the QS in the role of development management, employer's agent, project manager and project monitoring, but made no attempt to discuss that of the supply side of the QS. The justification for this maybe as a consequence of the professional boundaries between the CIOB (the professional body typically seen as representing the COQS) and that of the RICS, which represents in the majority CQS's in professional practices.

The roles and functions were further rationalised by Ashworth et al (2013) who summarised the QS duties circa 2012 as being:

- Investment appraisal
- Advice on cost limits and budgets
- Whole life costing
- Value management
- Risk analysis
- Insolvency services
- Cost engineering services
- Subcontract administration
- Environmental services and measurement and costing
- Technical auditing
- Planning and supervision
- Valuation for insurance purposes
- Project management
- Facilities management
- Administering maintenance programmes
- Advice on contractual disputes
- Planning supervisor
- Employers agent
- Programme management
- Cost modelling

- Sustainability advisor (Ashworth et al. 2013)

More recently, the RICS has made reference to the previously mentioned *Government Construction Strategy 2011* to identify potential opportunities to the QS role in the form of BIM and FM alongside the traditional functions of cost benchmarking and procurement. The QS will remain crucial to the delivery of the Government Construction Strategy even if the profession is not explicitly named as part of the solution and despite the QS professions lack of clarity on the services it has to offer (Saunders, 2013). The Strategy identified the new rules of measurement (NRM) as key documents that provide the QS with a structured approach to the management of the cost of an asset though its entire lifecycle, as being key to the recognition of the services the QS can offer to the industry. In particular, NRM3, which considers the life cycle cost of the asset and puts the QS at the centre stage of the procedures in relation to cost management post construction. Bucknall, (2013), further argues that the UK government's current drive for a 15%-20% reduction in the whole life cost of built assets is a quantity surveying charter as the QS is best-qualified to identify the key cost components where efficiency improvement can deliver outturn cost reduction.

The QS's ability to respond to whole life costs is not seen therefore as a challenge. It is the response to technology that appears to give cause for concern. Recognition of the impact of IT and more recently BIM on the profession did not go unnoticed. Traditional QS information on "quantities and measurement" is now available in an electronic automated format to other project stakeholders which may diminish the QS role from that of information broker to interpreter (Frei, 2010). This view is supported by Saunders, (2013) who claimed those QS organisations that fail to become BIM enabled will be left behind. Others questioned the very survival of the profession claiming it may even disappear as a formal profession unless it remains relevant and transforms itself to satisfy the needs of the global business environment (Ofoari and Toor, 2009). However, Frei (2010) questions if the QS profession has the ability to remain at the forefront of market development and describes the QS as conservative, slow to respond to innovation and choosing to be reactive rather than proactive, in a global market.

If the QS is to respond positively to the challenges set by the UK government, the QS organisation must ensure that they possess the necessary structure and skills to apply BIM, in order to meet these challenges and survive. But what is BIM and what potential is there to support the QS function?

2.5. Building Information Modelling (BIM)

The *Government Construction Strategy 2011* with its BIM adoption mandate*,* provides a massive incentive to contractors and construction professionals alike to arrange their organisations, train their staff and develop and utilise BIM tools and techniques, if they wish to continue to tender for publicly procured projects. The efficiencies demanded of the industry must be created by these project stakeholders by the effective introduction of BIM into their organisations. The construction industry can utilise BIM for visualisation, design appraisal, project management, information storage and retrieval, cost estimating, structural analysis, on site management, facilities management and contract preparation (Sun et al, 2008), but what is it?

2.5.1. What is BIM?

Definitions of BIM are many and varied, resulting in misunderstanding and confusion as to the interpretation of its value to the industry. There has been much debate over the need to have consistent definitions and terminology. Arenda-Mena et al. (2009), Goucher and Thurairajah,(2013), Brewer et al (2012) and Building Smart (2012) have all argued for consistency in describing BIM, its systems, processes and technologies, in order to reduce the misinterpretation in this field. The next section will seek to review definitions of BIM in an attempt to seek clarity of in terms of this research.

2.5.2. BIM and technology

Initially, definitions were mainly around technology, with BIM being "increasingly considered as an Information Technology (IT)- enabled approach that allows design integrity, virtual prototyping, simulations, distributed access, retrieval and maintenance of the building data" (Fischer et al 2004, p4). Weygant (2011) argued that BIM in its early days was distinguished by its ability to represent objects instead of lines, arcs, curves etc. and now has evolved into a powerful tool that is capable of performing "model analysis, clash detection, product selection and whole project conceptualisation" In contrast BIM can be said to be a complete set of design information stored in an integrated database containing information concerned with the entire building. The information in the model is parametric and thereby interconnected, allowing a change made within the model to be instantly reflected throughout the rest of the project (Krygiel et al, 2008).

Azhar et al. (2012) argue that from a technology perspective, a building information model is a project simulation consisting of 3D models of the project components with links to all of the required information connected through the life cycle of a project. The BIM technology is a consequence of adopting object-oriented parametric modelling techniques (Azhar et al., 2008b). Initially, when parametric feature-based modelling was first released, it revolutionised the CAD industry by fundamentally changing the way that organisations not only developed 3D models, but also how they made changes to designs. As an object is changed, an adjacent object is automatically adjusted to reflect this change, thus maintaining the relationship between the adjacent objects. In addition, each objects contains information related to the building, which will include its physical and functional characteristics and project life cycle information. It can be concluded, therefore, in order for a model to be categorised as BIM it must contain object attributes, must support behavioural changes and allow for changes in one view to be automatically updated in other views (Azhar et al 2012)

2.5.3. BIM and process

Eastman et al (2011) argue that BIM is both a technology change and a process change. Technology enables enhanced visualisations of a project, providing the tools to enable a building to be represented by intelligent objects, which recognise their relationships with other objects within the model and are capable of containing information about themselves. In addition, technology is the catalyst for significant change in process and contracts as it allows for changes to be made to key processes that are involved in putting a building together, thereby supporting the move towards Integrated Project delivery(IPD) and a collaborative way of working. Thereby encouraging construction industry stakeholders to move away from the traditional silo approach mentality where each stakeholder works independently from the other. BIM gets people and information working together effectively and efficiently through defined processes and technology (RICS, 2013). This view is supported by Hardin (2009) who purports, that BIM is not just a software or a model, but is more concerned with changing workflow patterns and project delivery processes to facilitate collaboration and bring about a change in the attitude of the project team.

It is difficult to consider BIM and process in isolation. BIM represents the transformation of the construction industry, offering a set of technologies, processes and policies, which in turn, affect the industry’s deliverables, relationships and roles. Succar (2009) observes that BIM is the coming together of policy, process and technology and that it stimulates simultaneous revolutionary and evolutionary changes across organisations and project teams: to industries and whole markets, as illustrated in Figure 2.9.

The BIM process field can be seen as a plan detailing outputs and inputs and positioning events in relation to time and place from start to completion. Contributors in this field are seen as clients, owners, contractors, design team members and all stakeholders involved during the project lifecycle. The policies field help to support the decision making by offering guidelines and rules to help reduce risks and to minimise conflict e.g. regulatory and contractual roles. Finally, the technology field consists of specialists who develop subject specific software and hardware to be adopted by the construction industry through the life cycle of a project.

The creation of these 3 fields of activity can be seen to create a methodology to manage the building design and the project information through the lifecycle of the building (Pentilla, 2006).

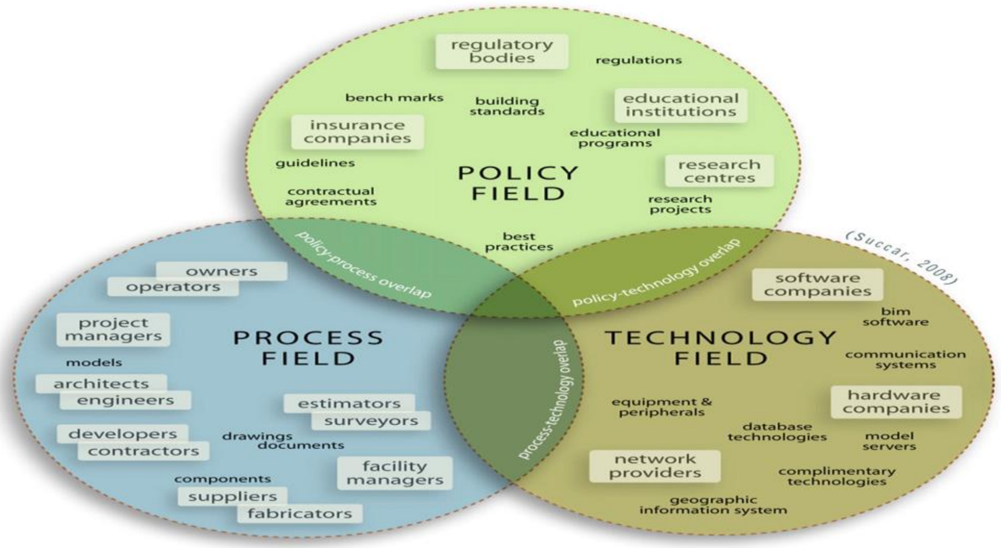


Figure 2-9 Interlocking fields of activity.

Source: Succar, (2009) p361.)

2.5.4. BIM and information

The construction industry is information intensive with its value being in the quality of information provided. Historically, information has been managed and communicated using paper-based systems and verbal instructions but now BIM provides the opportunity for this information to be digitally represented. BIM is a shared digital representation founded on open standards for interoperability and can be used as a virtual information model to be shared amongst or between the project team (Sebastian et al, 2009). This information can be shared through a projects life cycle as it is a design approach that uses ICT and tools to facilitate collaboration and decision making. It is a shared knowledge resource that provides information to support decisions that can be made through the lifecycle of a project. Project stakeholders are able to add, extract, update or change information in the model to reflect their roles at different stages of a projects lifecycle (Sebastian, 2010).

More recently Dave Philp (2013) defined BIM in terms of collaboration, clear open communication, high quality information linked to business outcomes and modelling that created better outcomes, as illustrated in Figure 2.10. Better quality of information therefore increasing its value.

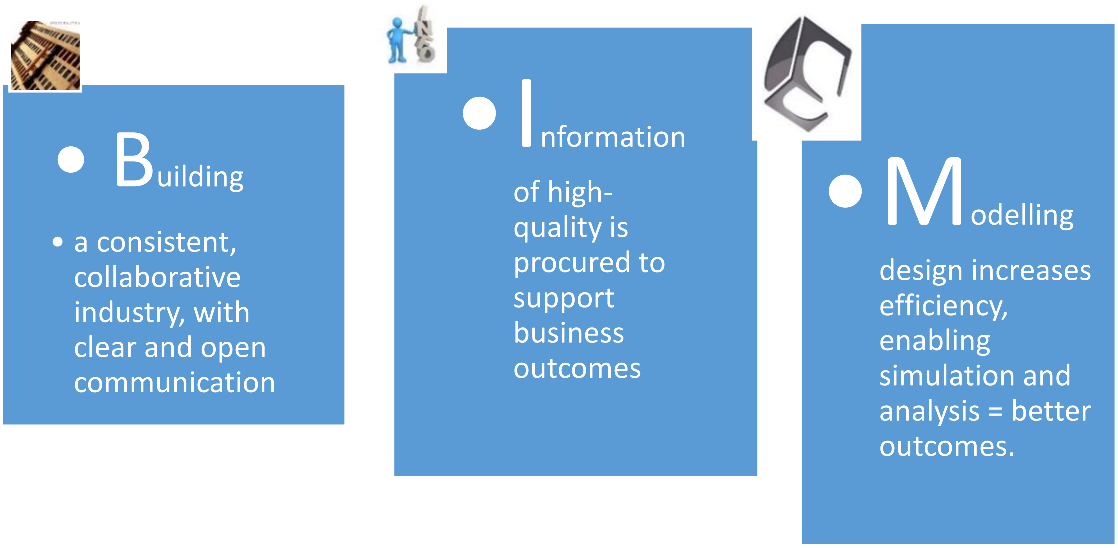


Figure 2-10 What is BIM?

Source: Adapted from Philp (2013).

This is an interpretation supported by the UK Government defining BIM as "essentially value creating collaboration through the entire life-cycle of an asset, underpinned by the creation, collation and exchange of shared 3D models and intelligent, structured data attached to them" (BIM Task Group, 2013).

2.5.5. BIM definition and importance.

A wide range of definitions of BIM have been introduced in a plethora of publications. Each publication offers their own explanation of BIM which in itself can cause confusion between readers (Barlish and Sullivan, 2012). All emerging definitions of BIM reflect its transformative capabilities and impact on the construction industry (Kaseem et al, 2014).

Ultimately, what does it matter, what is in a name, a label, a term? It is an understanding of the opportunity that it presents to the industry that is important and how it can be used to challenge current practices and thinking; to create a more efficient and transformational construction industry?

Race (2012) purports that there is no single, agreed explanation or definition of what BIM is. Each different definition created is from the perspective of its respective discipline and therefore, differs slightly from other definitions. As there is no one acceptable definition of BIM, Miettinen et al (2014) p.84, argue that BIM should be “analysed as a multi-dimensional, historically evolving, complex phenomenon,” therefore allowing BIM to be perceived to be many things including a digital illustration of a building, an object oriented three dimensional model, or a depository of project data which will facilitate interoperability and exchange of information with related software applications (Miettinen et al, 2014)

For the purpose of this research, the definition initially adopted is that “Building information modelling (BIM) gets people and information working together effectively and efficiently through defined processes and technology” (RICS, 2014). This definition focusses on the effective collaboration of people and processes to achieve efficiencies on a project and can be used by this research to consider the application of BIM throughout the lifecycle of a project for all stakeholders including the QS.

2.5.6. BIM maturity

Maturity can be defined in terms of behaviour and competence. Anderson and Jessen, (2003) view organisational maturity as the sum of *action* (ability to act and decide), *attitude* (willingness to be involved), and *knowledge* (an understanding of the impact of willingness and action). Therefore, once an organisation has an understanding of what BIM is (knowledge), it can start to plan for BIM implementation(attitude) by assessing its current BIM capability(action). To support organisations in undertaking this audit, several tools have been developed which measure the capability in terms of BIM maturity (Wu et al, 2017).

The most widely reported tool is that provided by Bews and Richards, (2008), who defined the BIM journey of organisations, projects and industry in their “BIM wedge” diagram which shows 3 key BIM stages, preceded by a Pre-BIM status or stage/level 0 (BIM Thinkspace 2015). Level 0 is unmanaged 2D CAD with stakeholders exchanging design information via paper or electronic prints. In contrast Level 1 is managed CAD in 2D or 3D format, the standards are managed and semi structured electronic data is shared by a common data environment. There is no integration of the various disciplines as each maintain and control their own areas. Level 2 involves a managed 3D environment. Collaborative working is supported across all of the stakeholders with all parties using 3D models, integrated but not necessarily shared. Design information is shared through a common file format such as IFC (Industry Foundation class). Level 3 represents fully collaborative working across all of the stakeholders by the adoption of a shared central which is accessible to all to modify and share data. This is illustrated in Figure 2.11.

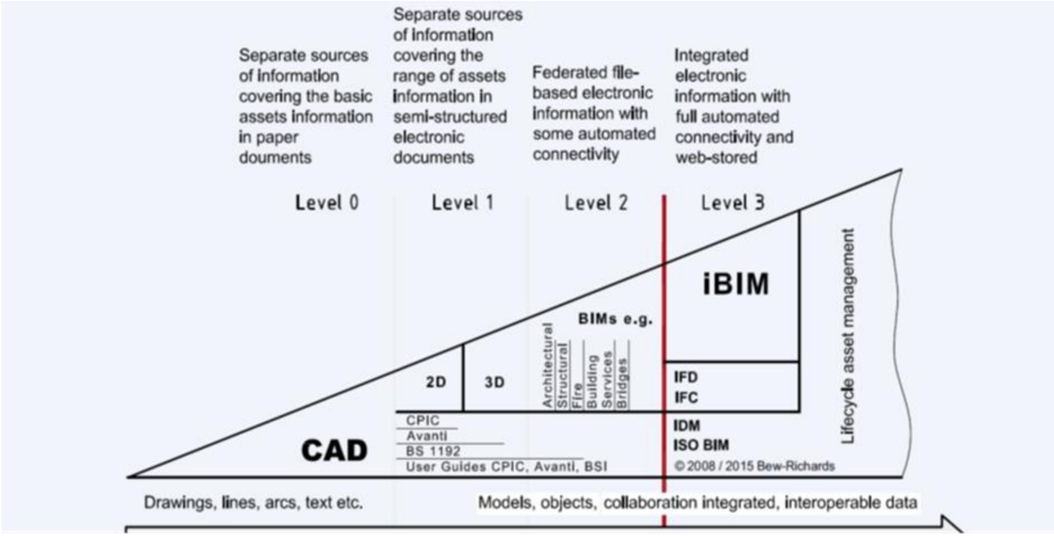


Figure 2-11 BIM maturity levels.

Source Bews - Richards (PAS 1192.3)

Succar, (2009) represented BIM maturity as a series of stages which stakeholders need to implement gradually and consecutively. These stages are similar to the levels identified by Bews and Fellows in the BIM wedge, and confirm the move from unmanaged and unintegrated to fully managed and fully integrated. Succar, (2009) further subdivided each stage into steps and identified stages as being transformational or radical changes and steps as being incremental. BIM maturity includes TPP (technology, process and policy) components and can be subdivided into three stages as illustrated in Figure 2.12.

Figure 2-12 BIM and their objects- flow diagram.

Source: Succar, (2009)

2.5.7. Dimensions of BIM

At each of the steps or stages of BIM maturity, dimensions of BIM can be adopted to support collaboration, information exchange and support the decision making process. A multidimensional "nD" capacity of BIM allows for unlimited number of dimensions to be added to BIM (Aouad et al, 2006). Eastman et al. (2011) and Karmeedan (2010) support this and define this multidimensional capacity of BIM as 'nD' modelling with the capacity to add an almost countless number of dimensions to the Building Model. As illustrated in Figure 2.13. This nD permits all relevant building information to be added to the model to give a true representation of the project and improve the efficiency of the delivery. If used appropriately the BIM technology has the potential to have a significant influence on the construction process by altering the way the project participants interact with one another (Lu and Korman, 2011).

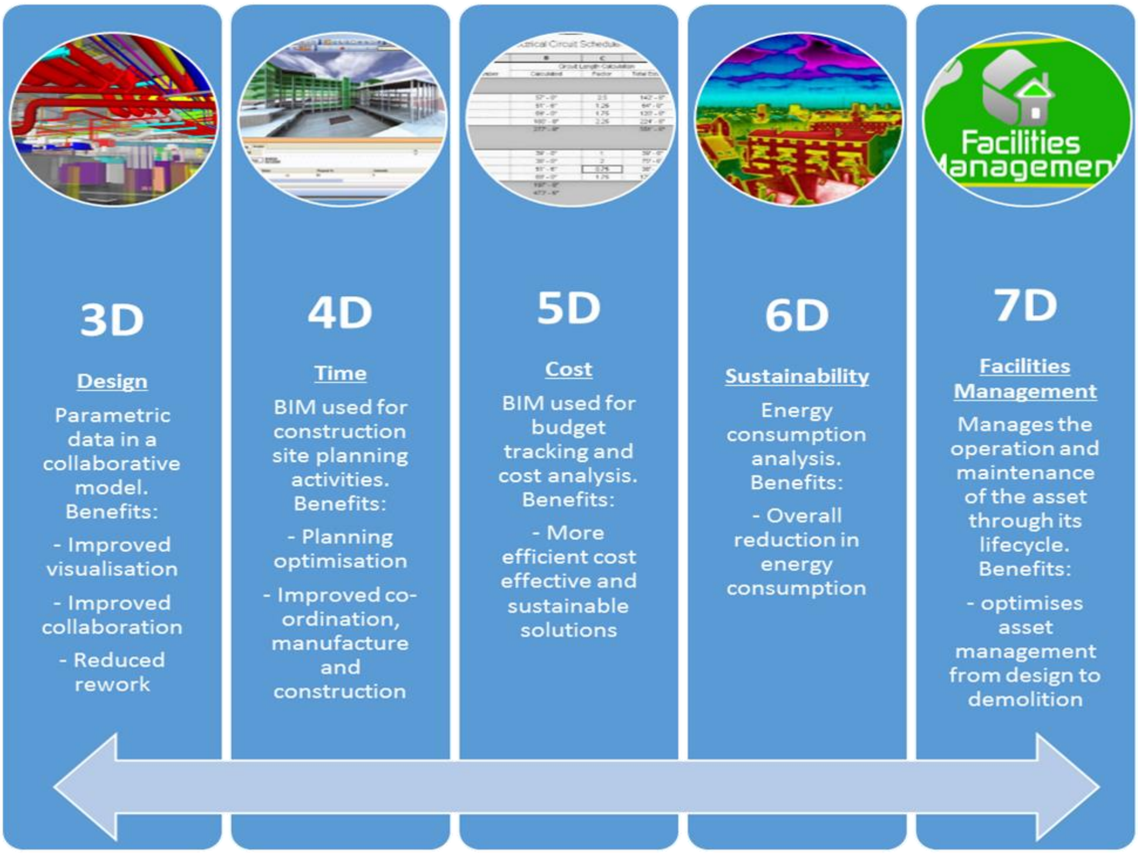


Figure 2-13 The dimensions of BIM

Source: Philp (2013)

Primarily 3D BIM refers to all project and asset information, data and documentation in electronic form (Bryde et al, 2013). 4D BIM adds a time element to 3D BIM. Kamardeen (2010, p. 285) defines 4D BIM as a

“planning process to link the construction activities represented in time schedules with 3D models to develop a real-time graphical simulation of construction progress against time. Adding the 4th dimension ‘Time’, offers an opportunity to evaluate the buildability and workflow planning of a project. Project participants can effectively visualise, analyse, and communicate problems regarding sequential, spatial and temporal aspects of construction progress. As a consequence, much more robust schedules, and site layout and logistic plans can be generated to improve productivity.”

Combined with 3D and 4D, 5D BIM allows the project team to visualize the progress of the activities and related costs over time to support greater accuracy and predictability of project costs. 5D BIM allows for the real-time extraction or development of fully valued parametric building components within a virtual model. 5D BIM therefore provides methods for extracting and analysing costs, evaluating scenarios and managing change. Mitchell (2012) refers to this as the 5D ‘Living Cost Plan’. He argues that these modern techniques can be used within traditional frameworks, but that it is the behaviour and how the technology is used that is more important than the software. Research into 5D BIM is gaining momentum (Wong et al. 2011, Cheunga et al. 2012, Thomas 2012, Zhou 2012, Olatunji et al 2010 and Frei et al. 2013). This developing research correlates with the developing environment of 5D BIM implementation in the construction industry.

6D-BIM considers sustainability and supports energy performance analyses which can result in more complete and accurate energy estimates earlier on in the design process. Furthermore, it supports the measurement and verification of energy during building occupation assisting in post occupancy evaluation of the project.

7D-BIM considers the operation and maintenance of the facility throughout its life cycle. It allows the project team to extract and track relevant asset data such as component status, specifications, maintenance/operation manuals, warranty data's etc.

The aforementioned dimensions of BIM can be adopted by the project stakeholders to support them through the various work stages of the project lifecycle, in the decision making process, and, to facilitate collaboration across the team.

2.5.8. The 8 pillars of BIM

BIM processes of collaboration and integration are not new. BS 1192:2007 is the foundation document to UK BIM processes. It defines the collaboration management processes that a project team are required to adopt for issuing information and provides a numbering system template so that information can be searched on electronic data bases.

However, it was not until after the publication of *the Construction Strategy 2011* and the *BIM Industrial strategy: Government and Industry in partnership 2012* that BIM processes were further defined by the publication of what are commonly known as the 8 Pillars of BIM. These 8 documents. enable the project team to define processes and procedures around the digital exchange of data sets through the life cycle of the project.

- PAS1192-2:2013 defines how data is to be managed during the construction phase of a project; also known as the Capex – or capital expenditure phase. It gives guidance on the processes required and recommends the use of several template documents, for example, the Employers Information Requirements (EIRs) and the BIM Execution Plan (BEP)
- PAS1192-3:2014 defines how data is managed during the Operation Phase of an asset (Opex) and therefore the way that facilities management teams should access construction information and build

upon the data set for the lifecycle of the asset.

- BS1192-4:2014 is the UK definition of COBie, the Construction Operation Building Exchanger format data scheme developed in the USA and used worldwide as a sub set of Industry Foundation Class(IFC). This is the standard for defining the method of exchanging data, primarily the non-graphical portion. COBie is defined internationally in ISO16739:2013
- PAS1192-5:2015 is the most recent document published and considers the need for cyber security to be considered when sharing data about assets and set the standard for cyber security on projects.
- BIM protocol is a legal addendum to allow parties to share data within a contract, when working up to Level 2 BIM.
- Government Soft Landings extends the period the project team are responsible for the project
- Classification- in order that data can be read accurately and quickly by software systems, classification of data is a critical process. Consistency is vital. In the UK Uniclass3 has recently been published as the intended standard to be used for classifying every part of an asset.
- Digital Plan of Works - another key part of BIM is the delivery of lean processes. The Digital Plan of Works seeks to define what information is required at what point in the lifecycle of an asset and can be used to allocate responsibilities for creating and issuing this data.

Each of the 8 Pillars cohesively inform the implementation of BIM to achieve the maximum benefit (Navendren, 2015), but what are the benefits of BIM?

2.6. BIM Benefits for Construction Stakeholders

BIM will unleash growth in UK construction, and in the wider economy (Saxon, 2013). The “Growth through BIM” strategy as identified by Saxon, 2013 will lift the built environment sector and its stakeholders and create a more effective construction industry. BIM has the potential to impact the nature and quantity of work to be done by all stakeholders at each stage of the project. “Roles and relationships will change and all stakeholders need to change their work plans and business models to exploit BIM fully” (Saxon, 2013, p.46). Figure 2.14 illustrates the stakeholders’ involvement in relation to the RIBA plan of work 2013 work stages. Each of these stakeholders will benefit from BIM in terms of improved collaboration which will extend existing organisational boundaries (Arayici et al,2011) and bring with it transformation to their role.

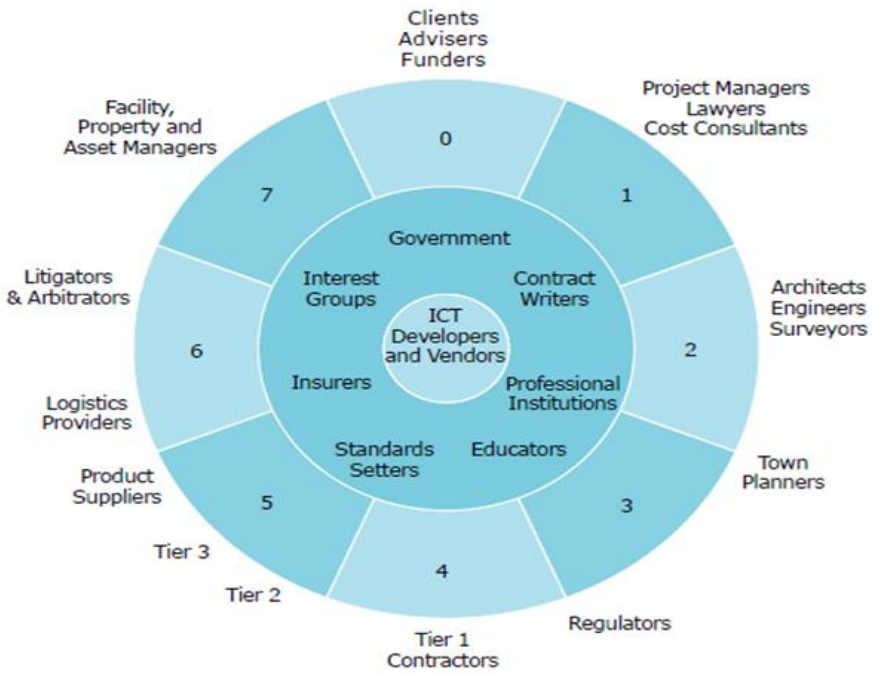


Figure 2-14 The project stakeholders’ involvement in relation to the RIBA plan of work 2013 work stages.

Source: Saxon 2013 p. 51

Generic organisational benefits include, reduction in time, cost and human resource and an improvement in quality and sustainable solutions (Yan and Damian, 2008). A view supported by Azhar et al, (2012) who argues that BIM creates an opportunity for sustainability measures to be incorporated throughout the design process, by all project stakeholders, as it allows for multi-disciplinary information to be superimposed within one model.

Eastman et al (2011) and Reddy, (2011) summarised the following benefits of BIM for project owners:

- Early design assessment to ensure project requirements are met.
- Building performance simulations improving the predictability of the building performance supporting post occupation evaluation.
- More predictable costs reducing the number of change requests resulting in a reduction in financial risk.
- Improved marketing of project by the adoption of 3D renderings and walk-though animations.
- Single source of project information within one file to support the management of the facilities post occupation.

In contrast, Kymmel (2008) identified the main benefits of BIM for project designers and engineers as:

- Improvement in the quality of input from project owners which facilitated better design by the meticulous analysis of the digital models and the production of visual simulations.
- Better predictability of environmental performance by the early incorporation of sustainability features into the building design to enable the prediction of its environmental performance.
- Better code compliance via visual and analytical checks.
- Early analysis of the model identifies potential design, construction and occupation issues much earlier on such that change can have less impact on the project itself.
- Faster production of shop or fabrication drawings

More recently, McGraw Hill, (2014) considered the benefits of BIM to contractors and identified many positive advantages of adoption, with major benefits being a reduction of errors or omissions and the least benefit being in relation to marketing new business, as illustrated in Figure 2.15.

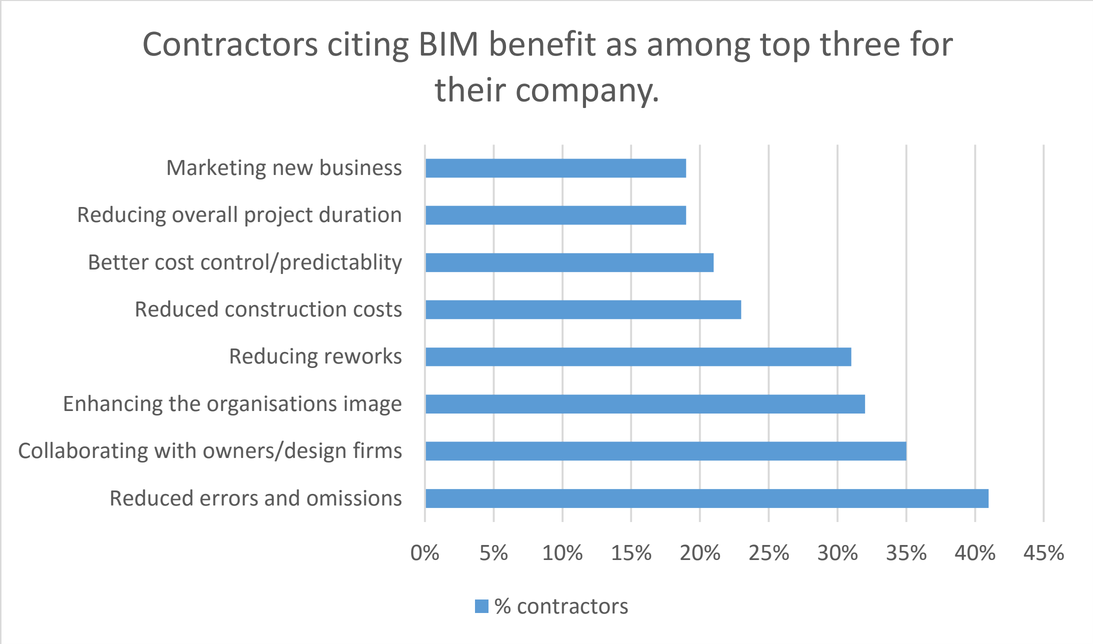


Figure 2-15 Benefits of BIM to contractors

Source: McGraw Hill construction (2014)

In addition, (Azhar et al., 2011) recognised the impact of BIM on the performance indicators of contractors and identified the following benefits:

- High profitability;
- Better customer service;
- Cost and schedule compression;
- Better production quality;
- More informed decision making; and
- Better safety planning and management

BIM therefore has tremendous potential to create benefits to all project stakeholders but what of the barriers?

2.7. BIM barriers to construction stakeholders

BIM undoubtedly has the potential to improve the way the construction stakeholders collaborate, exchange and store information and ultimately make their decisions. However, it is not without opposition. BIM has experienced resistance from the industry due to a plethora of factors. Yan and Damian, (2008) suggested that the barriers to BIM included:

- Technology insufficient to support wholesale BIM adoption.
- Cost of software, hardware and training
- Copyright issues.
- Waste in time and human resource
- BIM lack of suitability for all projects.
- People’s inability or refusal to learn new technologies and processes.

More recently, Ku and Taiebat (2011) suggested that the following barriers were exhibited by contractors when attempting to implement BIM:

- Learning curve and lack of skilled personnel
- High cost to implementation
- Reluctance of other stakeholders (e.g. architect, engineer, contractor)
- Lack of collaborative work processes and modelling standards
- Interoperability
- Lack of legal/contractual agreements

If the industry is to realise the efficiencies that BIM can help support, then it must encourage its stakeholders to look beyond the barriers and seek the benefits that it can bring to their roles. For the purpose of this research the benefits and barriers to the role of the QS and its business will be considered in depth in sections 2.8.3 and 2.8.4.

2.8. BIM and the QS

2.8.1. Why now?

The UK Government adoption of BIM to support the achievement of its *Construction Strategy 2011* and more recently its 2025 construction targets, is impacting the work practices of project stakeholders. The UK Governments Level 2 BIM mandate is pushing stakeholders to adopt BIM technologies and processes on all publicly procured projects. The QS as a construction stakeholder is also seeing a change to its working practices as organisations move towards BIM Level 2. The UK Government Building Information Modelling (BIM) Strategy paper for the Construction Industry Council (CIC) meeting (BIS, 2011), states that Level 2 may utilise 4D programme data and 5D cost elements and that quantity surveyors as cost managers should be familiar with BIM, and actively develop ways in which processes can be made more cost effective and add value.

Cost management is an essential element within large construction projects, especially when project cost is an important criterion. Quantity surveyors are responsible for this function, yet, a recent survey undertaken by the RICS in 2011, revealed that only 10% of quantity surveyors regularly use BIM, 29% have limited engagement, but more ominously, 61% of QS firms had no engagement (BCIS, 2011). Furthermore, the survey purported that QS's were utilising BIM predominantly for construction scheduling and to a lesser degree to calculate quantities. These results suggesting that the QS was not fully embracing BIM at a time when the UK Government was pushing for its adoption. Rather worryingly it claimed that only 4% of QS firms regularly invest in BIM training and only 10% were actively assessing BIM tools for potential adoption (BCIS, 2011). Although, Smith (2014) claims that the development of 5D capabilities is gaining momentum as cutting edge cost management firms recognise the competitive advantages it offers and are now implementing BIM in this role. Performing value engineering and cost estimation from the beginning of the design process with the potential to enable a faster and more cost-effective project delivery process, higher quality buildings, and increased control and predictability for the owner (Forgues et al, 2012)

2.8.2. The evolving role of the QS and BIM.

In 1971 the RICS defined the role of quantity surveyor as being associated with measurement and valuation (Nkado and Meyer 2001). Nowadays this role has diversified to such an extent that the QS must develop a range of knowledge and understanding to satisfy the needs of a plethora of different employers and their roles. Ashworth and Hogg (2007) argued that their skills have been enhanced to meet current needs in relation to cost management of a construction project. However, now with the current UK Government drive towards BIM adoption, the QS must extend and refine their knowledge and understanding to ensure that they possess the necessary skills to apply BIM into cost management in practice. If cost management can be considered as the process of planning and controlling costs throughout the complete duration of a construction project (RICS, 2012), then consideration must be given to how BIM can facilitate this.

The Government Construction Strategy (Cabinet Office, 2011) and the *Report for the Government Construction Client Group Building Information Modelling (BIM) Working Party Strategy Paper* (BIM Task Group, 2011) contained very little information about cost management. The strategy paper stated that for Level 2 compliance, quantities should be taken from the 3D model suggesting BIM automated quantity take-off is required. In comparison to other professional roles there is less clarity as to the impact on the QS as the industry is still being defined and developed in line with Level 2 and 3 principles of BIM (RICS,2014)

Currently, the guidelines (BCIS, 2011) state that Level 2 may utilise 4D programme data and 5D cost elements and that clients should expect QS's to be familiar with BIM and actively develop ways in which processes can be made more cost effective and add value. The UK government may require cost managers to utilise BIM automated quantity take off where possible, but it is not yet a statutory requirement. The *2025 strategy* however refers to the importance of whole life costs in supporting the achievements of its targets. In response to this, the RICS authored a guidance note to inform the QS/cost manager in the performance of their measurement role in a BIM environment and advised the QS to utilise the model data rather than traditional manual measurement in the production of quantities (RICS, 2014).

It follows therefore, that BIM can directly benefit cost management by rapid and accurate automated quantity take-off; facilitating cost planning and Bill of

Quantity(BQ) production. The automated quantity take off also facilitates cost control and analysis, as the building model progresses, and allows easier pricing of alternative design solutions (Klashka, 2006, Eastman et al 2011). Level 3 BIM development will fully incorporate 4D (time and schedule data), 5D (cost data) and 6D (life-cycle data) (BIM Task Group, 2011) and this will assist in fast and accurate calculation of life cycle costing (Azar and Brown, 2009, Jiang, 2011) which increasingly falls under the duties of cost management.

2.8.3. Benefits of 5D BIM

The benefits of BIM to the wider construction industry stakeholders has previously been discussed but what about those specific to the QS. This has been the subject of considerable debate over the years resulting in a plethora of literature deliberating the benefits of BIM to the QS; including: Popov et al, 2008; Boon, 2009, Matipa et al; 2010, Olatinji et al, 2010; Shen and Issa, 2010; Byland and Magnusson, 2011; Sattineni and Bradford, 2011; Boon and Prigg, 2012; Goucher and Thurairajah, 2013; Stanley and Thurnell, 2014. The benefits brought to the QS role support value creation enabling the QS to spend more time in the application of wisdom and intelligence in order to generate savings and efficiencies and create cost certainty (Mitchell, 2012). This literature identifies five themes in relation to benefit: automated take off, procurement and contractual advice, visualisation and decision making, change management and collaboration: consideration will be given to each in the next section.

Automated quantity take off

One of the advantages to the QS from BIM is the ability for electronic quantity take-off and cost estimating (Eastman et al, 2011). Eastman et al (2008) stated that though most BIM applications allow direct quantity take off, additional 3rd party software is required for cost calculation and allowing linking of quantities to cost databases. Haque and Mishra (2007) suggest at Level 3 BIM, cost estimating can be carried out through the 5D function, by linking the model to an estimating database as supported by Aranda-Mena et al (2008) who suggest Building Cost Information Service (BCIS) could be adopted. Software currently used by the QS for 5D BIM include Vico, Buildsoft, Autodesk Revit, Glodon and CostX. 5D BIM can provide a high level of cost detail which can be useful in the early design stages, and certain software providers are now making it possible to develop detailed cost plans by live linking the model to a 5D cost library (Thurairajah and Goucher,2013).

Automated take off can accurately and rapidly generate a range of essential estimating information, such as material quantities, costs, size and area estimates, which can automatically be updated as changes are made to the project, allowing the QS to be more productive. In a BIM model, cost data can be added to each object enabling the model to automatically calculate an estimate of material costs. This provides a valuable tool for designers, enabling them to conduct value engineering. However, it should be noted that overall project pricing would still require the expertise of a cost estimator. Furthermore, cost can depend upon additional project specific conditions such as working space, requiring specific skills of a cost manager or estimator (Roginski, 2011).

As a consequence of the automatic generation of quantities from the BIM model objects, more efficient preliminary estimates and more efficient detailed elemental cost plans should be produced. A further benefit of automatic quantification is such that human error and inaccurate assumptions made during measurement will be eliminated. Automatic quantities generation reduces the risk of human error and increases the accuracy of estimates when there is insufficient time for detailed measures. Hannon (2007) further argues that this will increase efficiency as manual quantification can take 50% – 80% of the overall time taken to estimate costs. Estimators with BIM capability benefiting from the 5D BIM function and automatic quantification can therefore produce estimates faster than those that do not (McCuen, 2008). 5D BIM being more effective than that of the traditional 2D estimating methods, especially with the reduction of errors and time taken (Shen and Issa, 2010).

The cost manager in a 5D environment is custodial of the cost data and quantities. As this data is integrally linked to the live BIM model the cost manager is capable of simulating and exploring, in real time, numerous design and construction scenarios for the client. Muzvimwe (2011) considers this service has the potential to increase the value of the cost management service but that this is reliant on the cost manager having the appropriate BIM capability, is sharing their cost data in the model and has the experience, expertise and perception to analyse and critique the information that is being generated by the model. Mitchell (2012) supports this claim and encourages cost managers to become key players in the BIM environment and embrace the 5th dimension and take on the role of 5D Cost Manager.

Procurement and contractual advice

Procurement and contractual advice also fall within the boundaries of cost management as the procurement strategy and risk allocation can have a great effect upon the cost and success of a project. There is a clear link between BIM and the ability to reduce risk on projects as detection is developed at an earlier stage than with traditional approaches. The importance of identifying risks early on in a project is considered as an essential component to a project's success. The use of BIM to reduce risk is supported by Boon (2009) identifying that the QS is able to analyse risk earlier and develop alternative construction options if BIM is adopted.

Furthermore, by finding problems early, it may be possible to save both time and money. Thurairajah and Goucher (2013), agree that clash detection is a key benefit of BIM for cost consultants as they will be collaborating earlier on in the design process thereby increasing the potential for more effective optioneering and value creation. There are documented examples that BIM can reduce overall project costs by between 5% and 10%, though the actual saving depends on the specifics of each project and the level of BIM integration (Eastman et al, 2011, Lane, 2012). This could be considered another enabler for cost management: by formalising a procurement strategy that integrates BIM (and the associated cost advantages), a cost manager will provide the client with better value for money which may ultimately increase the value of their service. If therefore it is the QS that undertakes the role of cost manager, then presumably it is the QS who has the potential to take a leading role in the 5D environment to create value.

Visualisation and decision making

The 3D function of BIM improves decision making, reduces inaccurate drawing interpretation and reduces the assumptions the QS needs to make. Samphaongoen (2010) identifies improved visualisation as an asset to the QS enabling them to see and interact with the 3D model, facilitating a better understanding of the project. Through BIM's 3D viewer function, the facility can be viewed in an infinite number of ways, from any angle through the model (Sylvester and Dietrich, 2010). Improved visualization through this should be advantageous to clients, design teams and contractors in fully understanding a project's design (Haque and Mishra, 2007). Cost consultants should therefore have to make fewer assumptions (Thurairajah and Goucher, 2013), and as clients can clearly visualize the options available, it can be a valuable decision making tool, resulting in fewer cost plan revisions.

Change management

Design changes can be more easily and rapidly identified by overlaying previous BIM models with revised BIM models. Olatunji et al (2010) suggest that BIM allows the QS to identify factors that have economic benefit or consequence on various design options in order to select the most suitable and cost efficient proposal. Furthermore, early design advice should lead to increased client satisfaction as they are receiving earlier economic feedback on the alternatives available (Pennanen al., 2011), whilst having a greater understanding of the likely cost influences of design decisions (Deutsch, 2011). Furthermore, BIM supports the QS involvement at an earlier stage in the design than on traditional projects, allowing the design team to produce more design options, which enables the QS "to quickly and efficiently produce advice to the design team and client of the cost of each option in a manner that enables direct comparison to be made” (Boon and Prigg 2012, p.7).

As the design develops through BIM, it is possible to link models with a National Building Standards (NBS) application. This can be used to provide early and reliable specification data, which can be a useful cost management tool (Rider Levett and Bucknall, 2012) as a more accurate specification enables the QS to gain more accurate costs, early on in the design process. The 4D function of BIM can also add additional information, in the form of early construction schedule details (Meadati, 2009), which may not otherwise have been available creating more reliable estimates that more accurately reflect the scope of work.

Collaboration

5D BIM also improves communication and access to information across the project team, enhancing collaboration on projects to support the production of effective models. Popov et al. (2008) assert that the use of 5D for cost modelling encourages collaboration on projects assisting in the management of the project overall. However, in order to achieve effective 5D, designers need to generate suitable 3D information, and this needs to be checked for clashes by the construction team. 5D software also has the ability to check for clash detection, and in this way a collaborative atmosphere is further encouraged (Won et al. 2011). Finally, BIM will purportedly provide opportunities for the QS and clients by streamlining workflows and increasing the quality of cost services (Boon and Prigg 2012).

More recently, Wu et al, (2014), found that the efficiency and accuracy of QS functions significantly improve with 5D BIM. BIM delivers a more efficient operational solution for the QS for cost estimating, with the potential to link the building model to the relevant quantities and cost information allowing for their update to be simultaneous with the design changes. Finally, a summary of the benefits of BIM to the QS as identified by this literature review is shown in Table 2.1.

Table 2-1 Summary of the main benefits of BIM to the QS, review of current literature.

	Harrison & Thurnell, (2014)	Stanley and Thurnall, (2014)	Goucher and Thurairajah (2013)	Sebastian, (2011)	Zhou et al, (2010)	Shen and Isa, (2010)	Sabol (2008)	Haque and Mishra,, (2007).	Popov et al (2006)
Automated quantities - Improves efficiency at budget estimate stage.	x	x			x	x	x	x	x
Automated quantities - Improved efficiency at detailed cost plan stage.	x	x					x	x	x
Automated quantities - Improves efficiency of BoQ.	x								
Automated quantities – frees up QS time to offer other service to client.	x		x		x				x
Automatic quantities generation provides less room for human error.	x								
Increases ability to resolve RFI's in real time.	x	x	x	x				x	x
Improves project visualisation, reducing assumptions.	x	x	x	x		x	x	x	x
Improves accuracy of estimates, model project options before and during construction.	x	x	x			x			
Improves Collaboration.		x	x	x			x	x	x
Improves communication and access to information in the project team	x		x				x	x	x
Improves the quality of the data of the finished project for the end user-lifecycle.		x		x				x	x
Earlier risk identification e.g. clash detection.	x	x	x	x				x	
Provides a commercial advantage over competitors	x		x						

2.8.4. Barriers to 5D BIM

Whilst 5D BIM can undoubtedly offer many advantages to the QS it is not without hindrance. As with the benefits of 5D BIM there has been considerable literature in relation to the barriers to 5D BIM: including: Harrison and Thurnell, 2014; Stanley and Thurnall, 2014; Goucher and Thurairajah, 2013; Olatunji, 2011; Howell and Batcheler, 2012; Sabol,2008; Shen and Isa, 2010; Smith et al 2014 and Zhoui et al, 2010. This literature identifies the following themes in relation to barriers: cultural resistance, inaccurate/incomplete data in the model, incompatibility with current industry recognised elemental formats, incompatibility with current standard method of measurement, legal and contractual and setup costs. Consideration will be given to each in the next section.

Cultural resistance

There is a cultural resistance to change from the traditional QS, and therefore, it is crucial to change the mind-set of staff to embrace and evolve with BIM. The inflexible mind-set of staff is seen by many as a significant inhibitor to major change (Harrison and Thurnell, 2014). Many argue that the uptake of BIM may be attributed to the profession itself purporting that the QS may reject BIM as they feel automation threatens their job (Kennett, 2010, Rendall, 2011). Redundant work practices seem to pose the greatest threat as many QS's are fearful of redundancy. BIM is seen as a potential threat to replace their work in many of the traditional QS functions and as such they are resistant to embrace it (Matthews and Withers, 2011, RICS, 2011, NBS, 2012).

In terms of the QS role, the QS continues to concentrate on 'measurement', 'cost planning' and performing a 'traditional quantification'.(Zhou et al, 2012) as opposed to offering value engineering and lifecycle costing as standard services which create and add value to their role. For some, the move towards 5D BIM may be a bridge too far as Stanley and Thurnell, (2014) suggest that cultural transformation is a much greater challenge than any technological challenge arising from BIM.

Inaccurate/incomplete data in the model

The old adage “rubbish in, rubbish out” can be applied to the application of 5D BIM as the information extracted from the model is only ever as good as that input (Woo, 2007). The extracted quantities in 5D BIM do not allow for an understanding of construction methods and procedures, which in turn, reduces the accuracy of estimates (Shen & Issa, 2010). Furthermore, Boon and Prigg (2012) assert that BIM models currently contain numerous design errors and often have important information missing from them rendering the data incomplete or inaccurate, to effectively support 5D BIM. The necessity therefore to review and check extracted quantities could result in no saving in time over traditional manual take off. QS’s are finding that it is often what is not in the model that is an issue rather than what is in it. The extraction of quantities for preliminary budget estimating is relatively simple, but it is critical that the QS identifies items missing from the model at the time of extraction (Boon and Prigg, 2012). More recently, the RICS (2015) guidance document identifies good practice when producing measurement outputs assisting the QS/cost manager to understand how BIM will impact on their working practices and influence their service delivery.

Incompatibility with current industry recognised elemental formats

There are concerns that the data embedded into the BIM model objects by design consultants is often not compatible with elemental estimating formats or schedules of quantities formats required by the QS. Standardization issues, such as “wording” used to describe 3D objects is not consistent with that required for the same objects in 5D software, presenting problems for the QS when producing pricing documents. (Boon, 2009). Olatunji et al. (2010) assert that BIM, and in particular 5D BIM, requires the collaboration, database integration and commitment of companies to the use of BIM software, and that as these areas are still in a separated and fragmented state, it further limits the effectiveness of 5D BIM. The industry continues to work in “silos” working separately in their own environment, resulting in a separation of the information required for BIM, presenting a major barrier to 5D BIM implementation (Bylund & Magnusson, 2011). In order to support the implementation of 5D BIM there needs to be collaboration across the design team to ensure that the information the designer needs to build the 3D model allows for additional information required by the QS to model costs; a balance needs to be agreed (Boon and Prigg, 2012).

Incompatibility with current standard method of measurements

Matipa et al (2010) suggest that current Standard Methods of Measurement were not developed with 3D models in mind. Similarly, models are often not set up to take into account these standard methods of measurement. For example, allowances for waste, jointing and lapping are not made within the model automatically, as BIM superficially presents automatic quantities, thereby reducing the accuracy of estimates, if measurement is required to be in accordance with these standards. The Royal Institution of Chartered Surveyors (RICS) in the UK have worked with industry to develop new rules of measurement (NRM) to help support and facilitate 5D BIM by simplifying the rules for measurement. However, as the extraction of quantities is extremely complex due to the model containing unreliable information, an expert is often required to analyse the value of the information provided (Monteriro and Martins, 2013).

Interoperability of models

Interoperability is an issue for 5D BIM. In order for the QS to maximise the potential of BIM, there needs to be a seamless sharing of information across all BIM applications and disciplines involved. Interoperability has improved through the creation of IFCs, which via a neutral file format allows for the effective exchange of information between BIM platforms (Grilo and Jardim-Goncalves, 2010). However, many software vendors often run software in proprietary type formats that restrict the exchange of critical building data between multiple organisations, and such incompatibility between the BIM model and estimating platforms is seen as a major barrier to 5D BIM implementation (Olatunji, 2011). The complete interoperability of models is essential to the QS otherwise items may be lost from the model as they are combined and therefore excluded from estimates. In an attempt to overcome this, several information exchanges have signed up to an agreement (Laakso and Kiviniemi, 2012), to reduce these potential risks.

Legal and contractual

The legal and contractual issues relating to BIM projects are still being addressed and create considerable uncertainty for 5D BIM and the QS. Uncertainty as to risk and labilities restrict the potential for full collaboration (Smith, 2014). The uncertainty over legal liability is also creating issues for insurers in the industry, which has obvious implications for the QS providing services on BIM projects. The legal issues such as who has rights to the information contained in the BIM models, who is in charge of the information that is in the model, what happens when there are errors in the model and other responsibilities that relate to the model need to be addressed (Boon, 2009). This creates uncertainty over insurance coverage and may lead to insurance exclusion for BIM projects. The use of BIM for quantity surveying services is too risky as there is no contractual framework governing its use. Klein (2012) concurs, and reports that 'before the full potential of BIM can be released with parties working in collaboration, there needs to be an innovation in contracts and insurances that underwrites stakeholders for financial loss' (p.14). Furthermore, many organisations seem concerned by the impact of market pressures on their business strategy, especially regarding the best way to adapt, simplify, adopt and market certain ICT and practice innovations, within existing industry and legal structures (Olatunji,2010).

Setup costs

The cost of implementing BIM is seen as significant. 63% of Quantity Surveyors agreed that 'BIM is too expensive for us to consider at the moment' with the cost of a BIM workstation including software cost and training estimated at £10,000 per organisation (NBS, 2012). In addition, with approximately 1 in 20 employees requiring extra training to become software 'experts' at an estimated cost of £5,000 per person (Matthews and Withers, 2011), with 40,000 RICS Quantity Surveyors, this could add another bill of at least £10million to the industry (Zhou et al, 2012).

A summary of the barriers to BIM adoption by the QS as identified by a review of the literature are shown in Table 2.2.

Table 2-2 A review of the literature identifying the main barriers to the adoption of BIM by the QS

	Harrison & Thurnell, (2014)	Stanley and Thurnall, (2014)	Goucher and Thurairajah (2013)	Olatunji, (2011)	Howell and Batcheler, (2012)	Sabol,(2008)	Shen and Isa,(2010)	Smith et al (2014)	Zhoui et al, (2010)
BIM data is not compatible with elemental estimating formats.	x					x			
BIM data is not compatible with BQ formats.	x								
BIM data incompatible with current Standard Methods of Measurement.	x	x		x		x		x	
Lack of industry standards/protocols to support estimating	x	x							
Lack of contractual Framework.	x							x	x
Lack of Trust in the quality of the model, quantities reviewed manually.	x						x	x	
Lack of Government lead in setting standards/protocols/coding .	x	x							
Lack of integration in the model decreases the reliability and effectiveness of 5D.		x				x			
Interoperability of the software.	x	x		x	x			x	
The high cost and time associated with training.	x	x	x					x	
Software and hardware upgrades too expensive.	x		x					x	
Initial setup cost inhibits its use.eg software, training and hardware costs.		x							x
Reluctance to change as current software deemed appropriate.		x	x						
Cultural resistance.	x	x						x	
Lack of client demand			x						x
Lack of team experience of BIM							x	x	
Too much information can confuse decision making.	x					x			
QS unwilling to share cost data.								x	
Threat to the survival of the QS role				x					
The fragmented nature of the construction industry limits the potential of BIM.		x							

2.8.5. Value creation services.

Innovation is said to create value. Innovation is something adopted and/or adapted that is new to a person, organisation or industry sector in general (Slaughter, 1998). BIM is innovation in terms of process, technology and service to the QS. BIM can offer innovative solutions to the construction stakeholders. In a 5D BIM environment the QS can focus on adding value to their services as opposed to spending up to 80% of their time measuring quantities (Whatmore, 2012). The modern QS can take the traditional QS role to the next level, utilising models to provide detailed and accurate 5D estimates and real time cost plans (Mitchell, 2012). In terms of life cycle costing BIM offers an opportunity for the QS to deliver further data to the client, as, 5D BIM can provide clients with cost advice for making lifecycle management decisions (Saint, 2012). In addition, cost consultancy firms have reported several alternative service provisions that are possible through the use of BIM, as part of the cost estimating stage; these include value management, capital allowances and risk analysis (Meadati, 2009). More recently, the QS has been developing methodologies for the measurement of embodied carbon in order to offer carbon savings by addressing the embodied carbon, alongside the operational efficiency of a building (UK Green Building Council, 2015).

2.9. Summary

In the current business environment, the construction industry is subject to a diversity of forces that exert major impacts on performance objectives and targets (Liu and Fellows, 2008). Industry report after industry report have set targets and objectives the knock on effect of which is to replicate change in the organisation of the service providers that are responsible for achieving these objectives, not least the QS profession. The role of the QS has seen significant changes from its early days in 1971 and positive reengineering of the industry remains a key priority even to this day (Frei et al, 2013).

Despite the recorded benefits of BIM, there is a wealth of documentation to suggest that Quantity Surveyors within the UK are lagging behind other construction professions, in their BIM uptake (Klashka, 2006, Lane, 2012, BCIS, 2011a). In 2011, the RICS carried out a survey to gauge the use of BIM by its members (BCIS, 2011b). This survey is especially relevant as it targeted quantity surveyors within the UK and received 153 respondents out of approximately 40,000 members. The survey found that only 10% of respondents regularly used BIM with a further 29% recording some BIM engagement. More recently,2016, the NBS conducted a BIM survey with around 1000 responses from different disciplines within the construction industry of which only 3% were quantity surveyors (NBS, 2016). The results of this survey confirmed that 54% were currently utilising BIM.

The potential for BIM to create value for the QS has been identified in this chapter. How organisations establish strategies to manage the change to support this growth, will be discussed in the next chapter.

3. Organisational growth strategies

In order to achieve the optimum benefits of BIM, organisations are required to change their work practices and upskill the project participant (Froese, 2010), with successful BIM implementation being dependent on successful organisational change (Succar, 2009). Furthermore, organisations need to understand the nature of this change, especially how to develop effective borders for surviving with this change, in the light of competition (Olatunji et al, 2010). In order to understand organisational change, it is essential to understand organisational theories that underpin it.

3.1. Organisational theory

Organisational theory is the study of organisations in order to identify patterns and structures that can be adopted by its stakeholders, in order to solve problems, maximise efficiency and improve productivity. There are many different ideas and concepts on how to manage or operate an organisation. Mutti and Hughes, (2001) argue that that research into organisational theory has changed fundamentally, with a shift in emphasis from structure to culture. It is important for the success of the organisation that employees identify with its culture, because it is the only way for their involvement with the company to occur (Goldsmith and Clutterbuck, 1985). Employees that can relate to the organisations vision are more likely to respond positively to change. Furthermore, despite the endless research in this field and an improved understanding of how organisations work, firms continue to fail, often by simply failing to apply what has been learnt. Construction companies are known to be uncertain and risky environments, good management practice is needed in order to maintain the characteristics required for success (Mutti and Hughes, 2001).

If innovation is essential to organisational success, and BIM is seen as innovation, then the implementation of BIM must be managed. More especially, if an organisation’s capacity to innovate, depends upon the knowledge and expertise of its staff, then how the organisation manages itself to acquire, store and transfer that knowledge must be considered and the critical success factors prerequisite, to support this, must be identified.

3.2. Critical success factors(CSF's)

CSFs are an area of management that demand continuous and vigilant attention, as the identification and careful consideration of critical success factors (CSF), can positively influence a project (Tsiga et al, 2016). CSF's are specific areas of a business that, if satisfactory, will support the competitive performance of the organisation (Rockart,1982). In the early 1980's, McKinsey's 7S model was developed, by Tom Peters and Robert Waterman, at the McKensey and Company consultants, as a tool to analyse organisational design. The alignment of 7 internal factors: strategy, structure, systems, shared values, style, staff and skills; were identified as being critical to the success of the organisation.

Each industry has its own CSF or performance areas which requires attention. (Tsiga et al, 2016) There has been extensive research in relation to the CSF' to the construction industry (Toor and Ogunlana, 2009, Malach-Pines et al,2009), but only recently has there been some attempt to identify them in relation to the QS firm. Frie and Mbachu, (2013) identified 7 critical success factors for quantity surveying firms which are: professional attributes, firm profile, people, market positioning, service performance, practice management and processes as illustrated in Figure 3.1. In addition, Frei and Mbachu identified that the development of CSF's would include consideration to the following themes:

- IT proficiency and development
- Knowledge management
- Adaptability and strategic management
- Flexibility of service delivery
- Interpersonal skills
- Global Reach
- Suitable organisational structure

- Negotiation and commercial management
- Strategic marketing

Figure 3-1 CSF's for QS firm

Frei and Mbachu(2013), p 16

3.3. Organisational Learning

Knowledge management is an enabler of innovation (Maqsood and Finegan, 2009) Walker, (2016) argues that many construction industry academics, researchers and practitioners now view knowledge differently with much of the research focusing on reflective practice, knowledge management and organisational learning. There are no definitive definitions of organisational learning. They range from aspirational type definitions of organisations to normative definitions. (Davis et al , 2007). A post-modernist viewpoint held by is

> *"where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free and where people are*

continually learning how to learn together" (Senge, 2006, p.1)

In contrast, normative definitions promote *"learning organisations as an organisation skilled at creating, acquiring and transferring knowledge, and at modifying its behaviour to reflect new knowledge and insights."* (Garvin, 1993, p.79). The process of organisational learning is cyclical as individuals' actions lead to organisational interactions with the environment, and outcomes are interpreted by individuals who learn by updating their beliefs about cause-effect relationships (Lee, Courtney, and O'Keefe 1992). The organisational learning occurring when individual members of the organisation act as learning agents for the organisation, and embed the results of their inquiry in private images and shared maps of the organisation (Agyris and Schon, 1978).

De Geus (1988) observes that an organisation's ability to survive depends on institutional learning, which is the process whereby management teams change their shared mental models of their company, their markets, and their competitors. Furthermore, the rate at which organisational learning takes place can be linked to growth, competitive advantage and organisational survival (Stata,1989). These benefits generate strategic results at an organisational level and provide advantages, which improve the organisational competitive positioning (Inocencia, 2011).

As society moves to a more knowledge based society it creates increasing demands on an organisation's ability to transform information into knowledge (Lindgren and Wallstron 2000, Armistead et al, 2000, Hislop et al. 2000). Organisations need to learn more in the face of escalating competition, developments in new technology and changes in industry and customer needs. The learning organisation must employ people who are skilled at creating, acquiring and transferring knowledge. In turn, this will cultivate tolerance, foster open discussion and enable holistic and systemic thinking enabling the organisation to respond to the unpredictable more quickly than their competitors. In order to create a successful learning environment, Garvin et al (2008), suggest that there are 3 building blocks to a learning organisations: a supportive learning environment, concrete learning processes and practices, and leadership behaviour that reinforces learning. Each block, whilst vital to the whole, is independent and can be measured separately, suggesting that, whilst one block can have influence on the other, each block is significant in itself. However, how can these blocks be supported? Can the organisational structure provide support?

3.4. Organisational structure

Organisations can be defined as clusters of individuals working together employing various technologies and co-operating together in order to achieve tasks, which would otherwise not be possible (Watson, 1994). It is the interaction between these individuals within an organisation that dictate its structure (Mutti and Hughes, 2001). Bennis, (1996) meanwhile considers organisations as social systems which are self-organising and comprise diverse people with diverse and variable interests. Structure has come to signify the patterned relations of components which make up any system. It is a framework on which different interconnected components are attached, thus, it is impossible to amend organisational structure without affecting the organisation itself (Fineman et al., 2009).

The relationship between the environment and organisational structure is especially important. “Organisations are open systems and depend on their environment for support, selecting their environments from a range of alternatives” (Starbuck, 1976, p. 1069). When a change is threatening the industry, organisations need to be able to respond to their environment and accept change, in order to move the business forward. Scholes and Johnson, (2002) concluded that organisations have been traditionally geared towards stability rather than characterised by change, as a consequence of their hierarchical and bureaucratic structures, rendering them ill equipped to face the challenges of the 21st century.

Organisational structure reflects the way in which information and knowledge is distributed within an organisation and, consequently, it substantially influences the distribution and coordination of the company's resources, the communication processes and the social interaction between organisational members (Chen and Huang, 2007). A good communication flow also plays an important role in decision making, which is an important determinant of the success of an organisation (Goldsmith and Clutterbuck, 1985). Therefore, the organisational structure influences the ability of the company to adapt to change, to learn, to innovate and to improve its ability to generate added value for its customers (Inocencia, 2011).

There are a number of ways of positioning relationships to support communication and decision making that make up an organisational structure. These include structures based on geographical or product based divisions, others in functional areas and others form matrix structures (Jones et al, 2003; Bryman,1986). In a functional organisation structure, tasks are linked together on the basis of common functions. This approach is mainly suited to relatively stable environments (Jones et al., 2003). Large organisations offering a wide range of products or service favour the product-based structure (Fineman et al., 2009). Where organisations are national or multinational a geographic structure may be adopted to support decision making and control (Cole,2003). Finally, a matrix structure may be adopted for highly complex industries where the other options are not deemed appropriate (Cole, 2003). However contingency theorists argue that no single structure is appropriate in all circumstances (Bryman, 1986). Furthermore, structures can be formal, informal, rigid or flexible. It is argued that in uncertain and turbulent environments organisations must adopt an extremely fluid task-oriented structure (Jones et al., 2003).

Whilst there is much discussion around whether organisational structure determines organisational learning, or if organisational structure is an outcome of organisational learning, many argue that organisational structure plays a crucial role in determining learning processes (Fiol and Lyles, 1985; Dodgson, 1993; Bapuji and Crossan, 2004). The learning process requires information and the organisational structure channels the information flow, managing its direction and distribution. The characteristics of organisational structure is also acknowledged as being key in influencing company productivity and innovation (Germain, 1996). According to Fiol and Lyles (1985), centralised and decentralised decision-making structures have very different impacts on the organisation's learning ability. However, a more recent study observed that large companies do not generate additional organisational learning if they have a specific organisational structure, be it either organic or mechanistic (Inocencia, 2011).

BIM is essentially concerned with utilising technology, skills and knowledge in a collaborative way to inform the decision making process pre, post and after construction. The effective transfer of communication is therefore essential to the success of organisations offering BIM. Nicholas, (1994) explained, that the traditional hierarchical and functional structures have to be overshadowed by more flatter, cross-functional ones for the purpose of enhancing communication and integration. BIM communication also takes place by adopting technology to share data within a common data environment. The appropriateness of any proposed BIM organisational structure therefore needs to be complemented by collaborative BIM technological tools and related innovation process – a repository for composite model creation, coordination and information sharing, by all team members and is based on the project activities (Sackey et al., 2014). The organisation structure therefore should benefit communication, decision making, detailed design coordination, and functionality assessment (Kamara et al., 2002).

Finally, common theoretical frameworks emphasise the importance of an appropriate structure to the successful implementation of innovation in organisations (Slaughter, 1998). Where structural and procedural obstacles are removed, actors have skills necessary to apply the innovation and have incentives to implement innovation which is more likely to be effectively implemented (Klein and Knight 2005).

3.5. Organisational birth and growth

Innovation is considered as one of the most pressing constituents of the competitive advantage of organisations (Porter, 1998). Goyal and Pitt (2007) considered innovation as essential for the very survival of the organisation. The construction industry, its product and its services are complex and subject to both internal and external financial pressures. Innovation as a process is therefore vital for the construction industry to advance and deliver the aspired change agenda (Elmualim and Gilder, 2014) and create the desired efficiencies. However, innovation, as a practice in the construction industry, has been characterised as important, but ill-defined as a concept (Sundbo, 1997) although incremental process innovations are common and highly regarded for cultural change.

If BIM is to be considered as innovation then the impact that it has on the organisation must be considered in relation to its growth. Cameron and Whetten (1983) considered the lifecycle of an organisation and recognised four stages in its growth. Entrepreneurial, being the first stage categorised by early innovation, niche formation and high creativity. Collectivity follows on from this and is distinct in that it recognises extraordinary cohesion and commitment among the participants. The next stage is one of formalisation and control, with the aim of stability, with the final stage being that of elaboration, characterised by expansion and decentralisation.

In contrast, Land and Jarman (1992) considered organisations as developing in 3 phases; birth, growth, and maturity. Organisational growth is where the entrepreneur via trial and error applies innovation to support its survival in the market place and to grow its business. The evolution to the third phase is often difficult and fatal as the organisation standardises processes and procedures in order to support its operation. The organisation needs to continue its core business, whilst simultaneously attracting new, thereby allowing new innovations previously denied entry to the organisation to become a part of the system. As a result, the organisation must do things differently and also do different things. (Land and Jarman, 1992). The entrepreneurial environment (of inventing business) is incompatible with the controlling environment of the core business and if the aim is to integrate new inventions/ activities within the main stream business then the core business must be changed by the inventions it embraces, resulting in a newly formed organisation. The greatest challenge facing today's organisations is the transition from phase two to phase three (Walonick, 2008).

But what of the factors that contribute to organisational growth? Child and Kieser, (1981) identify other factors that contribute to organisational growth. The first is that growth is a by-product of another successful strategy. The second is that growth is deliberately sought because it facilitates management goals. The third factor is that growth makes an organisation less vulnerable to impacts from the environment as larger organisations tend to be more stable and less likely to go out of business (Caves, 1970; Marris and Wood, 1971). As organisations grow, resources increase, thus improving the security of the organisation.

Child and Kieser (1981) identified four distinct operational models for organisational growth (Walonick, 2008). Growth can occur as a result of dominating its field of operation, with growth stemming from its existing business. Or conversely growth can result from diversification into new fields providing new markets. They suggest that new developments in technology could also stimulate growth by providing more effective methods of production. Finally, they proffer by improving management practices this too will facilitate growth by enabling a more supportive atmosphere capable of promoting growth.

More recently, theorists have considered the health of organisations as an indicator of an organisations ability to grow, with, the health of each subsystem purported to impact on the organisations overall effectiveness (Hill, 2003). DeSmet et al, (2007), identified nine core management components which would positively impact on the health of organisations, particularly in relation to monetary growth. These included: leadership, direction, environment, values, accountability, coordination and control, capabilities, motivation, external orientation and innovation. The selection of strategies for organisational improvement being at the discretion of practitioners through comparison with other organisations (Frei et al, 2013). Whatever strategy is adopted to consider the health of an organisation, the aim is to diagnose an organisation's relative level of strategic heath and identify the key areas that need treatment. Frei et al (2013) developed a framework of key variables for the QS organisation to achieve sustainable growth and viability. They identified the critical success factors (CSFs) of the QS profession as process, practice management, service performance, market positioning, people, firm profile and professional attributes. In addition, they articulated four contributors to the threats and opportunities of the QS profession: market/competition, capability/capacity, recognition/relevance, and information/communication/technology. Furthermore, they identified the source of opportunities as being from involvement in newly identified or emerging markets and expansion in, or penetration of, existing markets. A healthy organisation being defined as one which can withstand the impact of its operating environment and anticipate and adapt to change (Frei et al, 2013).

However, Whetten (1987) argued it is difficult to establish cause and effect in these models. Do technological advancements stimulate growth, or does growth stimulate the development of technological breakthroughs? Which comes first? If it is to be believed that BIM is an innovation in the construction industry, then is adoption a consequence of the need for business growth or did adoption bring about business growth? Conversely can it be therefore said that organisations that do not adopt BIM go into decline, as to innovate is to survive. The QS profession requires urgent and far reaching strategic transformation if it is to survive and remain relevant (Frei and Mbachu, 2009) particularly as it relates to digital transformation and BIM.

3.6. Organisational Decline

The QS profession, it is argued, must evolve and respond to the changes in the global business environment as it is not impregnable to these changes, which threaten its very existence (Frei et al, 2013). Nevertheless, the need for the QS to be at the forefront of this change has been subject to much debate (Smith, 2004; Harun and Abdullah, 2006; Davis et al,2007). Nonetheless the QS response to BIM has been slow, leading “many observers to predict, and many within the profession to fear, that quantity surveying might disappear as a formal profession” (Ofari and Toor, 2009, p.39).

Is BIM going to instigate the decline of the QS? Traditionally, most theories appertaining to organisation development regard decline as a symptom of ineffective performance where organisational growth is an indicator of successful management. Implicit in these theories is the idea that organisational growth is synonymous with expansion. In the 1980's, as new management strategies were adopted by organisations to reduce costs and consolidate operations, organisational decline became a focus for consideration. However, there was no clear definition of organisational decline other than it centred on a reduction in profit or budget. Decline was considered by many to have a negative impact on individuals, diminishing morale and innovativeness, and on the organisation as a whole, by impacting on leader influence and long-term planning. In addition, decline was associated with, conflict, secrecy, rigidity, centralisation, formalisation, scapegoating, and conservatism (Cameron et al, 1987). Others characterised organisational decline to over-confidence by the organisation in its ability to prosper, leading to an apathetic attitude towards new innovations, quality, and customer satisfaction. (Nystrom and Starbuck (1984).

Whetton (1987) argued, however, that it was an increase in organisational size that promoted decline, the larger the organisation, the less flexible it becomes, particularly in its response to changes in environmental influences. Or perhaps organisations have a “shelf life”. Wilson (1980) related the biological life-cycle model to organisations de-development, identifying two different categories of organisational decline referring to them as "k" and ""r" extinction. “K” extinction is as a response to external factors, as each organisation has a macro niche that shrinks in size as a consequence of a reduction in the supply of its environmental resources or as a consequence of other organisations competing for these limited resources. Internal factors are the cause of “r” extinction causing an organisation to decline without reaching its maximum potential, usually as a result of bad management or a failure to remain competitive. The QS organisation is susceptible to external influences, the external business environment and also internal influences in terms of its BIM implementation strategy. Is it the combination of the “k” and “r” extinction factors as they appertain to the QS organisation that affect organisation decline or maybe growth cannot continue indefinitely and the QS organisation has maximised its growth potential? Therefore, BIM does not have the potential to continue to bring growth to the business as growth cannot continue infinitum. Land and Jarman, (1992) identify possible causes as to why organisations reach upper growth limits, which include: market divisions; internal competition for resources; increasing cost of manufacturing and sales; diminishing returns; declining share of the market; decreasing productivity gains; growing external pressures from regulators and influence groups; increasing impact of new technologies; new and unexpected competitors.

As BIM proliferates the industry and QS organisations are pushed into adopting BIM, consideration must be given to the ability of BIM to promote growth. The QS organisation must employ a survival strategy capable of offering sustained growth to the organisation whilst simultaneously managing the organisational change required to support it.

3.7. Change Management

Change management has been defined as “the process of continually renewing an organisation’s direction, structure, and capabilities to serve the ever-changing needs of external and internal customers” (Moran and Brightman, 2001, p 111). The object of organisational change being to move from its existing position to a more appropriate one (Ragsdell, 2000). With change, comes opportunity, but it must be anticipated, prepared for, and managed (European Commission, 1998). The cost of failing to respond to new opportunities, processes, or technologies can result in economic loss to the organisation (Cannon, 1994). In today's complex, global environment change is an ever present feature of organisational life (Burnes, 2004). Whilst the definitions of organisational change are many and varied, change can be characterised as:

- the rate of occurrence: incremental, continuous and discontinuous,
- how it comes about: planned, emergent, contingency and choice
- by scale: fine tuning, incremental adjustment, modular transformation and corporate transformation (Todnem, 2005).

Whichever method is selected by the organisation, change must be managed effectively, if the organisation is to survive and succeed in the current fast moving economy (Begat et al 2015). Research suggests that there is an excessively high failure rate sometimes as high as 80% (Bryant 1998; Burnes 2004; Styhre 2002; Zairi et al. 1994). The plethora of contradictory and confusing strategies and approaches in this field do not provide consensus, as to the most appropriate way, to manage change. Burnes, (2005) argues that ultimately this lack of a valid framework, could in itself be responsible for the high failure rate associated with organisational change.

Change is triggered by internal or external factors (Begat et al 2015). External change, is change that occurs outside of the organisations boundary of control, often as a consequence of factors in relation to macroeconomics, technological advances, globalisation and legislation. Burnes, (2005) argues that organisations need to be aware of these external factors and be prepared, as to be reactionary, reduces the window of opportunity, and may even impact organisational survival. In contrast internal change provides organisations with a much greater degree of control, in terms of organisational objectives and strategies, therefore enabling a more proactive approach (Burnes, 2005).

Although there are many different approaches to organisational change and many ways of categorising, there does appear to be some consensus, in that, all organisations are currently facing unparalleled levels of change. Concluding that the ability to manage change should be a core organisational competence. (Brown and Eisenhardt 1997; Cooper and Jackson 1997; Dawson 2003; Dunphy et al. 2003; Scholes and Johnson 2002). Therefore, all organisations need to recognise the importance of identifying where they need to be in the future, and identify the change required to support it on its journey (Todnem, 2005).

3.8. Summary

There is an abundance of literature in relation to organisational survival, change and knowledge management including: acceptance of change (Starbuck,1976); new and expansive patterns of thinking(Senge,1990), institutional learning (Geus, 1988); knowledge management (Inocencia,2011); creating a supportive open learning environment (Garvin,2008); organisational structure and communication (Chen and Huang, 2007) ; change management (Cameron and Whetton, 1983, Beget et al, 2015, Burnes, 2005, 2005 and Todnem 2005); organisation growth (Land and Jarman, 1992, Caves,1970,Marris and Wood, 1971, Singh, 1971); organisational culture and communication (Goldsmith and Clutterbuck 1985); organisational learning(Garvin, 1933): organisational decline(Cameron, Whetton and Kim, 1987, Nystom and Starbuck,1983, Wilson 1980).

More recently, Succar (2015) argued that insufficient research has been conducted to date to ascertain the conceptual structures that would support BIM adoption, and that both BIM implementation and BIM diffusion, are yet to be reliably assessed at the market level. The following chapter will consider the use of frameworks as applied to BIM in order to inform the development of the value creation framework for this research.

4. The use of frameworks in the context of BIM

The literature thus far has provided a general understanding of BIM, the implications for the QS and reviewed the theories that underpin organisational growth and survival. Consideration must now be given to the BIM frameworks that exists to provide theoretical and practical guidance for BIM implementation. BIM frameworks and tools inspire parallel innovative and evolutionary changes from individuals and groups, through organisations and project teams and across industries and whole markets (Succar, 2009, first cited in Underwood and Isikdag (2010).

The issues around BIM implementation continue to proliferate as organisations and national bodies recognise its potential for adding and creating value. Much of the focus of the literature is on BIM development, implementation and frameworks which include: Macro- BIM adoption: Conceptual structures Succar and Kassem (2015), Building Information Modelling: applications and practices (Kaseem et al, 2015), An integrated approach to BIM competency assessment, acquisition and application (Succar et al, 2013) Building Information modelling implementation plans a comparative analysis (Ahmad et al, 2012), The project benefits of BIM (Bryde et al., 2013); Roadmap for BIM Implementation (Khosrowshahi, and Arayici, 2012); BIM proven tools, methods and workflows (Hardin, 2009); BIM A strategic implementation guide (Smith and Tardif, 2012); Building Information modelling framework for practical implementation (Jung and Joo,2011); BIM standard framework and guide (Richards, 2010); The business value of BIM (Young et al., 2009); Building information modelling framework: A research and delivery foundation for industry stakeholders (Succar,2009), Successful sustainable design with BIM (Krygiel and Nies,2008). An overview of several of these frameworks will be provided in the subsequent section.

4.1. What is a framework?

By definition a framework is a particular set of rules, ideas or beliefs which are used in order to deal with problems or to decide what to do (Collins, 2016). It is a skeleton of interlinked items, which supports a particular approach towards a definite objective which can be adapted to fit reality if required. Minskey (1975) explained a framework as a network of nodes and relations. Frameworks display “the gestalt, the structure, the anatomy or the morphology of a field of knowledge or the links between seemingly disparate fields or sub-disciplines” (Reisman, 1994, p. 92). A framework usually denotes a structure, overview, outline, system or plan consisting of various descriptive categories, e.g. concepts, constructs or variables, and the relations between them that are presumed to account for a phenomenon (Sabatier, 2007) Frameworks do not provide explanations; they only describe empirical phenomena by fitting them into a set of categories (Frankfort and Nachmias, 1992) . The purpose of creating a framework being to direct research and enrich communications with a shared understanding, by integrating relevant concepts into a descriptive or predictive model (Naumann, 1986).

4.2. BIM frameworks?

A BIM framework should be all-inclusive and address all relevant BIM issues whilst at the same time present key issues in a systematic manner (Jung and Joo, 2011). BIM frameworks in the main, focus on change, as BIM itself generates change (Watson 2010).

4.2.1. BIM fields, stages and lenses

Succar (2009) attempts to understand this change by examining how BIM can influence, and is influenced, by associated actors and developed a framework, which presents BIM in a multidimensional setting; relating BIM not only to technological aspects but also organisational. The study further argues that there is a need for a systematically defined framework that goes beyond understanding enquiry and organisation. It is important therefore that BIM is categorised and segregated in a manner that supports not only academic enquiry but also industrialist application. He suggested that the BIM framework most appropriate to satisfy the needs of both parties would be a multi-dimensional framework represented by a tri axial knowledge model comprising:

- BIM fields
- BIM Stages
- BIM Lenses

These include three interconnecting fields of Technology, Process and Policy each with “players” that support the “deliverables” required in each field. Knowledge is transferred between each field at the various stages through the life of the project, with a series of “steps” leading to the completion of a stage. The third dimension of Succar’s framework is the application of BIM lenses to enable the researcher to focus on any/one aspect of the industry, from which the intention is to generate knowledge.

4.2.2. BIM maturity

Furthermore, Succar (2009) describes BIM in terms of “maturity” claiming the higher the BIM implementation maturity the greater the changes required to the organisations business processes and work flow practices, contending that, it is not just individual actors that will be impacted. Consequently, at higher levels of BIM implementation inter-organisational teamwork will be in focus, demanding changes collectively between disciplines (Succar 2009). However, as firms become more experienced with BIM, their maturity heightens and they become more willing to share models within the project network (Taylor and Bernstein 2009).

4.2.3. BIM and practical implementation

Jung and Joo (2010) developed a BIM framework for practical implementation with the aim of identifying driving factors for the practical BIM effectiveness. They identified six major variables which they then grouped into three dimensions, BIM technology, BIM perspective and construction business functions.

Furthermore, they describe BIM implementation to be at three levels;

industry, organisational and project. Generic BIM standards are developed at the industry level whilst at the organisational and project level standards are specific depending on their purpose and the strategic direction of the business. Practical BIM implementation effectively therefore incorporates BIM technologies in terms of property, relation, standards, and utilisation across different construction business functions at project, organisation, and industry levels (Jung and Joo, 2010).

This research considered the impact of BIM implementation at organisational level and the QS organisation is taken to be any organisation that offers quantity surveying services, bringing together the CQS and COQS reflecting the most recent view of the RICS, 2015. The QS organisation is a construction industry stakeholder and the services it provides at project level range from investment appraisal to cost modelling and as such this framework can be applied to the QS functions at all 3 levels, project, organisation and industry as identified in Figure 4.1.

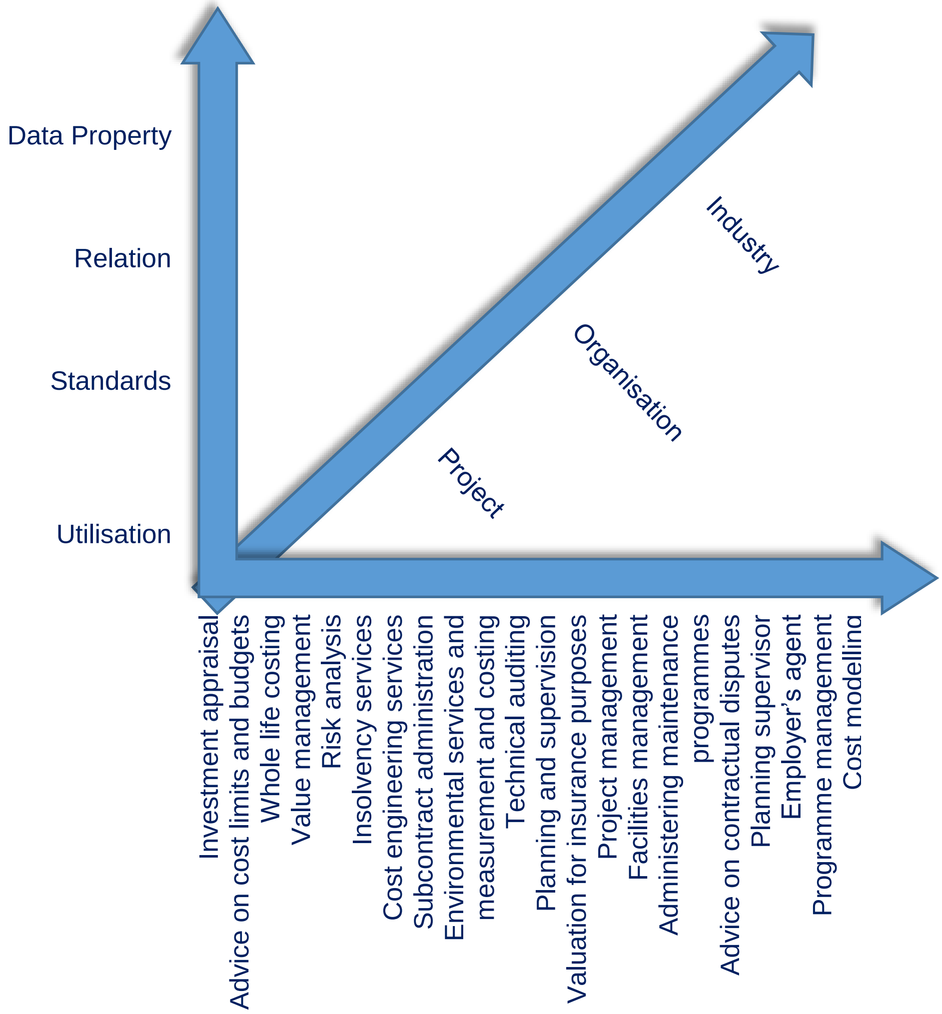


Figure 4-1 Framework for practical implementation by the QS organisation.

Source: Adapted from, Jung and Joo, (2010).

4.2.4. BIM readiness, capability and maturity

More recently Kaseem et al, (2015) considered the three implementation phases, readiness, capability and maturity and introduced the Point of Adoption (PoA), where organisational readiness transforms into organisational capability/maturity.

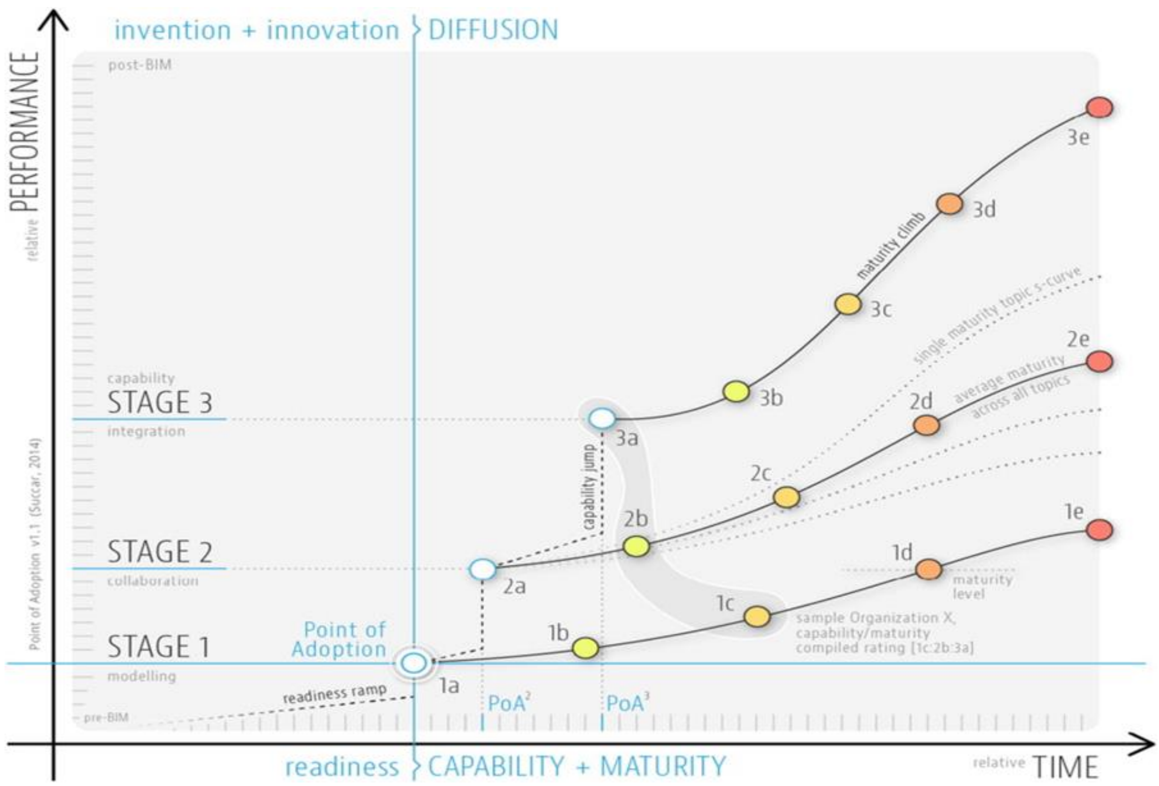


Figure 4-2 Point of adoption model v1.1

Source: Kaseem et al (2015).

As illustrated in Figure 4.2, readiness is the period that the organisation uses to plan for BIM, the POA is when the organisation adopts object-based modelling tools and workflows. The organisation moves from no BIM abilities to minimum BIM capabilities (Stage 1). As the organisation interacts with other adopters and engages in model-based collaboration it moves to Stage 2 and marks the next POA. Finally, the last POA (Stage 3), occurs when the organisation adopts integrated, network-based tools, processes and protocols to collaborate with several stakeholders across the supply chain. Kaseem et al (2015) refer to the movement from one stage to the next as capability jumps. In order to jump to the next stage(POA) the organisation must make considerable investment in both human and physical resources, the return from this investment in the next stage being new organisational capabilities and deliverables.

If these stages can be considered similar to the BIM levels previously discussed by Bews and Richards (2008), it might be reasonable to assume if an organisation considers itself to be working at BIM Level 1 then it has reached Stage 1 (POA1), BIM Level 2 then it has reached Stage 2 (POA2), and BIM Level 3 then it has reached Stage 3 (POA3) as denoted by Kaseem et al, (2015). Each organisation comprises sub organisations (project teams) and project teams comprise different individuals with different skill sets and maybe different physical resources. Therefore, different project teams within one organisation will have different capabilities. Hence, Kaseem et al (2015) argue that each sub organisation could be at different stages simultaneously. One project team therefore could be at the readiness stage and preparing for BIM, one project team could be implementing a BIM system/process, and another project team could be continually improving its performance and moving up the maturity scale. It is possible therefore that a QS organisation can have different project teams with different capabilities working at different stages and levels of BIM. In order to make these capability jumps, considerable investment would need to have been made initially in order to improve the performance of the organisation in relation its BIM deliverables (Kaseem et al, 2015). The QS organisation must identify what its capabilities are within the organisation and identify a strategy for implementation based on this.

4.2.5. Normative" and activity-theoretical /evolutionary frameworks

More recently Miettininen and Paavola (2014) developed two frameworks for understanding and implementing BIM, "normative" and the "activity-theoretical /evolutionary frameworks", the normative approach being characterised by the need to create efficiencies and economies in technological systems. Succar's maturity models are representative of such frameworks. The activity –theoretical model/evolutionary is not widely adopted in BIM literature as it relates to cultural historical – activity theory, science technology and organisational studies and the evolutionary economics of innovation (Arthur 2009, Ziman 2000, Miettinen 2009). Common themes in these traditions are the unknowns of technology, a focus on tools, the importance of continuous learning and studying local activity. However, Miettininen and Paavola, (2014), argue that cultural historical activity theory can be applied to BIM as it relates to learning at work, development of information systems, study of innovations and design collaboration.

4.3. Gap in the literature

Consideration has previously been given to the BIM maturity levels (Bews and Richards, 2008) and level of maturity (Succar, 2009) but what about the maturity of the organisation itself? As QS organisations start to adopt BIM they move from the chaos and uncertainty of the entrepreneurial stage of birth, through to growth and finally to the more controlling stage of maturity (Land and Jarman 1992). Each of these stages brings with it organisational change until, finally, it is typified by expansion and decentralisation. Will this expansion be in the maintenance of the QS existing business or will it attract new business associated with its adoption of BIM? Or will the business be the same but with different BIM processes? Is the intention of QS organisations to dominate their field or is it to diversify and enter into new markets, for example, carbon and asset management? These are questions that currently the literature does not address.

In addition, investigations into BIM implementation across specific individual markets have been comparatively rare in spite of an ever-increasing range and depth of national BIM initiatives and noteworthy BIM publications (Succar et al, 2015). BIM and the QS organisation has been the subject of little investigation with much of the research around estimating, the QS function application of software until more recently critical success factors for the QS firm (Frei et al, 2015). It is this later research that inspires this investigation to consider the opportunities offered by BIM that can create value to the QS organisation.

There is an abundance of literature in relation to organisational growth and survival, organisational change and knowledge management including:

acceptance of change (Starbuck,1976); new and expansive patterns of thinking(Senge,1990), institutional learning (Geus, 1988); knowledge management (Inocencia,2011); creating a supportive open learning environment (Garvin,2008); organisational structure and communication (Chen and Huang, 2007) ; business change (Cameron and Whetton, 1983); organisation growth (Land and Jarman, 1992, Caves,1970,Marris and Wood, 1971, Singh, 1971); organisational culture and communication (Goldsmith and Clutterbuck 1985); organisational learning(Garvin, 1933): organisational decline(Cameron, Whetton and Kim, 1987, Nystom and Starbuck,1983, Wilson 1980). More recently, Succar (2015) argued that insufficient research has been conducted to date to ascertain the conceptual structures that would support BIM adoption and that both BIM implementation and BIM diffusion are yet to be reliably assessed at market level. It is the intention of this research to present a validated framework for value creation to the QS organisation in response to industry sector BIM adoption.

4.4. Themes drawn from the findings of the reviewed literature

The discussion in Chapters 2, 3 and 4 has identified the following themes to be drawn from the literature:

- BIM has the potential to change the construction industry and to create value.
- There are context specific definitions of BIM but how do they impact on the QS's interpretation of BIM.
- The benefits of BIM to the QS are many and varied and are based on perceptions.
- BIM maturity Level 2 is the mandated norm for the industry and as such if an organisation is working at BIM Level 2 it is working at the expected level.
- The QS role is an evolving role and is responding to the opportunities presented by a BIM enabled environment.
- That organisations demonstrate specific characteristics in relation to organisational growth and survival.

- Organisational learning is an important feature of organisational growth and survival.

The literature review provides the critical backbone to this research which, along with the conclusions drawn from it, can be used to inform the framework for the value creation for the QS organisation in a BIM enabled era.

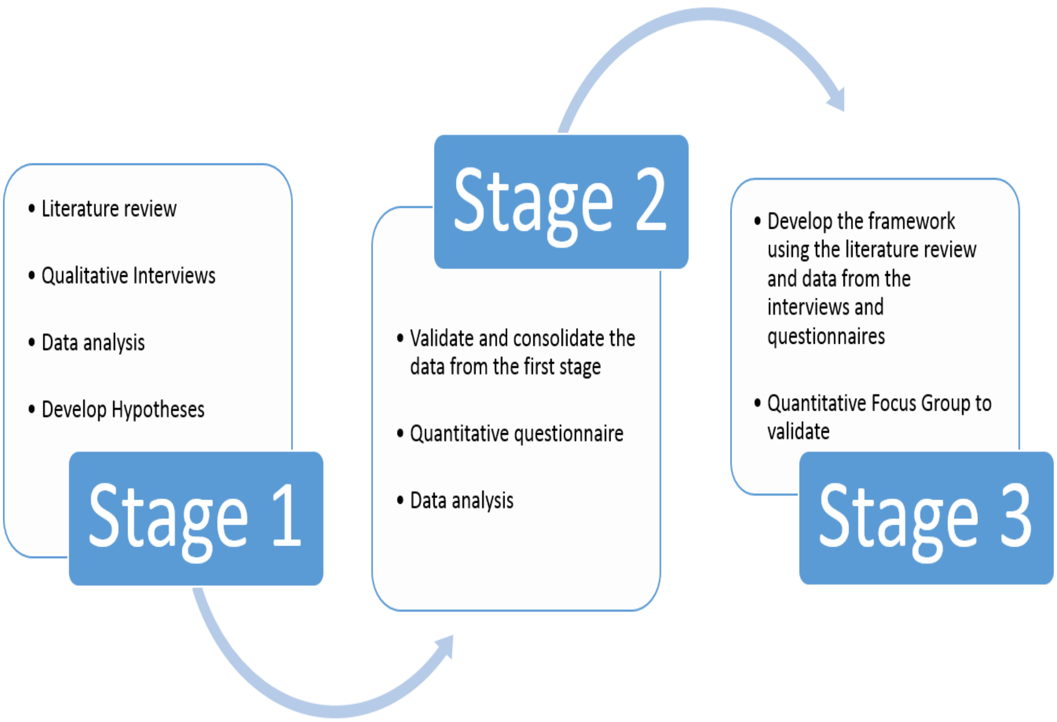
4.5. Chapter Summary

This chapter has reviewed the theory and literature of the QS, BIM and organisation growth, with the intention of developing a comprehensive understanding of the current “state of knowledge” as it pertains to BIM adoption and the growth of the QS organisation. By so doing it has identified the gap that will be addressed by this research. The discussion has confirmed that BIM is set to challenge the QS industry and is an opportunity and that BIM frameworks alongside organisational theories offer the potential to support the QS organisation through its transition from Pre BIM to Post BIM.

5. Research Methodology

5.1. Introduction

This chapter presents the research strategy adopted for this research. The strategy is considered in 3 methodological phases; research philosophy, research approach and research methods. The philosophical position of this study is reviewed initially in order to inform the research approaches and the research method. Consideration is given to the approaches available at each of these methodological phases to ascertain the method that might best help address the research objectives. The research strategy is identified is illustrated in Figure 5.1, the rationale for its selection is discussed in the following sections.



	Stage 1		Stage 2	Stage 3	
Research Philosophy	Ontological perspective		Ontological perspective	Epistemological perspective	**Pragmatic**
Research Approach	Inductive		Deductive	Inductive and Deductive	**Abductive**
Research Method	Qualitative		Quantitative	Qualitative	**Mixed Methods**

Figure 5-1 Research strategy adopted in this research.

5.2. Research definition and purpose

Prior to determining the research methodology, it is important to clearly define the research focus and its purpose (Creswell et al, 2007). Research is described as the process of developing, performing and investigating an inquiry about an occurrence or experience in order to develop solutions or strategies to enhance the existing status quo (Ghauri et al 2005). Research is concerned with addressing the questions of ‘what’, ‘why’ and ‘how’ and has many interpretations. Generally, there is an agreement that it involves the pursuit of new knowledge in a particular field that will add a “uniqueness” to its knowledge base. Research can be characterised as having one of several key purposes: to describe, to explain and understand, to effect change, to predict, to evaluate or to assess impacts. (Blaikie, 2009). The purpose of this study is to develop a framework for the QS organisation to create value in a BIM enabled era, and as such, is an inquiry to develop a strategic approach, to organise their business to adapt and evolve in response to BIM.

5.3. Research philosophy and approaches

Research philosophy is the all-embracing term used to communicate the development of knowledge and the nature of that knowledge in relation to research (Saunders et al, 2012). There is much debate around the need to adopt a particular philosophical view point, with much of the debate “around positivist and interpretivist research philosophy or between quantitative methods and qualitative methods” (Saunders et al, 2012 p129). However, in recent times it has been suggested that consideration is given to the philosophy adopted as a multi-dimensional set of continua rather than as distinct positions (Niglas, 2010).

There are many diverse approaches that can be employed and the importance of their choice and impact cannot be underestimated, as the failure to understand and think through philosophical issues can have a detrimental effect on the quality of the research outcome. (Easterby-Smith et al., 2002). Giving due consideration to the philosophies at an early stage will help to identify the type of evidence required, how to gather the evidence and how to interpret the evidence to find a solution to the research question. Reference to research philosophies will enable the researcher to resolve the research questions by identifying, adapting or even creating research designs that projects beyond one's own experience and knowledge (Easterby-Smith et al, 2002).

Creswell (2009) asserts that there is a relationship between the exemplars of scientific investigation and the suitable design and approach to be utilised in achieving the research objectives. It is the consideration of the robust research philosophies available that will enrich the researchers understanding of scientific knowledge and ultimately improve the accuracy of the research (Cameron and Price, 2009).

Research philosophy consists of a theoretical perspective as identified by Crotty (1998), which is informed by ontology and epistemology. Grix (2010) confirms that ontology and epistemology are the foundations upon which the research is built. It can be argued then that the researcher's ontological and epistemological assumptions inform the choice of methodology and methods of research.

5.3.1. Ontological position

Ontology focuses on what exists and is a view on the nature of reality, relating to the real world and its characteristics (Cresswell, 2013). Furthermore, it can be seen as a way of constructing reality (Denzin and Lincoln, 1998). Saunders et al. (2012) identify two aspects of ontology, the first being objectivism and the second subjectivism as identified in Figure 5.2.

Figure 5-2 Aspects of Ontology

Objectivism purports “the position that social entities exist in reality to, and independent from, social actors" (Saunders et al, 2012 p 131). This viewpoint lends itself to the scientific method of enquiry in that the elements that can be subjected to a quantitative analysis are investigated. Therefore, by its nature, the scientific method is reductionist (Creswell, 2013; Williamson, 2002).

Subjectivism consider that it is the perceptions and actions of the social actors that create the social entity itself and that the continuous interaction of the social actors results in the constant state of change in the social phenomena (Bryman, 2008; Babbie, 2013). Social constructionism views this reality to be socially constructed and helps with the understanding of the details of what is happening as a result of this interaction.

The research question to be addressed involves the analysis of BIM implementation on the QS organisation and as such is interpreted through the individual’s experiences in their work environment and the culture of the organisation and is therefore dependent upon human perceptions. It could therefore be argued that the social reality in organisations is internal to the individual and therefore follows the constructivist school of ontology.

5.3.2. Epistemology

Epistemology is concerned with the theory of knowledge with regard to its methods, validity and scope and the distinction between justified belief and opinion. It describes the major way of thinking about research philosophy and the theory of knowledge (Bryman 2008) and what constitutes acceptable knowledge (Saunders et al, 2012).

Saunders et al (2012), identify 3 aspects of epistemology: Positivism, Realism and Interpretivism as identified in Figure 5.3.

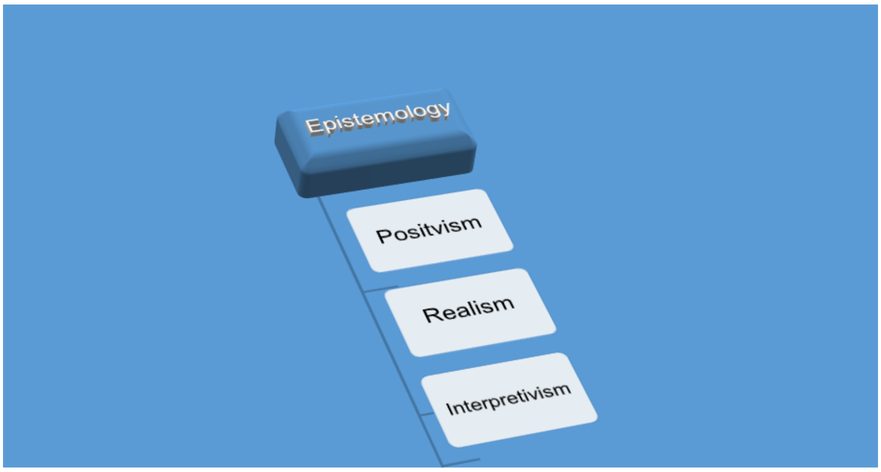


Figure 5-3 Aspects of Epistemology

As a philosophy, positivism believes that only “factual” knowledge gained through observation, including measurement, is reliable. In positivism studies the role of the researcher is limited to data collection and interpretation through objective approach and the research findings are usually observable and quantifiable. It adopts the stance of the natural scientist and collects data about an observable reality, searching for regularities and casual relationships in the data to create law like generalisations like those produced by scientists. (Gill and Johnson 2010, cited in Saunders, Lewis and Thornhill, 2012, p.134). Dainty (2007) identifies construction management research as being firmly rooted within the positivist tradition, which he believes did not provide the construction management research community with a sufficiently rich and nuanced appreciation of industry practice. To counteract this, he proposes “a more expansive outlook towards mixing methodologies and research paradigms could yield deeper insights into, and understanding of, the way that practitioners ‘do’ management in the construction sector (Dainty, 2007: p.9).”

Realism research philosophy also relates to scientific enquiry and is dependent on the idea of the objectivity of reality of the human mind. As a branch of epistemology, this philosophy is based on the assumption of a scientific approach to the development of knowledge. Realism can be divided into two groups: direct and critical.

Direct realism can be described as “what you see is what you get” (Saunders et al 2012, p136). In other words, direct realism portrays the world through personal human senses. Critical realism, on the other hand, argues that humans do experience the sensations and images of the real world accepting that real structures exist independently of patterns or events (Bhaskar, 2008). Novikov and Novikov (2013) argue that critical realism provides perceptions and pictures of the real world which can be deceptive and usually do not portray the real world.

Interpretivism integrates human interest into a study. Accordingly, “interpretive researchers assume that access to reality (given or socially constructed) is only through social construction such as language, consciousness, shared meanings, and instruments” (Myers, 2008, p38). Interpretivism is “associated with the philosophical position of idealism, and is used to group together diverse approaches, including social constructivism, phenomenology and hermeneutics; approaches that reject the objectivist view that meaning resides within the world independently of consciousness” (Collins 2010). According to Saunders et al (2012), the interpretivist approach leads the researcher as a social actor to appreciate differences between people.

Interpretivism originates from two intellectual traditions of Phenomenology and symbolic interactionism. Phenomenology is the science that studies the relationship between facts (phenomena) and the area in which this is a reality (psyche, consciousness) (Hussey and Hussey,1997; Collis and

Hussey,2009). It is the part of science that analyses and studies phenomena thrown into consciousness, that is, the essence of things which are in plain contrast to the precision of the measurement procedures as advocated by the positivist philosophy (Easterby- Smith, 2008: Hussey and Hussey,1997: Collis and Hussey 2009). In comparison in symbolic interactionism "individuals are recognised as being in a continual process of interpreting the words to the effect that we interpret the actions of others with whom we interact and this interpretation leads to adjustment of our own meanings and actions" (Saunders et al, 2012, p137).

5.3.3. Pragmatism

Philosophical choice is often a debate between epistemology and ontology. However, Tashakkori and Teddlie (1998) advocate that the philosophy adopted in any research should be seen as a continuum, rather than opposite positions. Pragmatism argues that the most important determinant of the research philosophy adopted, is the research question, and that it is possible to work with both philosophies (Easterby- Smith et al, 2011). Pragmatism offers a middle ground, it shares strong links with constructivism and also enables the researcher to use empirical methods (Cameron, 2009). A pragmatic research philosophy suggests that there are singular and multiple realities that are open to empirical inquiry, positioning itself toward solving practical problems in the ‘‘real world’’ (Creswell et al, 2007, p. 20-28; Dewey, 1925; Rorty, 1999). Furthermore, Tashakkori and Teddlie, (1998, p. 30) claim "study what interests you and is of value to you, study in the different ways in which you deem appropriate, and use the results in ways that can bring about positive consequences within your value system."

5.3.4. Philosophical approach adopted by this research

A pragmatic research philosophy is adopted by this study as the research question is directed at solving practical problems in the ‘‘real world’’. This research aim requires an understanding of BIM and its implications for the QS and its business organisation, in order to establish a framework. Therefore, the research philosophy adopted in this research, is a pragmatic approach, as it adopts both positivist and interpretivist positions. The most important determinant being the research question itself (Saunders et al, 2012, p678). Seymour et al (1997, p118) argue that construction management research should adopt an interpretivist approach and focus on making more sense of the world as opposed to focusing on generalisations (positivism) as this will “recognise the prospective viewpoints of practitioners in the process… and better reflects the realities of construction management”.

This researcher does not have direct access to the real world, and obtains their knowledge from a subjective ontological perspective drawing perceptions and subsequent actions form the affected social actors (Saunders et al, 2102); the contractor’s QS and the consultant’s QS that form the basis of this study. The epistemological stance taken is that of interpretivist, this allows the researcher to understand motives, meanings, reasons and other subjective experiences which are time and context bound (Hudson and Ozanne, 1988; Neuman, 2006). This research is therefore positioned within the Interpretivist tradition and, involves an ontological position of subjectivism and the epistemological position of interpretivism.

5.4. Research approach

In addition to determining the philosophical approach to the study, the researcher must determine the research approach, to provide detailed direction for the research design, and method of enquiry, for the collection and analysis of data. The relationships between theory, method and empirical phenomena must be carefully considered when designing the research approach (Saunders et al, 2102).

There are three principal research approaches –deduction, induction and abduction (Dubois and Gibbert, 2010), each with its own specific links to theory, empirical phenomena and methods.

5.4.1. Deductive research approach

The deductive approach starts with a theory, often related to a hypothesis which is then tested through empirical observation. The deductive strategy is based on hypothesis testing and can be appropriate at explaining ‘what’ questions, being the dominant reasoning applied within natural science. Deduction is “a form of reasoning where a conclusion is logically derived from a set of premises…and thus conclusion… does not contain any new knowledge” (Ketokivi and Mantere 2010, p330). A deductive study is characterised by the testing of a theoretical proposition through empirical research (Saunders et al., 2012) and often involves the testing of prior hypotheses or theories using quantitative data that incorporates standardised measures and statistical techniques. Furthermore, this approach results in a restricted relationship and sequence between theory and empirical data (Bryman and Bell, 2007).

5.4.2. Inductive research approach

In comparison, the inductive reasoning is often referred to as a ’bottom up’ approach and is used to explore a phenomenon while identifying themes and patterns to formulate theory to create, for example, a conceptual framework (Saunders et al, 2012). Induction is the converse of deduction (Anvuur, 2008), as it develops a theory from empirical facts or observations as opposed to testing a theory (Spens and Kovacs, 2006). The observation of the empirical world leads to the formulation of concepts to explain the observation. An inductive strategy is appropriate to answering ‘what’ questions “. The aim of the Inductive research strategy is to establish limited generalisations about the distribution of, and patterns of association amongst, observed or measured characteristics of individuals and social phenomenon” (Blaikie 2009, p83). Participants are therefore carefully selected using purposive or theoretical sampling approaches based on their appropriateness in terms of the inquiry (Philip, 1998).

5.4.3. Abductive research approach

An abductive research strategy is more complex than both inductive and deductive in that it produces an understanding as opposed to an explanation, it provides reasons rather than causes, in so doing answering both 'what' and 'why' questions (Blaikie 2009, p89). An abductive approach moves back and forth, in effect combining deduction and induction (Suddaby 2006, cited Saunders et al 2012, p147). Abduction is broad in its approach and whilst it bears a close resemblance to induction, it differs in that it builds a theoretical understanding informed by context, people their worldview, language, meanings and perspectives (Bryman, 2012). Issues have been identified in relation to its middle-ground position between induction and deduction (Timmermans and Tavory, 2012). As a result, it has been suggested that abductive researchers must provide an unambiguous explanation of the research process and demonstrate ethical rigour, to ensure the reliability of the research in question that will enable other researchers to replicate the research and its findings (Timmermans and Tavory, 2012).

In terms of which method to adopt, Denscombe (2008) takes a very pragmatic view and suggests that the actual choice of research methods is 'horses for courses,' in that the method of investigation that is most suited to the questions, should be selected, rather than being confined by a purely philosophically-led choice. In fact, it is possible to combine induction and deduction in the same research work (Saunders et al, 2012). More than one strategy can be used within the same research, but one will normally dominate (Neuman, 2006, Blaikie 2007, and Maree 2007).

5.4.4. Research approach adopted by this research

The research approach adopted in this study to support the philosophy, is an abduction approach. This approach is best suited for new research topics with little literature in its actual context (i.e. QS organisations value creation frameworks) but with a wealth of information in another context (i.e. BIM) (Saunders et al, 2012). The research starts with the induction approach by going back to the literature review and extracting knowledge which is then used to inform the themes to be addressed in the questions, asked in the semi structured interviews. A deductive approach is then taken in the design of the questionnaires, as it allows a continuous interplay between empirical observation and theory, and supports the generation of new ideas and surprises (Van Maanen et al, 2007). The high level themes identified in the semi structured interviews then inform the structure of the questionnaire, and the detail in the questions. The abductive approach enables this study to then build a theoretical understanding of the critical success factors to be included within the framework, which is informed by context (the QS organisation), people and their worldview (the QS) in terms of language, meanings and perspective. Finally, it is validated via a focus group adopting inductive and deductive logic. Abduction can be aligned with both subjectivism and interpretivism and as such is an appropriate research approach to be adopted by this study (Blaikie, 2010).

5.5. Research method

The research method will formulate a plan as to how the questions of the research can be addressed and the data collected. Research methods applied in construction engineering and management were given detailed consideration by the Journal of Construction Engineering and Management in 2010 (Vol. 136 Issue 1.) to understand which methodology if any was more predominantly used. Thirteen papers were published of which five applied a variety of quantitative methods, five qualitative methods and three papers offered methodological insights into a range of research methodologies, namely research validation and mixed method research. (Zou et al, 2014). The conclusion to be drawn from this research is that there is no one dominant method in this field of research. A view supported by Amaratunga et al, (2002) who expressed the methodological choice is the choice between quantitative and qualitative research, which are both represented in the Built environment, or a mixture of the two, mixed methods.

5.5.1. Qualitative research methods

Qualitative research methods are seen as social research that study phenomena that are not explained through numbers and indices, but through views of the world, via the participant’s perceptions (Bryman and Bell, 2007). It is a form of social inquiry that focusses on the way people interpret and make sense of the experiences and the world in which they live. This approach seeks to understand and explore individuals or a group’s attitudes, behaviour and experiences (Dawson, 2009). A view supported by Smith (2004) who defines it as a social reality created by the participants of the research; where the data obtained by the participants are studied and compared and contrasted in order to develop a theory through words, meanings and visuals.

Snape and Spencer (2003) identified the following distinctive characteristics of qualitative research:

- “Aims which are directed at providing in depth and interpreted understanding of the social world of research participants by learning about their social and material circumstances. Their experiences, perspectives and histories:
- Samples that are small in scale and purposively selected on the basis of salient criteria.
- Data collection which usually involves close contact between the researcher and the research participants, which are interactive and developmental and allow for emergent issues to be explored.
- Data which are very detailed, information rich and extensive.
- Analysis which is open to emergent concepts and ideas and which may produce detailed descriptions and classification, identify patterns or association or develop typologies and explanations.
- Outputs which tend to be focussed on the interpretation of social meaning through mapping and re representing the social world of research participants” (Snape and Spencer,2003 p3)

It is often associated with an interpretive philosophy (Denzin and Lincoln, 2005) in that it "makes sense of the socially constructed meanings expressed about the phenomenon being studied"' (Saunders et al, p163). Notwithstanding that, when adopted as part of a mixed methods approach it can also be associated with realist and pragmatist philosophies.

Qualitative research represents circumstances, happenings, people, interactions and behaviours that are observable. It incorporates what people say and experience, their attitudes, beliefs, thoughts and reflections as expressed by themselves (Silverman, 2009). Qualitative enquiry can trace evolution and advancement over time, as perceived by the participants and is not based on numeric data to formulate its conclusions. It is often described in relation to inductive logic through building a rich theoretical description of the meaning of collected and analysed data and therefore moving from particular to general (Creswell , 2009, Saunders et al , 2012).

Qualitative research approaches include "an array of interpretive techniques which seek to describe, decode, translate, and otherwise come to terms with the meaning, not the frequency, of certain more or less naturally occurring phenomena in the social world" (Van Maanen,1983, p9). Commonly used strategies include: grounded theory, ethnography, action research and case study.

Grounded theory

Grounded theory methodology was developed by Glaser and Straus (1967) to systematically derive theories of human behaviour from empirical data in order to make sense of everyday experiences in specific situations (Charmaz, 2006, Glaser and Straus, 1967). The process involves several steps of data collection in parallel with sequential and consecutive data analysis (Straus and Corbin,1997). The data is coded to reflect the emerging issues and each statement guides the next stage until the final theory is grounded (Jones and Alony, 2011). Open coding is used for the disaggregation of data, axial coding to identify relationships between the categories and selective coding is used to produce a theory by the integration of the categories. Over time the originators of this theory have taken different stances in its application with Glaser (1992) purporting that the theory should stem from an empty mind. In contrast, Strauss and Corbin (1992) argue that it is better to start with a general understanding of the area under research to develop structured questions in order to force the emergence of the theory.

Ethnographic study

The aim of the ethnographic approach is to describe and interpret shared patterns of behaviour, language and beliefs of a group of interacting individuals (Creswell, 2013). The premise being that what people believe, understand and act upon, cannot be detached from their context (Sackey, 2014). It requires the researcher to focus upon describing and interpreting the social group through first hand field of study (Saunders et al, 2012). The researcher must ensure that a balance is achieved between the perspectives of those inside the social group and those outside in order to remain open-minded, such that the understandings and meanings of those inside the study is meaningful to those outside (Fellows and Liu, 2009 and Riemer,1997). It is widely adopted in the field of innovation and information technology and management research (Davies and Nielson,1992).

Action research

Action research is based upon the management of change involving close collaboration between practitioners and researchers (Saunders et al, 2012). It is a participatory approach to research in that the researcher is within the field of the research and becomes a partner in the action of the process of change (Baskerville and Wood-Harper, 1996). It is 'the systematic collection of information that is designed to bring about social change' (Bogdan and Biklen 1992: p.223). It encourages collaboration between the researcher and practitioner to address complex real problems allowing the researcher to gain feedback from the practitioner in order to adjust and develop the research outcome. It is problem focused, context-specific and forward looking and can be adopted in change intervention (Hart and Bond,1995). Action research is not without its weaknesses. Methodologically, it is often difficult and time consuming as care needs to be taken to maintain transparency of purpose. Scientific rigour can also be overlooked if there is a need to produce immediate and practical research findings (Argyris and Schon 1991).

Case study

A case study is a pragmatic inquiry that examines a contemporary phenomenon within its real-life context. This methodology uses a variety of methods to obtain an in depth knowledge to explore a single phenomenon in a normal situation (Collis and Hussey, 2009). Case study research can provide a rich mix of data as it can accommodate both qualitative and quantitative data (Yin, 2003; Gerring, 2007). A case study approach consists of an in depth exploration of a programme, event, process or individuals (Creswell, 2009). It is the selection of a suitable case or cases that offer the researcher adopting this strategy with the greatest dilemma (Creswell, 2013).

Qualitative research is growing in the Built environment (Amaratunga et al, 2002) a view supported by Knight and Ruddock (2008) who analysed the data collection methods adopted for publications in the peer reviewed journal Construction Management and Economics. The reserach found that 75% of the publications, employed qualitative methods, with individual interviews being adopted most frequently, followed by focus groups and latterly group interviews.

The process of acquiring data is usually through the method of interviews or by open ended questionnaires. This method endeavours to acquire in-depth views and opinions in relation to the research question. It involves fewer people than quantitative methods but it usually involves the participants for a greater amount of time (Creswell, 2009).

There are two common forms of qualitative strategies:

- Exploratory – appropriate when limited knowledge is available on a particular topic or the researcher wants to gain additional dimensions to existing knowledge.

- Attitudinal – appropriate for the evaluation of views and perceptions with respect to a particular topic (Naoum, 2013).

In data analysis the qualitative researcher seeks to produce a convincing explanation of the phenomena, based on a holistic interpretation of the social understandings captured in the empirical data (Carcary, 2009). Just how competent this analysis is, determines the strength of the qualitative method (Miles and Huberman, (1994). Furthermore, the time taken to analyse the data could be longer than that of quantitative data for which computer programmes can be utilised to generate results in an efficient manner (Berg, 2009).

The strengths of the qualitative method include:

- Obtaining a more realistic feel of the world that cannot be experienced in the numerical data and statistical analysis used in quantitative research;
- Flexible ways to perform data collection, subsequent analysis, and interpretation of collected information;
- Provide a holistic view of the phenomena under investigation (Bogdan and Taylor, 1975; Patton, 1980);
- Ability to interact with the research subjects in their own language and on their own terms (Kirk and Miller, 1986); and
- Descriptive capability based on primary and unstructured data.

The weaknesses of the qualitative method include:

- Departing from the original objectives of the research in response to the changing nature of the context (Cassell and Symon, 1994);
- Arriving to different conclusions based on the same information

depending on the personal characteristics of the researcher;

- Inability to investigate causality between different research phenomena;
- Difficulty in explaining the difference in the quality and quantity of information obtained from different respondents and arriving at different, non-consistent conclusions;
- Requiring a high level of experience from the researcher to obtain the targeted information from the respondent; and
- Lacking consistency and reliability because the researcher can employ different probing techniques and the respondent can choose to tell some particular stories and ignore others. (Matveev, 2002).

5.5.2. Quantitative research methods

“Quantitative research develops and uses mathematical models, theories and hypothesis to describe relevant natural phenomena” (Bryman and Bell, 2007, p154). Its main purpose is to explain the causes of the phenomena, comparing theory and practice, identify discrepancies, statistically analyse, make connections and generalisations (Crotty,1998, Cameron and Price 2009, Ghauri and Gronhaug, 2005). Quantitative study is when researchers assume an objective social reality. Quantitative research commonly uses pre-conceived principles to determine the data that will be collected (Smith, 2004). Unlike qualitative research, a quantitative research will collect and analyse numerical data, and is concerned with frequencies rather than words and meanings.

The common research approaches adopted within quantitative research are normally experimental and survey approaches, adopting questionnaires or structured interviews to quantify the collected data (Saunders et al, 2012). These approaches use standardised measures that allow for the varying perspectives and experiences of people to be fitted into a limited number of predetermined response categories to which numbers are assigned (Ghauri et al, 2005). They are tightly structured emphasising the precision of the measurement procedure. (Easterby Smith, 2008).

Experimental research is commonly used in the natural sciences and is a collection of research designs that use manipulation and controlled testing to understand casual processes. This strategy uses predictive hypotheses as opposed to open research questions. As the research question and objectives have been said to inform the strategy the researcher must consider the nature of the research question in its selection. However, “most business and management research questions will be designed to inquire into the relationships between variables, rather than test a predicted a relationship” (Saunders et al, 2012, p176).

A survey approach is usually associated with a deductive research approach and it is normally used in business and management research to address a series of questions including “what”, “who” and “where” (Saunders et al, 2012). It is often associated with qualitative and quantitative research as it collects its data via structured interviews and questionnaires, normally on several cases and variables in order to establish patterns (Bryman, 2012). When sampling is used it is possible to draw conclusions about the whole population providing the sample collected is representative of that population.

The strengths of the quantitative method include:

- Stating the research problem in very specific and set terms (Frankfort-Nachmias and Nachmias, 1992);
- Clearly and precisely specifying both the independent and the dependent variables under investigation;
- Following firmly the original set of research goals, arriving at more objective conclusions, testing hypothesis, determining the issues of causality;
- Achieving high levels of reliability of gathered data due to controlled observations, laboratory experiments, mass surveys, or other form of research manipulations (Balsley, 1970);
- Eliminating or minimising subjectivity of judgment (Kealey and Protheroe, 1996);

- Allowing for longitudinal measures of subsequent performance of research subjects.

The weaknesses of the quantitative method include:

- Failure to provide the researcher with information on the context of the situation where the studied phenomenon occurs;
- Inability to control the environment where the respondents provide the answers to the questions in the survey;
- Limited outcomes to only those outlined in the original research proposal due to closed type questions and the structured format;
- Not encouraging the evolving and continuous investigation of a research phenomenon (Matveev, 2002).

5.5.3. Mixed methods research methods.

As both quantitative and qualitative methodologies have positive and negative attributes, there is sometimes justification for combining these methodologies in order to neutralise or reduce the bias of one methodology (Creswell, 2009, Amartunga et al, 2002). Mixed methods “use more than one data collection method and analysing technique in the service of a number of research strategies, however, they will need to be used with different ontological assumptions” (Blaikie 2010, p106). Two philosophical positions can lead to mixed methods research designs. Where researchers adopt a realist ontology and interpretivist epistemology researchers may for example use quantitative analysis of officially published data followed by qualitative research methods to explore perceptions (Tashakkori and Teddie, 2010). A mixed methods research design may adopt either a deductive or inductive approach or a combination of the two, in that, “quantitative or qualitative research may be used to test a theoretical proposition, followed by further quantitative or qualitative research to develop a richer theoretical perspective” (Saunders et al, 2012. p164).

In comparison to mono methods, were the researcher uses single data collection technique and analytical procedure, mixed methods adopt more than one data collection and analytical procedure, to answer the research question. The later method is one that is often advocated within business and management research as it offers greater potential for data collection, analysis and interpretation (Saunders et al, 2012).

To construct a mixed-method design, the researcher must make three primary decisions:

- Whether both the methods are given equal priority is a key decision
- Whether to conduct the qualitative and quantitative stages concurrently or sequentially.
- Where the mixing of the qualitative and quantitative methods will occur. (Doyle et al, 2009)

Creswell, (2009) asserts that mixed methods may be conducted sequentially or concurrently. Sequential mixed methods involve more than one phase of data collection and analysis, utilising the data from one method to inform the findings of the other. Where qualitative data informs the quantitative data it is termed sequential exploratory design and were quantitative data informs the qualitative data it is termed sequential explanatory design. Multiple phases of data collection can also be included in sequential mixed methods, known as multiphase design, whereas, concurrent mixed method research, adopts a single phase of both quantitative and qualitative data collection and analysis.

Mixed methods research can adopt quantitative or qualitative data equally or unequally (Creswell et al, 2007). Morse (2010) asserts that a mixed method design involves primary (core) method be it either quantitative or qualitative and one or more supplementary components of either quantitative or qualitative that provide insights and examinations for the core component of the research data, such as interviews. It must be noted however, that the participants of both the primary and the core may or may not be the same, but must be from the same population (Morse, 2010). Where one methodology supports the other it is referred to as embedded mixed methods research (Creswell et al, 2007) and where one methodology is embedded within the other in a single data collection then it is known as concurrent embedded design.

Johnson and Onwuegbuzie (2004) identified the following strengths and weaknesses of mixed methods as:

Strengths

- Words, pictures, and narrative can be used to add meaning to numbers;
- Numbers can be used to add precision to words, pictures, and narrative;
- Can provide quantitative and qualitative research strengths
- Researcher can generate and test a grounded theory;
- Can answer a broader and more complete range of research questions because the researcher is not confined to a single method or approach;
- Results can be used to develop and inform the purpose and design of the Stage 2 component;
- A researcher can use the strengths of an additional method to overcome the weaknesses in another method by using both in a research study;
- Can provide stronger evidence for a conclusion through convergence and corroboration of findings;
- Can add insights and understanding that might be missed when only a single method is used;
- Can be used to increase the generalisability of the results; and
- Qualitative and quantitative research used together produce more complete knowledge necessary to inform theory and practice.

Weaknesses

- Can be difficult for a single researcher to carry out both qualitative and quantitative research, especially if two or more approaches are expected to be used concurrently; it may require a research team;
- Researcher has to learn about multiple methods and approaches and understand how to mix them appropriately.
- Methodological purists contend that one should always work within either a qualitative or a quantitative paradigm;
- More expensive;
- More time consuming; and
- Some of the details of mixed research remain to be worked out fully by research methodologists (e.g., problems of paradigm mixing, how to qualitatively analyse quantitative data, how to interpret conflicting results).

5.5.4. Research method approach adopted by this research

Pragmatism as discussed in section 5.3.3 - 5.3.4, allows the researcher not to be constrained and ‘‘be the prisoner of a particular [research] method or technique’’ (Robson, 1993, p. 291). This study will therefore adopt a multilevel sequential mixed design, as, it seeks to gain knowledge from the semi structured interviews that will later inform the questionnaire. The different methods will be used to inform and supplement each other, each method addressing a different layer of the research topic and each adopting a different methodological approach. Methods were mixed to “produce a more complete picture, to avoid the biases intrinsic to the use of mono method design, and as a way of building on, and developing, initial findings” (Denscombe, 2008, p. 272).

This study will commence with an extensive examination of the literature available on BIM, the role of the quantity surveyor and organisational growth and survival in order to evaluate all available literature on the research topic and to identify any gaps in knowledge. A qualitative approach will then be adopted in the next stage to assess what the participants in the construction industry understand by BIM, how it might impact on the QS and whether or not the role itself would survive. This exploratory data will be gathered via semi structured interviews which will be explained in detail in Chapter 6. This is appropriate as the objective of qualitative research is to extend knowledge and understanding by exploring the meaning of the research with individuals and groups in terms of the research topic (Creswell, 2013). The research topic being addressed in this study "is to develop a framework for the QS organisation that will support value creation when adopting and implementing BIM.". The combination of a qualitative methodologic approach works well with an abductive research approach (Saunders et al, 2012) to provide in depth understanding of the research topic. The next stage of data collection will involve a quantitative methodologic approach. The data gathered from the semi structured interviews along with the literature review will inform the questionnaire. From the analysis of the questionnaire, the semi structured interviews and the literature review a framework will be developed.

The chosen methodology is therefore as identified in Figure 5.4.

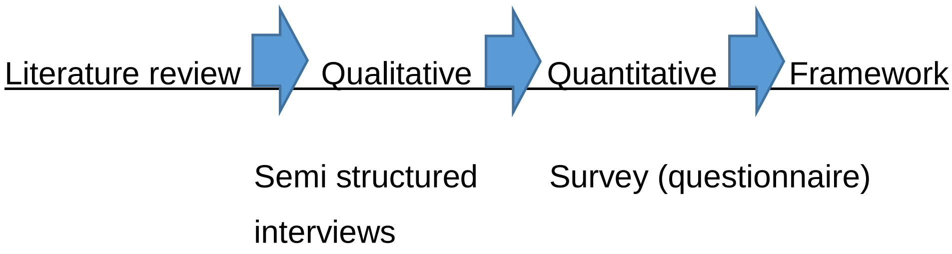


Figure 5-4 Methodological choice adopted in the research

The actual selection of the population sample has been described as one of the most important stages of mixed methods studies (Collins, Onwuegbuzie, and Jiao 2007) and is considered in the next section.

5.6. Sampling

Regardless of whether the research is quantitative, qualitative or mixed method design it needs to select a sampling technique (Ritchie et al, 2013). The sample to be studied should represent the full set of cases in a way that is meaningful and which can be justified (Becker, 1998). The full set of cases from which a sample can be taken is the population. Sampling is done usually because it is impossible to test every single case in the population and to save time, money and effort while conducting the research. Although sampling procedures in the social and behavioural sciences are often divided into two groups: Probability and Non probability as identified in Figure 5.5.

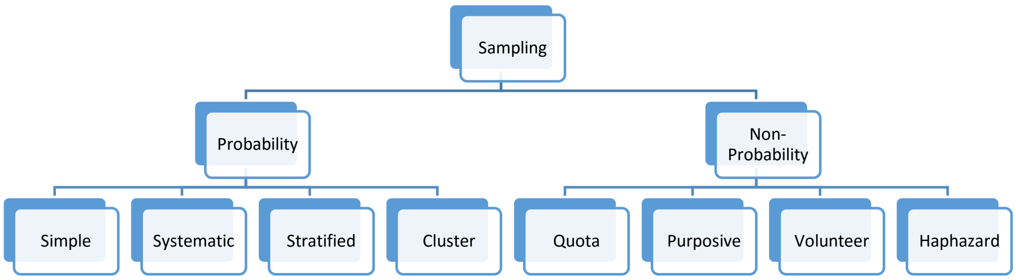


Figure 5-5 Sampling Techniques

Source: Adapted from Saunders et al 2012

Probability sampling techniques are primarily used in quantitatively research and involve ‘‘selecting a relatively large number of units from a population, or from specific subgroups (strata) of a population, in a random manner where the probability of inclusion for every member of the population is determinable’’ (Tashakkori and Teddlie, 2003, p. 713). In probability sampling, every case in the population has an equal chance of being selected as a subject for the research. It guarantees that the selection process is completely randomized and without bias. It is often associated with quantitative research and survey research strategies.

Purposive sampling techniques have also been referred to as non - probability sampling or purposeful sampling or qualitative sampling (Teddlie and Yu, 2007) . Maxwell (1997, p87) defined purposive sampling as a type of sampling in which, ‘‘particular settings, persons, or events are deliberately selected for the important information they can provide that cannot be gotten as well from other choices’’. Purposive sampling techniques are primarily used in qualitative (QUAL) research and may be ‘‘based on a specific purpose rather than randomly’’ (Tashakkori and Teddlie, 2003, p. 713). The researcher does not desire to sample participants on a random basis, rather, they select people, organisations, documents, departments, etc, that can contribute to the research question (Bryman, 2012). Purposive sampling frames are typically informal ones based on the expert judgment of the researcher or some available resource identified by the researcher. In purposive sampling, a sampling frame is ‘‘a resource from which you can select your smaller sample’’ (Mason, 2002, p. 140).

A convenience sample is a non-probability sample in which the researcher uses the subjects that are nearest and available to participate in the research study. This technique is also referred to as "accidental sampling," and is commonly used in pilot studies prior to launching a larger research project.

Mixed Methods (MM) sampling strategies involve the selection of the cases for a research study using both, probability sampling, to increase external validity and, purposive sampling strategies, to increase transferability (Collins, Onwuegbuzie, and Jiao,2006; Kemper, Stringfield and Teddlie, 2003).

The researcher must make well developed decisions in terms of samplings methods adopted as this is crucial to the success (Marshall and Rossman, 2010). Other decisions include who or what should be sampled, with which form of sampling and how much should be sampled, sample size, etc (Creswell, 2013).

5.7. Research methods adopted in this study

As previously discussed it is essential to consider the research objectives to be addressed when considering the methodology employed to collect the data. Table 5.1 illustrates which methodology(s) will adopted to achieve each objective.

Table 5-1 Research methods proposed for this study

Objective	Literature review	Interviews	Survey	Focus Group
To assimilate the existing literature and theories on BIM implementation and organisational development to provide a comprehensive academic basis for the framework of value creation through BIM.	•	•		
To establish the critical success factors of BIM to the QS that will identify the opportunities and challenges to the quantity surveying organisation when adopting and implementing BIM;		•	•	
To determine the implication of organisation BIM learning in creating and adding value to the quantity surveying organisation.		•	•	
To determine the organisational changes needed to accommodate BIM in a quantity surveying organisation to support the value proposition of BIM.		•	•	
To develop and validate a framework of value creation for a quantity surveying organisation when adopting and implementing BIM.	•		•	•

The adoption of a mixed method will enable the qualitative data from the interviews to inform the design of the questionnaires and then the analysis of the quantitative data from the questionnaires will be used along with the literature review to develop the framework.

5.7.1. The literature review

The literature review was necessary to understand the knowledge that exists in this field of research and to identify the gaps in the knowledge. Bryman (2012) states that the need for a literature review in any research project is to ensure that the researcher knows what is already known about the subject area so old ground is not being covered. The literature review will be instrumental in the achievement of the first objective of the research to provide an insight into the following:

Objective 1

To assimilate the existing literature and theories on BIM implementation and organisational development to provide a comprehensive academic basis for the framework of value creation through BIM Knowledge gained in relation to this research

- Definition – do we know what it is?
- Benefits
- Barriers
- BIM maturity
- BIM Stages
- BIM documents – 8 pillars of BIM

This enabled the researcher to identify patterns, themes and issues and to define the knowledge gap in relation to BIM and the Quantity Surveyor.

Furthermore, the literature review supported the achievement of all of the objectives by identifying specific characteristics and concepts in the areas of BIM implementation organisational growth, change management, organisational learning and knowledge management and finally to the development of the framework. The first stage of the research methodology is outlined in Figure 5.7.

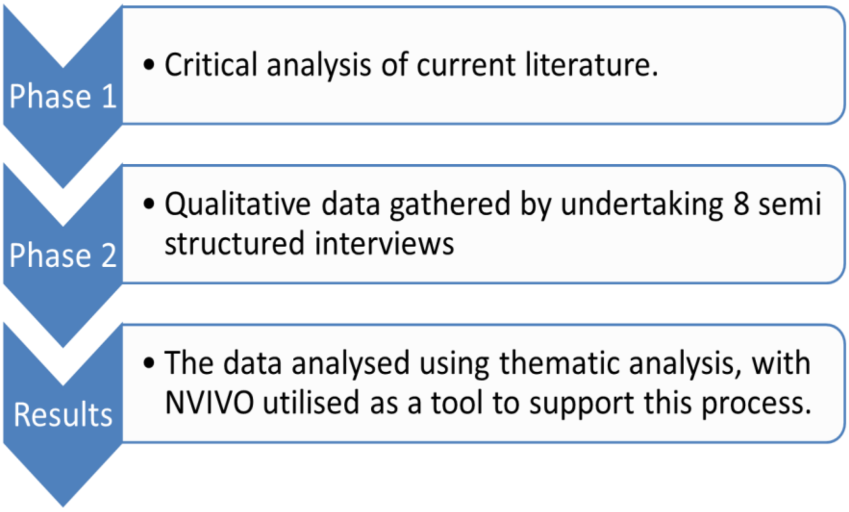


Figure 5-6 Research methodology for Stage 1 of the research

5.7.2. Individual interviews

The interview is a well-established tool in qualitative research and can be modified to fulfil various research aims. They can be utilised at any point in the data collection process and may be used together with other techniques within the same research study (Brewerton and Millward, 2001). Bogdan and Biklen (1992) described an interview as a "purposeful conversation" (pp135) A view later reinforced by Kale and Brinkmann (2008), as they identified an interview as a professional conversation between the interviewer and the interviewee through which knowledge is created in the interaction. Kvale (2007) further argues that much of the analysis of the interview actually occurs during the interview process where the researcher clarifies their understanding of meaning with the person being interviewed. Numerous other authors have supported these views and identified interviews as being a powerful method available to understand individuals (Britten, 1995, Fontana and Frey, 1994). Furthermore, the individual interview is one of the most widely adopted methods of collecting data in built environment research (Dainty (2008), Amaratunga et al (2002).

Interviews can be divided into three classes: structured, semi-structured and unstructured. The most common type of interview is the semi-structured interview. “It has the advantage of being reasonably objective, while still permitting a more thorough understanding of the respondent's opinions and the reason behind them than would be possible using the mailed questionnaire" (Borg and Gall, 1983, p. 442]. This a view not supported by Bogdan and Biklen(1992) who concluded that with semi structured interviews you do not have the opportunity to understand how the participant themselves structure the research topic. The participants being directed by the semi structured questions offering “generally little room for variation in response except where an infrequent open-ended question may be used” (Fontana and Frey, 1994, p.363). Despite these reservations semi structured interviews are the most frequently used form of interviews in the research field of the Built environment (Fellows, 2009, Baiden and Price, 2011), being especially suitable in the construction industry because it increases the depth and breadth of the knowledge about the research question. (Shehu and Akintoye, 2010).

Interviews can be “in depth” or “exploratory”. Exploratory interviews can provide greater breadth and depth to the original research question, offer new dimensions, ideas and help to develop the hypothesis. It can identify important differences between the participants. Oppenheim (2000), argues that the purpose of the exploratory interview is not to gather facts and statistics but moreover to develop ideas and hypotheses and is principally experimental in nature. Exploratory interviews can therefore be used in this research to guide the survey design and question building process.

It is normal for qualitative studies to conduct face to face interviews with the participants (Fontana and Frey, 1994, Creswell, 2009) but not mandatory (Sweet, 2002). Despite the introduction of computer-mediated communication such as e-mail and chat forums the face-to-face interview medium remains superior to the alternatives (Opdenakker, 2006; Seymour, 2001). The focus on the use of the telephone as an interview medium for qualitative research is scarce (Sturges and Hanrahan, 2004). Researchers are generally hesitant in using the telephone for qualitative studies although it has been successfully adopted to collect quantitative data from surveys.

There is however evidence to suggest that it has been used in qualitative semi-structured interviews (Bowman et al., 1994; Barriball et al., 1996).

The telephone is integral to, and a widely accepted means of, everyday communication in both business and private settings. However, as a data collection tool, the telephone remains relatively unacknowledged in qualitative research (Cachia and Millward 2011). Yet the telephone has many advantages over face to face. The telephone combines the virtues of low cost and ease of use (Cassani et al., 1992); the approach is cheap because researchers do not have to travel long distances to conduct interviews (Hash et al., 1985; Barriball et al., 1996). Creswell (1998) contends that the telephone as a medium is accepted as useful, if access is otherwise impossible. A view supported by Saunders et al (2012), affirming that the telephone may offer potential advantages associated with access, speed and lower cost, when conducting interviews. Furthermore, the telephone has been deemed appropriate when there is a requirement to collect sensitive information (Tausig and Freeman, 1988). It has also been established that participants perceive telephone interviews as an effective medium to maintain their anonymity (Greenfield et al., 2000).

In contrast some authors have expressed scepticism about the suitability of the telephone for in-depth interviews (Stephens, 2007, Novick, 2008 and Holt, 2010). Using the telephone as a medium may lead to issues of reduced reliability, where the participants are less willing to engage in an exploratory discussion, or even refuse to take part (Saunders et al, 2012). However, Miller (1995) contends that "telephone interviews are not better or worse than those conducted face-to-face" (p. 37). Although to be effective the researcher must gain the trust of the participants, and establish their integrity, competency and credibility and must be aware of ethical issues that may arise out of its adoption (Saunders et al, 2012). There have been many studies concerned with the appropriate duration of an interview. Burke and Miller (2001), recommended duration was between 15 and 20 minutes. However, participants are generally willing to engage longer in telephone interviews. (Cachia and Millward 2011). Recent studies found that semi-structured telephone interviews lasted on average between one and one and a half hours (Stephens, 2007, Holt's 2010). Furthermore participants are likely to engage in lengthy telephone-based interviews if they are sufficiently motivated and rapport has been successfully established (Cachia and Millward 2011).

The quality of the interview is important to the achievement of the objectives of the research. Quality is driven by the interaction between the researcher and the participant (Kvale, 2007). The method chosen to record the interview is important in determining quality. Saunders et al (2012) suggest that audio recording is adopted when conducting an interview by telephone, as taking notes can prove difficult with this medium. These audio recordings then need to be transcribed and translated into the written word. Kvale (2007) argues that the style of transcribing depends on the purpose but that if the transcript is used for sociolinguistic or psychological reasons, a word by word verbatim style is necessary. The interviews for this research were digitally audio-recorded with the participants' consent and a complete transcription (verbatim) was carried out by the researcher soon after they were conducted.

5.7.2.1. The interview strategy adopted by this research

Individual exploratory semi structured interviews were undertaken with QS's representing both the contracting organisation and the consultant organisations alongside two BIM industry experts, both employed in the construction industry, one as a civil engineer, one as an architect; a total of 8 participants. It is common for qualitative studies to conduct between 5 and 25 interviews (Kvale, 2007). The participants were all known to the researcher in a professional capacity and hence avoided issues previously identified in relation to trust, credibility and competence as the researcher had previously gained their confidence. Prior to the interview the participants were e-mailed an information sheet outlining the details of the research and a consent form. Each interview lasted approximately one hour and consisted of a skeleton plan of open-ended questions. The researcher required a flexible approach in the choice and order of questions, in order to ensure the development of the conversation with the participant. These interviews sought to examine the initial research question, “could the QS profession survive in a BIM enabled era?” The participants were used as a means of exploring the meaning and dimensions of the key ideas arising from the research, thereby enabling the identification of themes and patterns that could be developed further in the questionnaires.

The data to be collected for this research was not considered to be sensitive such that the participants would wish to protect their anonymity nevertheless the telephone as a medium was selected as the most suitable to collect the data. It was the geography and the access to the participants that posed the greatest issue. The 8 participants selected to take part in the interview process were located throughout the UK and held responsible positions in industry. They found it difficult to commit to one to one face interviews but were content to be interviewed via the telephone. The telephone interview offered greater flexibility than face-to-face in setting up the appointment on a day and time that is most convenient to the participants. This flexibility also provides the participants with control over their privacy through choosing the setting that they were most comfortable with (Holt, 2010). In this research the participants scheduled the interview early morning before work or late evening after work or between meetings thereby, maximising privacy and potentially enhancing their willingness to participate. Flexibility of adopting this medium also allowed the participants the opportunity to cancel at the last minute if an emergency arose in the workplace. The telephone offered this flexibility, minimising any unnecessary costs should the participant cancel at the last moment. These costs would have been significant in the event of a cancelation, due to the travel costs to access the locations of all of the participants.

In this research, as the participants occupy senior positions in the construction industry, the timing and duration of the telephone conversation will be crucial in terms of the availability and willingness of the participants and must be given careful consideration. All participants agreed to a one-hour telephone conversation at a mutually convenient time that would fit in with their busy business schedules.

In order to conduct an effective interview people, places and times need to be selected. Researchers in qualitative research select their participants according to their characteristics and knowledge. In addition, the researcher chooses people or sites that provide specific knowledge about the topic of the study (Creswell, 2013). A purposive sampling strategy was devised for this research informed by the literature and the personal expertise of the researcher to ensure the quality of the participants. The following characteristics were considered when selecting appropriate participants:

- Senior management position in the field of BIM/ QS employed in either a consultant or a contracting organisation.
- Organisation currently working at or near to BIM Level 2.
- Minimum of ten years' experience working in the construction industry.

The personal network of the researcher was then considered including contacts made via the RICS (Royal Institution of Chartered Surveyors) at their annual conferences: the QS Conference and the BIM Conference 2013 and 2014. Appropriate professionals were contacted initially by telephone to assess if they were interested in participating. Those that expressed an interest were then sent details of the research by e mail. The participants were selected based on the above characteristics.

The interviews once transcribed were thematically analysed using NVIVO 11. This "is a method for identifying, analysing and reporting patterns (themes) within data" (Braun and Clarke, 2006, p. 79). An inductive procedure was adopted to compile a set of themes and subthemes, aimed at representing the participants' experience, through a systematic comparison between transcripts. Rich results were drawn from the collected data, indicating the suitability and the quality of the telephone interviews.

5.7.3. The questionnaire survey

Substantial research undertaken in the built environment involves asking questions by conducting surveys either by interviews or by questionnaires (Amaratunga, et al, 2002). The survey supports empirical work and is one of the methods adopted by this research. It is normally associated with the deductive approach and is one of the most popular methods employed in business and management research (Saunders et al, 2012). Questionnaires are often used in surveys as they allow the collection of data from a large population in an efficient and economical way, allowing easy comparison of their perspectives (Saunders et al, 2012). Other advantages of questionnaires include: the speedy collection of data, feedback can be offered to participants, participants responses are mostly anonymous, which further encourages honesty and openness in their response (Wolpe, 1998). Finally, questionnaires are less intrusive for respondents because they can be sent by email.

However, Amaratunga et al (2002) argue that quantitative data such as that provided by questionnaires fail to discover deeper underlying meaning and explanations in the built environment, contending that they only provide a snapshot of the situation, measuring the variables at a specific moment in time and as some construction related aspects might be affected by temporal changes they may not be identified within a single survey. Other disadvantages with questionnaires include, the lack of personal contact that could lead to low-quality responses, although this problem can be resolved by creating a better design, wording, sequence and structure, but it is difficult to check participants' answers, as there is no flexibility to follow-up on them. The final disadvantage about questionnaires is that, if some people lack confidence in the research, there is a chance that they will not respond.

A good questionnaire is one that is capable of providing answers to the question being asked and therefore is self-validating. Questions concern facts, knowledge and opinion and should be intelligible, unbiased, unambiguous, Omni competent, ethical and should be piloted (Stone, 1993).

Furthermore, Kumar (2014) contends that when producing the questionnaire, the sample, the topic, the layout and the length of the questionnaire, and the quality of the letter explaining the topic and relevance of the project, all need to be given careful consideration.

Stone (1993) identified 10 steps in designing a questionnaire

1. Decide what data you need
2. Select items for inclusion
3. Design individual questions
4. Compose wording
5. Design layout
6. Think about coding
7. Prepare first draft and test
8. Pilot and evaluate
9. Perform survey
10. Start again!

Bias has been recognised as an important issue in questionnaire design. To collect the most accurate data from respondents, researchers must understand and be able to prevent or at least minimise bias in the design of their questionnaires. (Choi and Pak, 2005) identified 3 types of bias in questionnaire design:

1 issues with the wording
   - questions are ambiguous, complex, double barrelled, too short question
   - words use jargon, vague or too complex

2 missing or inadequate data for the intended purpose
   - insensitive measurement
   - faulty scale and format
   - missing/overlapping interval

3 leading questions

- framing,
- mind-set
- sensitive question
- inconsistency

To reduce the degree of bias in this research the questionnaire design included:

- Understandable, clear wording free from jargon.
- Questions of sufficient length to enable the respondent to understand the question and its purpose.
- A Likert scale 1-5 as a means of measurement, which included a neutral position, providing the researcher with a mid-point.
- Statements that were unambiguous and easily interpreted.
- Questions that did not direct the respondent towards specific answers.
- All questions were piloted.

There are various ways in which the researcher can score and measure the questionnaire including listing, ranking and rating (Saunders et al, 2012). Rating questions are utilised in this research which adopts a Likert scale to measure the extent of the individual participant perceptions to each statement. The Likert scale enables attitudes of the participants to be established by presenting the participants with a list of statements which declare specific emotions, asking them to rate them in terms of agreement or disagreement (Sekaran,2003). There is also a neutral option for those participants that do not have an emotional response to this research, thereby eliminating bias. By adopting a Likert scale for this research, on completion of the survey, each variable can be analysed individually or as a group, if a score is required for a number of variables.

There is much debate in market and social research as to the selection of the appropriate number of scale points (Garland, 1991). In the Likert scale, there is a level of agreement that statements normally have a scale of five or seven points where the participants need to specify their level for each statement (De Winter and Dodou, (2010)). This research has adopted a Likert scale 1- 5 which includes a neutral position, 3, to reduce the likelihood of bias, (Bishop, 1987). Even though it is recognised that the neutral response option is the biggest source of dispute (Johns, 2005; Krosnick et al., 2002) it was believed that the participants in the survey could realistically hold a neutral viewpoint due to the nature of the topic enquiry. Furthermore, this research included both positive and negative statements to encourage the participant to read each answer carefully and select the one most appropriate (Dillman et al, 2009).

Before the questionnaire is distributed it should be piloted and completed by a small sample of respondents to check that the research question can be answered. The piloting will test whether the questions are intelligible, easy to answer and unambiguous. The feedback will provide the opportunity for improving the questionnaire, filling in gaps and determining the time required for completion (Fellows and Liu, 2015).

Nowadays questionnaires can be distributed via post or via the internet. Internet questionnaires are normally delivered by e mail, via a website or social media. Initially, an online survey is created as a web form to store the answers and allow statistical software such as SPSS to provide statistical analysis. Social media typically refers to internet-based applications that allow for the development of user-generated information and provide a forum for users to interact with each other (Oleary, 2011). Social media therefore has the potential to snowball the questionnaire. Hubermann et al (2009) assert that the web has facilitated discussions over email and is changing the method of scholarly communication.

5.7.3.1. The questionnaire strategy adopted by this research

Stones, (1993) 10 step plan was followed in the design of the questionnaire thus the data required from the research was first identified in order to address the research objectives. The questionnaire has been designed to ask questions in order to answer the following the research objectives.

- To establish the critical success factors of BIM to the QS that will identify the opportunities and challenges to the quantity surveying organisation when adopting and implementing BIM;
- To determine the implication of organisation BIM learning in creating and adding value to the quantity surveying organisation.
- To determine the organisational changes needed to accommodate BIM in a quantity surveying organisation to support the value proposition of BIM.

The design of questionnaires can be structured, unstructured and semi-structured. A structured questionnaire focussing on the research objectives, with closed questions was selected as being the most appropriate for this research. It was held that it was easier to answer a specific closed question, and as such would yield a bigger response. The closed-ended questions required the respondents to select an answer from a number of given options, those options being mutually exclusive and exhaustive. The respondent’s answers could then generate data which could then be easily analysed quantitatively for trends and patterns. In addition, the researcher allowed limited flexibility to respondents in order to gather some qualitative data and offer the respondents the choice of “other” in which they could write free text.

The questionnaire was divided into 6 sections to help in the organisation of the research variables.

Section 1

Organisation

This section focuses on obtaining information about the organisation that the respondents worked for including: number of employees, type, location, turnover, years of operation and market sector. The data provided could be used to test the relationship with other variables identified in the study.

Section 2

QS Services

This section focuses on the QS services provided by the organisation and the impact of BIM on the QS role that provides these services. It gathers the perceptions of the respondents in relation to the services offered with BIM and those that do not, the work stage as laid down by the RIBA plan of work 2013, that BIM was adopted and if they felt this adoption had impacted on their role. This is essential to the research as it indicates which of the services are able to adopt BIM, which in turn, will identify the services the organisation should focus on in the BIM planning stage of implementation. Additionally, it will identify the services the QS offers that are unlikely to be impacted by the BIM. An understanding of the stage of adoption of BIM will support the research in determining the most effective stage of adoption for the QS organisation as it relates to other services. Finally, the perceptions of the QS on the impact of BIM to their role is central to the research is it is these perceptions that influence the success of BIM adoption by the organisation.

Section 3

BIM

This section focuses on what the respondents understanding of BIM is and how they perceive what the benefits and barriers are to the adoption of BIM to the organisation. This section also establishes the organisations experience of BIM as determined by its BIM maturity level, documentation used, the years adopted and its strategy for adoption. An understanding of what BIM is in terms of definition is seen as essential to the study along with perceptions, as the definitions placed upon BIM will influence how and for what purpose BIM is adopted by the organisation, i.e. what it means to them. The benefits and barriers to adoption can be used to identify the critical success factors that the QS organisation will consider at the strategic stage of adoption. BIM Level 2 is the Governments mandate for publically procured buildings, the maturity level that the QS organisation is working at can be used to measure successful adoption if success is perceived to be Level 2.

Section 4

Organisational Development and BIM

This section focusses on the organisation and its preparation for adopting BIM. It establishes why the organisation chose to adopt BIM, the changes required to the organisation in order to adopt and the holistic benefits to the organisation as a consequence of its adoption. The research is considering the value creation and survival of the QS organisation, hence, it is essential to see if the QS organisation possess the characteristics typical of an organisation that can grow and survive, and if not, if it has the potential to manage the change required to evolve and create value. This section will also help identify if the QS organisations' perceptions of the benefits of BIM align with those of the QS.

Section 5

BIM learning

This section seeks to establish who has led the development of BIM in the organisation and how the knowledge gained from adopting BIM has been collected, stored and transferred. It also considers the respondent's perceptions of their own BIM learning and how it relates to that of the organisation. BIM leadership is important in terms of, organisational learning is it being driven down from the top or driven up from the bottom? Knowledge is important to the QS organisation, particularly, when new services are offered in terms of acting on lessons learnt in order to increase the efficiencies and the effectiveness of the service and create value. This section will provide an indication of how QS organisations are currently capturing and transferring knowledge and identify if QS organisations are demonstrating the characteristics of a learning organisation, which is deemed to be an important component of organisational growth and value creation.

Section 6

Personal details

This section focusses on eliciting demographic data about the respondents in relation to their job title and age. This was important for providing basic data for the project about the individual completing the survey.

The questionnaire for this research was piloted with 2 academic members of staff from LJMU and 4 quantity surveyors. As a result, the following amendments were made:

- The wording of the questions was amended to ensure clarity
- Some of the questions were changed to include a definition and/or more detailed explanation
- Some questions included further options
- Spellings and grammar mistakes were corrected
- The measurement scale was amended and the ranking questions changed to a Likert scale
- Missing intervals were inserted.

Moreover, the pilot study showed that the questionnaires took between 15 to 20 minutes to complete. Some of the pilot respondents commented that the questionnaire was lengthy and that this might have a negative impact on the response. The researcher took the decision to make the amendments but to retain the questions and to distribute the questionnaire in its entirety as it was felt that all of the data was required to achieve the objectives of the research.

The design of the questionnaire ensured that there was a similar direction in the scales to prevent confusion in relation to the answer response options.

Saunders et al (2102) contend it is important to examine the internal stability of the questionnaire to ensure reliability. Cronbach's alpha determines the internal consistency or average correlation of items in a survey instrument to gauge its reliability and is commonly used when you have multiple Likert questions in a questionnaire that form a scale. In order to test the reliability of the Likert scale adopted in this research the Cronbach statistical reliability test (internal consistency) was conducted. This technique is common in statistical research, the coefficient Alpha ranges between 0 and 1. The higher the Alpha co efficient is the more reliable the scale, with 0.7 as the minimum acceptable reliable figure (Field, 2015). Using SPSS and Cronbach's Alpha the reliability of the responses for this research were tested.

For the purposes of this study, the surveys were administered via e mail and online. The survey was developed using Bristol Online Survey (BOS), an easy-to-use tool which allows the researcher to develop, deploy, and analyse surveys via the internet. BOS allows the creation of an unlimited number of surveys for an unlimited number of respondents. Additionally, it allows researchers to share surveys with each other, thereby encouraging research collaboration. In this instance e mail and LinkedIn were adopted to talk with colleagues and expand the research information. Furthermore, appropriate social media has been utilised to share the research with an audience, which possesses the appropriate characteristics required of the sample.

A purposive/non probability from of sampling which samples in a strategic mode (Bryman, 2012) in combination with a quota and snowball strategy was adopted to distribute this questionnaire. The purposive sample used to distribute this questionnaire were quantity surveyors known to the researcher and who were part of the professional network to which they belonged. The quota sample comprised of quantity surveyors who possessed identified characteristics and were identified as being members of professional groups accessible via the internet. i.e. LinkedIn.

The purposive sample were contacted via e mail which provided the sample with the aims and objectives of the research and a hyperlink connecting them directly to the online survey. In the mail they were also asked to forward the e mail to other QS colleagues in their professional network in order to encourage as many QS's to complete as possible (snowballing). The quota sample were contacted via professional groups on LinkedIn and included: BIM Experts, RICS, the BIM Roundtable, Quantity Surveyors and Commercial Managers and RICS Building Information Modelling. Information detailing the research aims and objectives and the hyperlink to the online survey was posted on these sites. A total of 183 respondents were utilised after the data was cleaned.

5.8. Data analysis

5.8.1. Sample size

The sample size must be sufficiently large to satisfy the requirements of the statistics adopted to analyse the questionnaire. The larger the sample size the closer its distribution will be to the normal distribution and thus the more robust the findings will be.

Initially literature focussed on the absolute sample size with Guilford (1954) recommending a minimum sample size of 200 in contrast Comrey (1978) suggested a sample of 500 would be a good sample size. Catell (1978) suggested that whilst 500 would be a good sample size that 200- 250 would be acceptable.

More recent literature suggests that these suggestions were inconsistent and recommendations on absolute sample size has been abandoned as misconceived (Jackson, 2001; MacCallum et al, 1999). It has been suggested that there are no absolute thresholds, as the minimum sample size is a function of several parameters including the level of commonalities, loadings, number of variables per factor, and the number of factors. communalities, loadings, number of variables per factor, and the number of factors (Gagné and Hancock,2006; MacCallum et al., 1999; Marsh et al, 1998; Velicer and Fava, 1998).

MacCallum et al (1999) developed a framework that did not set absolute thresholds for sample size. The framework indicated that factor recovery improves as: a) Sample size increases, b) Communalities increase, c) pattern factor increases; the effect of pattern factor decreases as communalities increase and it may also interact with sample size. The simulations carried out in this research applied a minimum sample size (N) of 60 although their theoretical framework is expected to be applicable to smaller sample sizes, just how small a sample size can be and still yield acceptable solutions remains unclear (De Winter et al, 2009).

The validity of the results can also be assessed in terms of confidence limits and confidence intervals. Confidence limits for the mean (Snedecor and Cochran, 1989) are an interval estimate for the mean. Instead of a single estimate for the mean, a confidence interval generates a lower and upper limit for the mean. The interval estimate gives an indication of how much uncertainty there is in the estimate of the true mean. The narrower the interval, the more valid the estimate. Confidence limits are expressed in terms of a confidence coefficient eg.90 %, 95 %, and 99 % intervals are often used. The confidence limit and confidence interval can also be used to calculate level of precision of an existing sample.

5.8.2. Data types

Quantitative data can be classified into data types “using a hierarchy of measurement, often in ascending order of numerical precision” (Saunders et al. 2012, p 475). There are four measurement scales used to categorise different types of variables: nominal, ordinal, interval and ratio.

Nominal data do not have a numerical value and are purely descriptive and are classified into categories according to the characteristics that describe the variable fixed e.g. Contractors QS or Consultant QS. Therefore, they do not allow for a comparison between numbers to be made (Brown, 2011). In contrast, ordinal scales typically measures non numeric concepts e.g., satisfaction, agreement etc. and identifies the data in rank order although the distance between the ranks is not measured. Ordinal data is the more precise form of categorical data in that the relative position of each case within the data set is known e.g. strongly agree, agree, neither, disagree, strongly disagree.

In contrast, numerical data are those whose values are measured or counted numerically as quantities (Berman Brown and Saunders, 2008, cited in Saunders et al (2012, p 475). Numerical data can be subdivided into Interval and Ratio. Interval data states the fixed interval between any two data values for a particular variable e.g. 21-30 years, 31- 40 years. In contrast, ratio data allows the researcher to calculate the relative difference between any two data values for a variable (Saunders et al, 2012).

The questionnaire in this research was designed to collate individual QS's perceptions of BIM within their organisation based on their personal experience and knowledge and as such is deemed to be subjective qualitative data. The questionnaire in this research was designed using nominal, ordinal and interval data types. The respondents were asked to award a score against some of the variables based on their level of agreement, where 1 is allocated Strongly disagree ,2 Disagree, 3Neutral, 4, Agree and 5 Strongly agree. Other variables were measured by asking the respondents to answer specific questions that could then be later measured at the analysis stage by applying a score against the response e.g. in relation to what changes were made to the organisation as a consequence of BIM the respondents were asked to state whether the variable identified was as a consequence of major change (allocated 2), minor change (allocated 1) or no change allocated 0.

5.8.3. Statistical significance tests

There are two main classifications of statistical significance tests: non parametric and parametric (Field, 2013).

Parametric

Parametric tests are based on the assumption about the distribution of the underlying population from which the sample was taken. The most common being that it was normally distributed. The data should be interval data and the participants randomly selected (Pallant, 2007). Parametric statistics are often considered to be more powerful because it is based on numerical data (Saunders et al, 2012).

Non parametric data

Non parametric tests in contrast do not rely on assumptions about the shape or form of the probability distribution from which the data is drawn. The data can be categorical or ordinal and the sample not randomly selected. (Field, 2013)

In determining the appropriateness of each test for the study, consideration needed to be given to the type of variable, i.e. interval, ordinal or categorical and whether or not they are evenly distributed. Table 5.3 illustrates the tests available.

Table 5-2 Statistical tests available for analysis of data

What are you testing?	Categorical		Numerical	
	Descriptive	Ranked	Continuous	Discrete
	Tests available		Tests available	
Normality of distribution			Kolmogorav - Sminov Shapiro-Wilk	
If two variables are associated	Chi square		Chi square	
	Cramer's V Phi			
If two groups are different(respondents over time)		Kolmogorav - Sminov Mann- Whitney U	Independent t Paired t(used for changes over time) Mann- Whitney U	
If three or more groups are different			Analysis of Variance (ANOVA)	
The strength of relationship between two variables		Spearman's rank correlation (Spearman's rho Kendall's rank order correlation coefficient Kendall's tau	Pearson's product moment correlation coefficient (PMCC)	

Adapted from Saunders et al (2012)

5.8.4. Test normality or distribution within the population

The sample must be tested for normality to assess whether the distribution as a whole for a variable differs significantly from a comparable distribution.

This test is essential to ensure that the questionnaire provides an accurate view of the perceptions held by the population surveyed, in that it held a statistically probable response. There are several tests that facilitate this but before one can be selected the data itself must be classified as parametric or non-parametric in order that the most appropriate test is selected.

In order to consider if the distribution of the scores in this research deviate from a comparable normal distribution the Kolmogorov-Smirnov test and the Sharpio- Wilk test were applied utilising the SPSS23 software in order to calculate automatically. These tests were conducted for each dependant variable under investigation and identified that the data in the questionnaire were not normally distributed. Field, (2013) warns of the dangers of significance testing particularly as it relates to sample size, however in this research with a sample size of 183 the Kolmogorov-Smirnov test was considered appropriate.

5.8.5. Descriptive statistics

Descriptive statistics describe what it is or what the data shows and are used to present quantitative descriptions in a manageable form. These statistics include the Mean (average), Standard deviation, SD, (how much the score deviates from the mean and the minimum and maximum scores.) These statistics are suitable for an initial description of the data.

5.8.6. Inferential statistics

Inferential statistics allows conclusions to be reached that extend beyond the immediate data alone and to infer from the sample data generalised results from which reliable conclusions can be drawn. Both parametric and non-parametric data are considered inferential (Field, 2013). Parametric tests can provide assumptions about the entire population provided that the data is assumed to be normally distributed. In contrast, non-parametric tests do not make assumptions regarding the entire population. It is essential therefore that this research selects the most appropriate test in order to answer the research question.

The chi square test considers if two variables are associated and calculating the probability if the data could occur by chance alone. A probability of 0.05 or smaller means that there is 95% certainty that the association between the two variables could not have occurred by chance alone.

The "*t*" test compares the differences in two groups using a measure of the spread of the scores. It is aimed at discovering whether two independent groups significantly vary from one another or not. If the likelihood of any difference between these two groups by chance alone is low this will be represented by a large t statistic with a probability less than 0.05. This is termed statistically significant (Saunders et al 2012).

The Mann-Whitney U test is "a statistical test to determine the likelihood that the values of ordinal data variables for two independent samples or groups are different (Saunders et al, (2012, p.674). It is often used to compare the means and medians of two independent possibly non normal distributions and when the assumptions of the independent samples t tests are not met. This test is the non-parametric equivalent of the independent groups "*t"* test (Dancey and Reidy, 2007).

In order to judge the size of the effect Cohen (1992,1998) suggested what constitutes a large or small effect (cited in Field,2005, p7).

- r = 0.10(small effect), in which the effect explains 1% of the variance
- r = 0.30(medium effect), in which the effect explains 9% of the variance
- r = 0.50(large effect), in which the effect explains 25% of the variance

The r value will be calculated for each variable in order to determine the size of the effect in this study.

If a numerical variable is divided into 3 or more distinct groups using a descriptive variable, the likelihood of these groups being different occurring by chance alone can be tested using one-way analysis of variance or one-way ANOVA. This test analyses the variance, the spread of data values, within and between groups of data by comparing means. These differences are represented by the F ratio. A large F ratio with a probability of less than 0.05 is termed significantly significant, concluding that the likelihood of any difference between the groups occurring by chance alone is low.

The Kruskal Wallis test is the non-parametric version of Annova and a generalised form of the Mann Whitney test. It allows for two or more groups, one independent variable with two or more levels and an ordinal dependant variable. A statistically significant difference in variables across the groups is identified if the significance level (Asynp) value is less than .05.

Pearson's correlation coefficient tests whether two variables are correlated with each other or not. This is suitable for finding the strength of relationships between variables, positive or negative. Positive correlation between two variables explains that if a score in one variable increases the other variable will also increase (linear increase) and negative correlation demonstrates that if the score in one variable increases the score in the other variable will decrease. The value of the coefficient falls between 1 and -1, with 0 representing perfect independence, the closer to -1 denotes a very strong negative relationship and the closer to 1 denotes a very strong positive relationship. (Hair et al 2006).

Spearman's rank correlation coefficient is a nonparametric (distribution-free) rank statistic which considers the measure of the strength of the association between two variables, without making any assumptions about the frequency distribution of the variables. Unlike Pearson's coefficient, it does not require "the assumption that the relationship between the variables is linear, nor does it require the variables to be measured on interval scales; it can be used for variables measured at the ordinal level" (Hauke and Kossowki, 2011, p.89). It does however demonstrate if a negative or positive correlation exists between the variables in much the same way as Pearson's allowing the same conclusions to be drawn from the non-parametric data of this research.

5.8.7. Data analysis methods adopted in this research.

To examine the relationships, trends and differences in the data collected the questionnaire responses were analysed using the statistical Package for Social Sciences (SPSS) version 23. This data has been identified as non-parametric and therefore is not normally distributed. SPSS23 software provides different options for non-parametric tests. The type of test selected will be determined by the type of variables used in the research, i.e. interval, ordinal or categorical (Jamieson, 2001)

The data in this research is non parametric and will adopt the Mann Whitney test to evaluate if the ranks for the groups are significantly different (Pallant 2007). A total of 183 participants consisted of 71CQS, 96COQS, 7 client QS and 9 other. The two main groups only, i.e., CQS and COQS, as the two main respondent groups, will be assessed to see if there is a statistically significant difference between each group this will be achieved by conducting the Mann Whitney test on the key variables. As the sample size exceeds 30, SPSS will produce a value for a Z- approximation test which includes a correction for ties in the data. It is also important to report effect sizes in order that a standardised measure of the effect observed in this study can be used to compare against other studies. (Field, 2013). Non parametric tests are not as powerful as parametric tests because they are based on fewer assumptions (e.g., they do not assume that the outcome is approximately normally distributed). Notwithstanding this it is held that this test will be the most appropriate, to accurately test the data in this research as it can be used when the data is ordinal and when the assumptions of its alternative the “t” test cannot be met, i.e. , the data is not normally distributed.

To assess the strength of the relationship between the ordinal data variables Spearman’s rank correlation coefficient test will be applied to the data in this research and will be used particularly to test the hypothesis to see if a negative or positive relationship exists between the selected ordinal data variables. Unlike the parametric equivalent test Pearson, the Spearman’s correlation evaluates the monotonic relationship where the relationship between the variables tend to change together but not necessarily at a constant rate. It does however demonstrate if a negative or positive correlation exists between the variables in much the same way as Pearson’s allowing the same conclusions to be drawn from the non-parametric data of this research.

5.8.8. Focus groups

A focus group is a group interview with a clearly defined topic to be discussed, with a focus on enabling and recording group interaction between the participants (Kreugar and Casey, 2009). However, it is important to distinguish between a group interview and a focus group. A group interview involves interviewing a number of people at the same time with an emphasis on the questions and responses between the researcher and participants, whilst focus groups rely on the interaction within the group, based on topics that are supplied by the researcher (Morgan 1997). It is a series of discussions to obtain perceptions on a defined area of interest in a non-judgmental, non-threatening environment (Franz, 2011).

Focus groups have a long history, and can be dated back to the applied social research programmes of World War II were they were driven by communications research to establish how people felt about wartime propaganda (Franz, 2011). In recent times focus groups have been increasingly adopted as a method in social science research for collecting qualitative data (Stewart et al.,2007). Morgan (1997) contends that they are still under-utilised in social research. Nesensohn (2014) undertook a search in the Journal of Construction Management and Economics and identified the number and range of focus groups studies adopted in the Built environment research, identifying different drivers for their adoption.

They can be used either as a method in their own right or as a complement to other methods, especially for triangulation (Morgan 1997) and validity checking.

Morgan (1997) identified that focus groups can be adopted as a:

- Single source method
- Supplementary source
- Multi method study

They can be adopted at any stage in the research: at the preliminary or exploratory stages of a study (Kreuger 1998); during a study, to evaluate or develop themes (Race et al 1994); or after a programme has been completed, to assess its impact or to generate further avenues of research. Finally, focus groups are often used in conjunction with other methods of collecting data e.g. surveys and interview for triangulated/multi method studies (Fellows and Liu, 2015).

5.8.8.1. Focus Group Design

The purpose of the research determines the design of the focus group (Knodel, 1993, Fern, 2001). Its design requires accurate planning and wise thoughts (Knodel,1993). Krueger (1993) asserts that when designing a focus group the following themes should be considered: (1) clarity of purpose, (2) appropriate environment, (3) sufficient resources, (4) appropriate participants, (5) a skilful moderator, (6) effective questions, (7) careful data handling, (8) systematic and verifiable analysis, (9) appropriate presentation, and (10) honour the participants.

Morgan (1997) contends that the operation of the focus group will be better when the participants possesses similar characteristics and understanding of the topic. For this research all participants' held senior positions in their role as a QS and all were leading the development of BIM within their organisation. The recommended number of people per group is usually six to ten (MacIntosh,1993), but some researchers have used up to fifteen people (Goss & Leinbach,1996) or as few as four (Kitzinger,1995). Furthermore, numbers of groups vary, some studies using only one meeting (Burgess 1996). The number of participants for this research was determined as 4 and one focus group was held. The number of participants for this research was kept small as it was held that it makes more sense to run smaller groups if the topic of interest is in a specific segment and the researcher is interested in the unique expectations (Fern, 2001).

Finally, neutral locations can be helpful for avoiding either negative or positive associations with a particular site or building (Powell & Single, 1996). This was an important consideration as it was recognised that bringing together 4 QS professional from across the UK would not be easy and that it would be preferential if a neutral location midway between all of the participants was the location for the focus group.

The focus group for this research gave careful consideration to Krueger's 10 themes when designing and organising the focus group for this research. The focus group for the research comprised 4 quantity surveyors: 2 working in a consultant capacity and 2 working for a contractor. An informal loosely structured conversational focus group was held with all 4 participants to consider the framework in order to validate.

5.8.8.2. Focus Group Sample

A purposive/non probability form of sampling which samples in a strategic way (Bryman,2012) was applied to this research.

Different kinds of sampling are available for the focus group format, such as:

1- Maximum Variation Sampling 2- Typical Sampling 3- Theory or Concept Sampling 4- Homogeneous Sampling 5- Critical Sampling 6- Opportunistic Sampling 7- Snowball Sampling.

A homogeneous group was selected for this research as it was felt the participants would feel more confident in giving their opinions as they share a similar social background, level of education, knowledge and experience about the topic of interest (Sim,1998).

5.8.8.3. Focus group participants

It has previously been stated that similar characteristics and topic knowledge are essential to facilitate open and transparent discussion in a focus group. Sage (2009) affirms it is crucial that the right people are asked to participate.

To ensure the appropriate people were invited to participate in the focus group for this research, the researcher defined the selection criteria and the required characteristics for this study as:

- Senior management position in the field of BIM/ QS employed in either a consultant or a contracting organisation.

- Organisation currently working towards or at BIM Level 2.

- Minimum of ten years' experience working in the construction industry.

- Participated in Stage 1 or 2 of the research.

The characteristics in relation to the QS role and BIM knowledge were obviously essential to ensure the participants had sufficient knowledge that they felt comfortable in their ability to exert and share this knowledge with the other members of the group. The number of years' experience and the organisation working at or near to Level 2 ensured that the participants were familiar with work practices before the introduction of BIM and therefore could use their reflections and historical knowledge to help formulate opinions in relation to the framework, from both a future and historical perspective. The fact that they were already aware of the research meant that they came to the focus group with a more in depth knowledge of the research topic and further facilitate the exchanging ideas and experiences in relation to the validation of the framework.

The researcher contacted 6 participants in their network that satisfied the characteristics established essential for the focus group. They were first contacted by telephone to establish if they had the capacity to become involve in a focus group for this research. Only 5 of the 6 telephoned agreed to contribute further in the research. Morgan (1997) asserted it is better to recruit more participants than required to allow for participants dropping out at the last minute. All 5 participants were then sent an email inviting them to participate as professionals with appropriate expert knowledge in a unique group discussion to validate the draft Survival framework formulated as a result of Stage 1 and 2 research to date. In addition, they were provided with further information about the research, details on the purpose of the focus group and the draft Survival Framework. Morgan (1997) recommend that the participants are followed up to ensure that they attend. The participants were sent a meeting request via Outlook with details of the venue, time and date once they had confirmed their willingness to participate. One week later they were e mailed an Agenda for the day, plus further information including: consent forms, participant information sheets, a profile template and the group skype link set up to facilitate the discussion. The day before the meeting they were contacted by text to remind them of the skype meeting the following day, reinforcing its importance to the researcher, as advised by Kreugar and Casey 2009). As a consequence of the strong follow up procedure adopted in this research 4 out of the 5 participants attended the meeting.

5.8.8.4. Recording and transcribing

Kreugar (1993) asserted that quality data required quality equipment. The equipment was carefully selected and a high quality laptop and voice recorder positioned appropriately in a room with restricted access to prevent any interruptions to the meeting. To ensure the quality of the recorded statements the participants were asked to test the equipment raising their awareness to speak clearly, not to adopt nonverbal communication and to avoid were possible speaking simultaneously. Simultaneous speaking is a major disadvantage when recording focus groups. (Fern, 2010). The systematic approach to the recording of this focus group was the first stage in the production of higher quality analysis (Kreugar, 1993).

The session was transcribed and the transcript checked and corrected by the researcher in order to facilitate further in depth analysis (Kvale, 1996).

5.8.9. Data analysis

Blismas and Dainty (2003), recommend the use of computer aided analysis in the field of construction management as it can enhance qualitative research by improving the facility to code and retrieve all of the data. Miles and Huberman (1994), warn of the dangers of such adoption as it could bring technical barriers, as learning how to use the software effectively, can pose a challenge for the researcher and as a consequence may slow down the analysing process. Having given careful consideration to adopt or not, computer aided analysis was adopted to organise, store and analyse the data for this research.

The next stage involved selecting the appropriate programme. A code based theory builder programme was adopted that divided the textual data into chunks attaching codes to the data, in order to make connections amongst the codes to help interpret a structure and/or to formulate propositions (Miles and Huberman, 1994). NVivo was selected as the most appropriate programme to support this researcher and thematic analysis used to analyse both the interviews and the focus group data.

5.8.9.1. Validation strategy and reliability

Once the data has been gathered it is important to check the validity of the data (Miles and Huberman, 1994) as an invalidated framework/model could affect the evaluation of the research (Amartunga et al, 2002).

Lincoln and Guba (1985) discussed validation in relation to the trustworthiness of the research and used terms of credibility, transferability, dependability and conformability. Transferability is often referred to as generalisability (Ritchie, et al, 2003). Trustworthiness in terms of interpretative research has expressed validation as the judgement of trustworthiness or goodness of the research (Angen, 2000). More recently, Creswell (2013) discusses validation in qualitative research as the endeavour to evaluate the result in relation to their accuracy.

The validation strategy adopted for this research is triangulation as this research adopts a pragmatist approach and collects its data using a mixed methodology. The basis of triangulation is to confirm the findings through the use of numerous autonomous sources and different systems or investigators, to demonstrate the self-consistency of the findings (Miles and Huberman, 1994). Jick (1979) supports the use of triangulation with mixed methodologies, as it can heighten qualitative methods to their deserved prominence, whilst at the same time demonstrate that quantitative methods can and should be used in a complementary fashion. Furthermore, triangulation using multiple methods can help facilitate deeper understanding and countenances the accuracy of the data collected (Bryman and Bell, 2007).

Blaikie (2010) suggests that triangulation is just one possible approach within a ‘mixed methods’ design, referring to “studies that combine qualitative and quantitative methods in parallel or in sequence” (p.219). Morse (1991) outlined two types of methodological triangulation: simultaneous or sequential. Simultaneous triangulation adopts qualitative and quantitative methods simultaneously but there is limited interaction between the two sources of data during the data collection stage, and the findings complement one another at the data interpretation stage. Sequential triangulation is adopted where the results of one approach are obligatory for planning the next method. It is the latter approach of sequential triangulation that will be adopted in this research as the results from the interviews informed the questionnaire and both informed the framework.

The adoption of first the literature review followed by qualitative and quantitative methods in this research, adopting semi structured interviews and questionnaires, served as a means to triangulate the data. In some instances, the two methods confirmed the literature and each other whilst there was some identification in the interviews that highlighted areas for further research. The literature feeding into the exploratory, the interviews feeding into the questionnaire and the questionnaire into the focus group and subsequently informing the framework. The intention being that the outcome of the triangulation will provide a more accurate measurement of a phenomenon or a more complete picture (Denscombe, 2008). In this research, the use of multiple lines of enquiry is intended to enhance the understanding of the problem.

5.9. Ethics

As these methods involve human participants it is essential that ethics is also given consideration within this chapter as “ethics are critical aspects for the success of any research project” (Saunders et al, 2012, p208). It is important whether the researcher collects secondary data or primary data, via interviews or questionnaires, that prior to commencing the research, the research is scrutinised and approved as adhering to ethical guidelines.

This research gained ethical approval from the Research Committee of Liverpool John Moores University June 2013. The documents adopted during this research and approved at the committee can be found in APPENDIX 1. The ethical activities that have been implemented by each of the adopted research methods is illustrated in Table 5.3.

Table 5-3 The ethical activities undertaken in this research

Ethical activity	Interviews	Questionnaires	Focus Group
Written consent obtained from the research participants	✓	✓	✓
Research participants were provided with an information sheet detailing the purpose, benefits and risks appertaining to the research	✓	✓	✓
The contact details of the researcher were provided to the research participants.	✓	✓	✓
The research participants were guaranteed anonymity.	✓	✓	✓

5.10. Chapter Summary

This chapter has introduced and established the research methodology chosen for this research into BIM, the QS, and organisational growth and value creation. It has provided a justification in relation to the aims and objectives of the research for each of the data collection methods adopted. Additionally, it has demonstrated why the methods are appropriate, how they have to be used and their deployment within this research.

6. Findings: interviews.

6.1. Introduction

The preceding chapters have justified the underlying premise of the research to be that of an interpretivist viewpoint. A case was made for a mixed methodology reflecting the desire for the empirical data to be underpinned by qualitative enquiry comprising exploratory investigation of BIM-enabled QS's from both a contracting and a consultant background along with BIM industry experts. This exploratory data feeds into the research design of the subsequent and more detailed quantitative investigation in the form of a questionnaire.

Having presented the data collection and analysis procedures of the study in the previous chapter, this chapter presents the results of the exploratory studies, the questionnaire, focus group and the subsequent development of the framework for analysing the QS organisation and Survival in a BIM enabled environment. The findings of the exploratory study, coupled with the review of the literature presented in chapter 2 will help formulate the structure and detail of the questionnaire. The findings from the literature, the exploratory interviews and the questionnaire will then support the achievement of objective 5 to propose a framework that can support the survival of Quantity Surveying organisations in a BIM enabled environment.

The outcome of the analysis will highlight issues requiring particular attention in the design process and inform the design for the potential framework to be validated by the focus group. The section concludes by summarising the key findings and the implications for the framework development.

6.2. Results of the exploratory interviews

The analysis is structured into 5 sections covering each of the high level themes and associated mid-level and low levels themes.

The exploratory interviews present a view of BIM implementation by the Quantity Surveying Organisation and its perceived benefits and barriers to both the organisation and the QS function, the goal being to identify the key drivers for BIM adoption by the QS and to identify the obstacles that could impact on the survival of the QS role. 8 industry practitioners, representing 3 consultant QS's (CQS), 3 contracting QS's(COQS) and 2 BIM industry experts(BE), backgrounds in civil engineering and architecture, participated in the exploratory interviews. Table 6.1 presents the details of the participants. The interview questions and sample transcript can be found in APPENDIX 2.

Table 6-1 Classification of individual interviews.

	Years in industry	Organisation currently working at or near to Level 2 BIM	QS in large contracting organisation	QS in consultant organisation	Member of the Government BIM task group
Interviewee 1	30	Y	Y		
Interviewee 2	20	Y	Y		
Interviewee 3	15	N	Y		
Interviewee 4	25	N		Y	
Interviewee 5	15	Y		Y	
Interviewee 6	20	Y		Y	
Interviewee 7	20	Y	Y		Y
Interviewee 8	30	Y	Y		Y

All participants were targeted based on demonstrable evidenced that they have implemented BIM in their organisations and have experience of BIM enabled projects. The participants are all senior members of their respective organisations with one contractors' QS and one consultant QS being responsible for the implementation of BIM within their organisation. All organisations are classed as large organisations, with an average turnover of 1.93 billion the average experience of the construction industry of each participant is 20 years. Large organisations were specifically selected as it was felt they were more likely to be implementing BIM in their organisations than SME's and as such would provide a rich data source.

The data collection for this study relies on semi-structured interviews focusing directly on the topic. The content of the analysis emerges from reading the interviews and identifying themes and sub themes through note taking in the first instance. By identifying the issues that appeared to be most important to the respondents a list has been developed including a thematic framework with themes and sub themes. The themes were identified adopting an inductive approach with the themes being strongly linked to the data because the assumptions are data driven. This framework is illustrated in Table 6.2.

Table 6-2 Initial thematic Framework: Individual Interviews

1. BIM
1.1 Definition
1.2. Level
1.3. Strategy
1.4 Use
2. Critical success factors
2.1 Barriers
2.2 Benefits
3. Quantity Surveyor
3.1 Barriers
3.2 Benefits
3.3 BIM application
3.4 BIM potential
3.5 Function
4. Knowledge and skills
5. Survival

Due to the amount of data provided by the interviews, indexing is carried out using Nvivo 11 to provide a structure to the data, the process of which enabled further refinement and the production of sub themes. Under the high-level theme there are several sub-themes which can be referred to as mid-level themes or child nodes. Some mid-level themes have another sub-division which is called low-level themes or baby nodes. As a consequence, 5 high level themes were identified some with associated mid and low level themes below. The distribution of passages in each high level theme as recorded per set can be seen in Figure 6.1. The CQS (Consultant Quantity Surveyor) records the most number of passages overall (238), the COQS (Contractors Quantity Surveyor) (192) and the BE records the lowest (101). The BE set only had two experts as opposed to the other sets which had three each, hence BE receiving the lowest number of passages overall is probably to be expected. This figure clarifies the emphasis of the qualitative research results. There is only a relatively small focus on ***Knowledge and Skills*** with the majority of the focus being on ***BIM*** and the ***Quantity Surveyor***. The participants had more to say in relation to BIM and the QS and far less to offer in terms of knowledge management suggesting that they didn't perceive knowledge management to be as an important an issue.

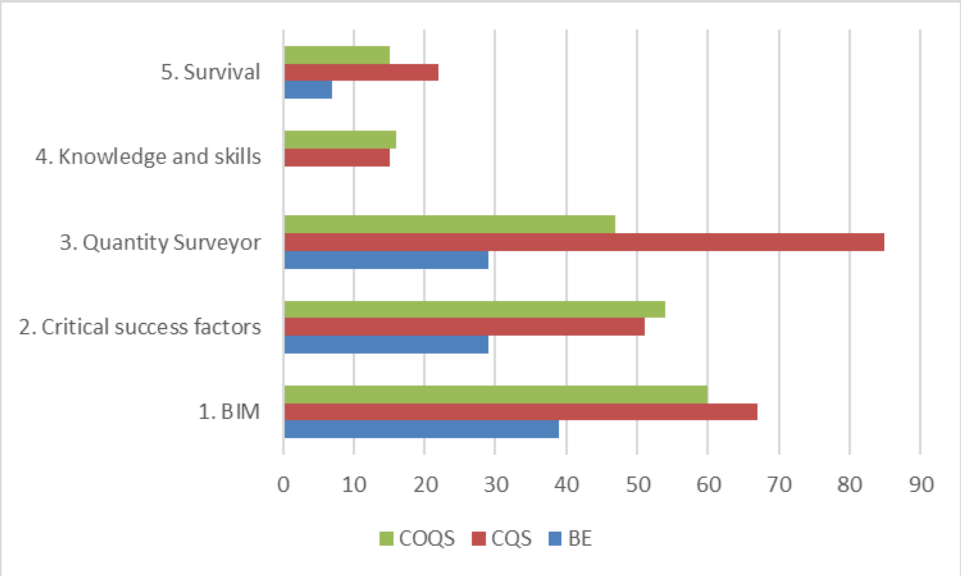


Figure 6-1 Division of recorded passages for all high level themes per set

The 8 interviews resulted in 5 high level themes, 11 mid-level themes and 34 low level themes. The total number of passages recorded over all themes is 531. This finalised framework is illustrated in Table 6.3. The contributions are evenly distributed between the CQS and the COQS in relation to most of the high level themes with the exception of the high level theme Quantity Surveyor where the CQS makes almost twice as many contributions as the COQS. This could be due to the fact that the COQS areas of responsibility were predominantly with the QS role whereas, as the job title suggests, 2 of the 3 COQS are predominantly involved with distributing BIM throughout the organisation as a whole and not specific to the QS field. The contribution from the BE is significantly less than the other two over all themes with no contributions in the high level theme of knowledge and skills. In relation to the high level theme, ***BIM,*** the expectation was that the contribution from the BE set would be significantly higher to that of the other sets due to the fact that they are senior advisors to the UK Government, one BE being the lead of the UK BIM Task Group Forum.

The two high level themes of ***BIM*** and ***Quantity Surveying*** recorded an almost identical number of passages with BIM receiving 166 and Quantity Surveying 156. The dominance of both themes is to be expected as a consequence of the research focus of this study. The mid-level theme ***definition*** within the ***BIM*** theme recorded the highest number of passages from all contributors in all sets. This too is to be expected as the selection of the contributors was based on their BIM knowledge and application. The high level theme of ***Knowledge and Skills,*** whilst not commented on by BE, were given once again, an almost equal weighting by the CQS and the COQS. The high level theme ***Survival,*** which is another major focus of this research, recorded passages from all contributors with the BE set recording less than half the responses of the other two sets. The CQS recorded the highest number of passages in this theme recording 50% more passages than the COQS. The high level theme of ***Critical Success Factors*** recorded a total of 134 passages which is almost equally distributed between the 2 mid-level themes ***benefit*** and ***barriers. Benefits*** recorded 65 passages, whilst ***barriers*** recorded a slightly higher number 65. In contrast, the high level theme ***Quantity Surveyor*** and the passages in relation to its midlevel themes of ***benefits*** **a**nd ***barriers*** showed a higher number of passages for ***benefits*** recording 42 passages barriers recorded significantly less with 25.

Table 6-3 Overview of the established passages and respondents for the thematic framework

High, medium and low level themes	Established passages by contribution in sets		
	BE	CQS	COQS
1. BIM	**39**	**67**	**60**
1.1 Definition	12	20	16
1.11 Collaborative process	5	6	9
1.12 Information management	2	6	3
1.13 Technology	4	6	2
1.14 Issues	1	2	2
1.2. Level	9	10	8
1.3. Strategy	9	19	8
1.3.1 No	0	13	0
1.3.2 Yes	9	6	8
1.4 Use	9	18	28
1.4.1 On what, by whom.	0	7	2
1.4.2 Project characteristics	0	4	1
1.4.3 Type of use	9	7	25
2. Critical success factors	**29**	**51**	**54**
2.1 Barriers	13	27	29
2.1.1 Capability	0	1	4
2.1.2 Client	3	2	0
2.1.3 Cost	3	2	4
2.1.4 Interoperability	0	2	0
2.1.5 Lack of confidence	0	9	6
2.1.6 Liabilities	0	1	7
2.1.7 People	5	4	5
2.1.8 Software	0	5	1
2.1.9 Standards	2	1	2
2.2 Benefits	16	24	25
2.2.1 Better data	1	3	1
2.2.2 Better Visualisation	1	0	4
2.2.3 Creates efficiencies	7	14	12
2.3.4 Improved Collaboration	0	2	5
2.3.5 Improved Communication	3	3	0
2.3.6 Improved decision making	4	2	3
3. Quantity Surveyor	**29**	**85**	**47**
3.1 Barriers	3	14	8
3.1.1 Confidence	0	4	4
3.1.2 Interoperability	0	0	1
3.1.3 Model	2	6	3
3.1.4 People	1	3	0
3.1.5 Software	0	1	0
3.2 Benefits	10	22	10
3.2.1 Better coordination	0	3	0
3.2.2 Creates Efficiencies	6	14	7
3.2.3 Faster information flow	1	2	2
3.2.4 Greater influence on the decisions	0	2	0
3.2.5 Increases accuracy	3	1	1
3.3 BIM application	3	16	9
3.4 BIM potential	4	17	6
3.5 Function	6	14	14
4. Knowledge and skills	**0**	**15**	**16**
5. Survival	**7**	**22**	**15**
Overall	**101**	**238**	**192**

The significant differences within the related passages and within the classification sets will be elaborated on in further detail under each of the five themes.

6.2.1. Theme1: BIM

The discussion within the theme ***BIM*** concentrated on the current perception of BIM in terms of its definition, maturity level, strategy for adoption and its potential use by the industry. This produced at total of 166 passages which involved a contribution from all 8 interviews. This theme is then further broken down into 4 mid-level themes, some with associated low level themes as illustrated in the thematic model shown in Figure 6.2

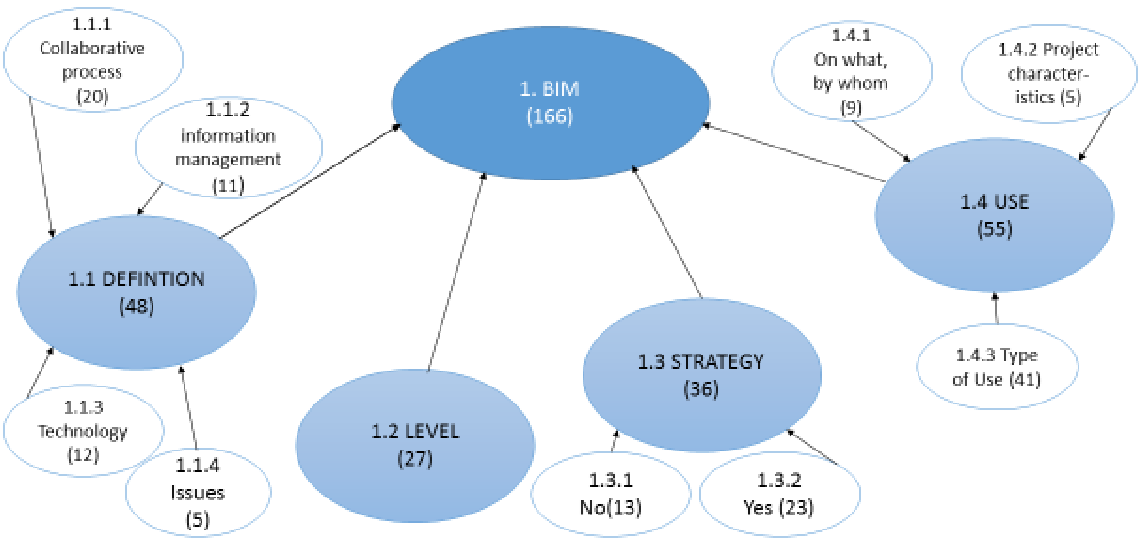


Figure 6-2 Thematic model 1- BIM

The differences of responses amongst the classification sets and the themes are shown in Table 6.4.

Table 6-4 thematic profile Theme 1- BIM

	BE	CQS	COQS
1.1 Definition	12	20	16
1.2. Level	9	10	8
1.3. Strategy	9	19	8
1.4 Use	9	18	28
Overall	39	67	60

6.2.1.1. Definition of BIM

The passages in this respect recorded a various degree of responses with the CQS recording the most and the BE the least. The interviews identified a number of low level themes within the sub theme of ***definition*** and these were concerned with how BIM is defined and what the basis for its definition should be, resulting in low level themes of ***collaborative process, information management*** and ***technology***. In addition, a fourth, low level theme, identifying the ***issues*** around its definition was acknowledged.

This mid- level theme ***definition*** produced 48 related passages, the CQS recording the most (20 passages) and the BE the least (12 passages) as illustrated in Table 6.4. All sets cautioned of the ***issues*** with defining BIM with 5 passages in total being recorded. The COQS2 stated "*we can say what BIM actually means to us".* However, *"the person asking the question doesn't actually fully understand what BIM is or how it should be delivered"* CQS1 argued.

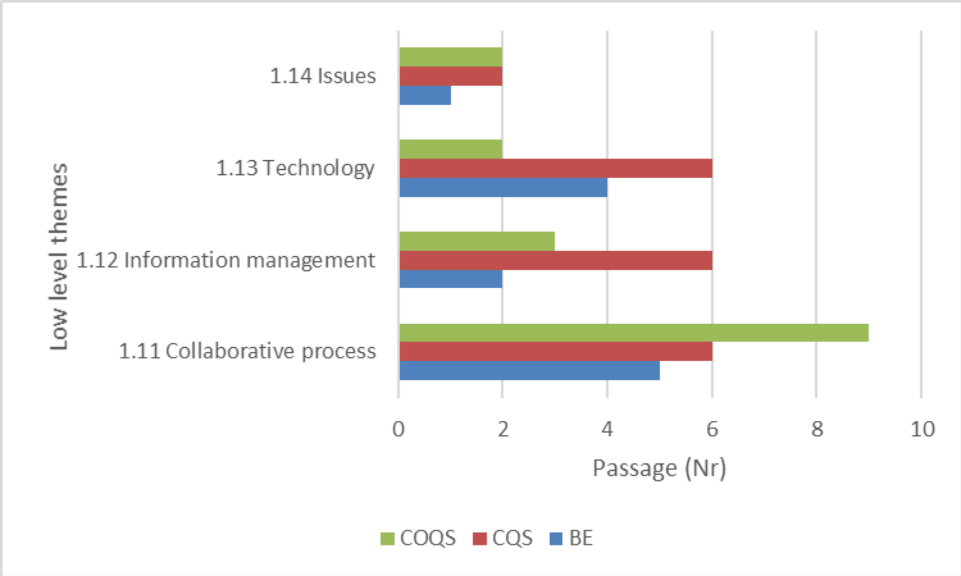


Figure 6-3 Division of the low level themes associated with Definition, according to set.

The difficulty with the definition was evidenced as the low level themes identified the different weighting the contributors choose to define BIM, as illustrated in Figure 6.3. The majority of the passages referred to BIM as being a collaborative process (20 passages) and not about the technology (12 passages). However, COQS3 combined process and technology asserting “whilst it is a process it does revolve around an electronic model for a project”. BE1 confirming the importance of models but adding ‘it’s a series of models it’s not a singular model’. In contradiction, CQS1 defined BIM as *“a set of protocols and a collaborative process rather than BIM as a 3D design tool”.* COQS2 commented on the importance of people and culture on its definition *offering an alternative combination “as a model, it’s a set of protocols and it’s also a process and it’s the kind of the culture and the dynamics of the project itself”.* COQS1 warns it should not be viewed as supplementary to the existing role *“it is a process that almost should be seen as the normal day to day job rather than something that’s additional”*

Information management recorded a similar number of passages (11) as Technology, with all sets recognising its importance. COQS1 assets, that BIM is about data storage and data management that can be “processed, mined, analysed call it what you want”. Furthermore, CQS2 makes reference to information through the life cycle of the project "*it's the information as everyone says, it's the "I" in BIM, so it's how you manage information throughout the life of a project".* All sets emphasised the project life extending beyond the traditional handover of the project extending to its operational life.

BE1 summed up all three themes succinctly in his definition stating BIM "*is prepared by different parties in the project lifecycle and it's within the context of a collaborative environment where the project participants, as the stakeholders, provide defined validated outputs and complete data transactions using proprietary information exchanges and various systems, in a structured and useable form"*

The results support the views expressed by Race (2012) that there is no single, agreed explanation or definition of what BIM and that the definition could evolve over time and with greater knowledge (Miettinen and Paavola, 2014). Interestingly, it can be concluded, the majority of the contributors agree it is a combination of process, collaboration, information and technology. All sets concluding that process is the key to its ultimate definition, thereby, recognising the importance of changing workflow patterns and project delivery processes to the successful implementation of BIM (Hardin, 2009).

6.2.1.2. Level of BIM

The second mid-level theme identifies the ***Level*** at which the industry is currently working in relation to BIM producing 28 related passages, as shown previously in Table 6.4. All sets recording a similar number of passages with BE(9), CQS(10) and COQS(8)

Most contributors agree that they were working at almost Level 2. CQS1 asserting that *"Level 2 and a bit is very exceptional*" if not impossible asserts BE1 "*let me tell you if everybody tells you they are at Level 2 they are lying to you".* BE2 claiming the complete set of PAS documents are not available *"so they can only be doing it in the spirit of Level 2".* A view not shared by CQS1 as he *claims "I wouldn't say we are all the way to Level 3 with BIM yet, but we kind of go beyond Level 2 in terms of the richness of the sharing".*

COQS2 differentiates between the operational and organisational level of BIM stating *"we can operate at Level 2, but we are not companywide at Level 2"*. A view supported by CQS1 "*We work at the level of maturity that we can with the team and with the project and with the client. The majority is probably still not even at Level 2 with many contractors' sort of working at about 1.8*". Interestingly both the contractor and consultant contributors agree that as an organisation, 100% Level 2 is currently not conceivable, due to the disparities between project team and clients. Finally, COQS3, asserts that other factors influence the level as *"it depends on the requirements of the customer. We tailor our solution to the dictate of the market".*

The industry currently appears to be operating below Level 2 but the organisation itself may well not be. Variations of levels, being identified throughout an organisation specific to the project, the project team, the client and the market conditions. Interestingly, the literature identified that BIM Level 2 was the mandated norm for the industry, i.e. the expected level and yet the contributors were not as an organisation hitting this industry standard.

6.2.1.3. BIM Strategy

The third mid-level theme is concerned with the adoption of a ***BIM strategy,*** which produced 36 related passages, this was mainly generated by the CQS set with 19 passages, as shown previously in Table 6.4. It was found that all but two of the contributors, notably CQS2 and CQS3, did have a BIM strategy; although there was much variance in its format and visibility (Marsh, 2014). However, CQS1 the only consultant claiming his organisation did have a BIM strategy identified its many layers emphasising *"Yes we've got one, well it's at two levels. At a group level we've got a whole lot of standards and protocols around delivering the project in BIM and then at a business level we've got a BIM strategy. In fact, our BIM strategy is one of our strategic priorities for the business so it's something that's reported back to* *the board every month".* The absence of a company BIM strategy did not prevent the business from offering project specific BIM strategies, CQS2 asserts, *"We do have a BIM working group. But what we do in terms of BIM, we develop strategies for clients'.*

In contrast all of the contributors from the contracting set worked for organisations that held a BIM strategy. Although, COQS1 comments *"that it has only been recently, only the last twelve months whereby we've really pushed through a group wide strategy which is now identified in a number of our flagship projects".* COQS2 breaks down their business BIM strategy into investigation and implementation asserting *"the strategy has now moved on a step now. So its yes we want to investigate and we're very much in the doing and making it happen stage now".* The need to investigate and research prior to implementation is essential claims CQS1 "as *we are doing quite a lot of research and activity into thinking about what BIM means for our service delivery model, what BIM means for the markets we face and the projects we deliver and how we organise and deliver those project".*

BE1 refers to the application of the BIM strategy being "*for asset lifecycle integration"* but recognises that *"not everyone in the company is aware of that and we are trying to up skill both our own workforce and the supply chain aligned with that strategy".* The BIM strategy therefore cannot be considered in isolation it must take into account the needs and drivers of the supply chain, a view supported by CQS1 who claims *"it's injected in to our commercial strategy, our project management strategy and everything else"*

A word of caution however was raised by contractor COQS3 *stating "we've already failed on lots of targets that are within the BIM strategy"*. To reduce the risk of failure it may be argued there is a need to investigate and implement a strategy that satisfies the requirement of the business and its market, whilst recognising that BIM might not be appropriate for all projects and clients.

It can be concluded therefore that the Contracting organisation is further ahead of the consultancy organisation in terms of planning and putting strategies in place for BIM. The consultants are still at the research stage investigating the business value of BIM and are proceeding with caution in terms of BIM implementation.

6.2.1.4. BIM use

BIM ***use*** is the fourth mid- level theme, which produced a total of 55 related passages and identified three low level themes in relation to ***type of use, on what and by whom*** and ***project characteristics***. This is illustrated in Figure 6.4.

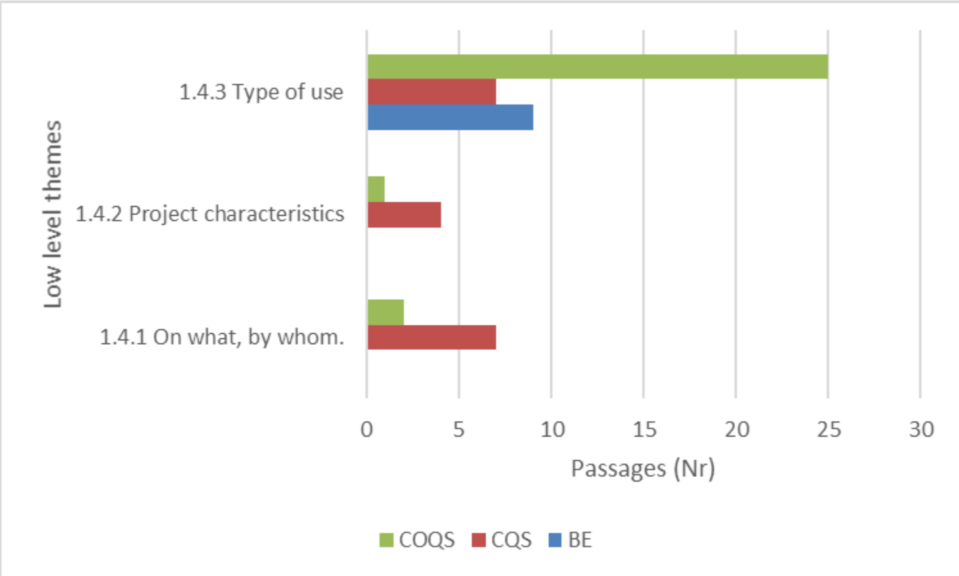


Figure 6-4 Division of the low level themes associated with BIM use, according to set.

There was an uneven distribution amongst the sets in relation to this theme with the majority being recorded against the COQS (28), CQS (18) and BE (9), all of the BE passages being recorded against ***type of use.*** The majority of the passages (41) were in relation to this theme of which 25 were attributed to the COQS set. The remaining two low level themes recording a total of 14 passages. This result was to be expected as the COQS have BIM strategies in place which will identify how the business intends to use BIM, as identified in 6.2.1.3 previously.

The majority of the contributors make reference to BIM being adopted to support collaboration, engagement and interaction throughout the project in order to facilitate decision making. BE2 succinctly states its use as *“a collaboration and coordination tool”*, whilst COQS3 makes reference to its value to support *the “sharing of information and collaboration across the design team, that’s core and fundamental to the value of the business”.* This view is supported by BE1 *“we do the entire asset lifecycle, through design, construct, and consultancy. So we use BIM throughout the business in terms of investment we use a non graphical data to make financial decisions. During design projects we would try to use it to be more effective in terms of our work force but also in terms of coordination and cost surety”.*

BIM can be adopted at the design, construction and operational stages of a project. Diverse applications for BIM were identified in the construction stage especially by the BE and COQS set *who use “BIM for safety, visualisation, optimisation, and logistics programme” claims BE1. A view supported by COQS2 claiming “we’re doing pre visualisation, we’re doing model co-ordination, clash detection, we’re doing time lining”.* COQS3 discussing outputs in terms of *“cost estimates, programmes estimates”*

In contrast, the CQS set generally are much more conservative, possibly due to them still being in the investigative stage, in their use of BIM, as a quantification tool *“adopting BIM measure to take off quantities on projects only were BIM is being implemented”* CQS2 records. In addition, it was noted by CQS2 that *“project managers may also interact with models in terms of collecting data”.* Similarly, to the COQS and BE sets, CQS1 represented a much wider ranging utilisation of BIM in his organisation claiming *“In terms of our UK Project Management and Quantity Surveying business we use BIM. We have experience of working with BIM in a QS capacity, in Project Management, Building Surveying and to a certain extent in terms of Health and Safety and sort of CDM co-ordination”*

BIM allows for other members of the project team, particularly the architect, to take on the traditional QS role of measuring quantities. BE2 purporting *“as* *architects we do the odd bit of quantification"*. COQS1 agreed with this affirming "*we had the architect working from the very beginning in a REVIT model to manage overall building area because during a bid stage building area is the absolute king in terms of driving cost."*

Other uses for BIM identified within the passages include facilities management (FM) and off site manufacture. Whist it is early days for COQS1, claiming, *"we've started a number of workshops with our FM colleagues because we're doing FM as well*." BE1 asserts that "FM is a big part of our offering, we call it our BIM platinum." *COQS2* is the only contributor currently considering off site manufacture with its sister company and "*getting documents, design models and data out on to site on tablet pc's, ipads, Samsungs etc."*

Collaboration was identified as the major use of BIM by all of the contributors, supporting the views expressed in the literature of Goucher and Thurairajah, (2013); Sebastian, (2011); Sabol (2008); Haque and Mishra, (2007) and Popov et al (2006)). Interestingly one of the greatest benefits identified in the literature in terms of creating efficiencies for the QS, automated quantification, (Harrison & Thurnell,(2014), Stanley and Thurnall, (2014), Zhou et al, (2010),Shen and Isa, (2010), Sabol (2008), Haque and Mishra,, (2007) and Popov et al (2006)); was not identified as one of the major uses of BIM. Furthermore no contributors identified BIM as being adopted to improve communication or to improve the quality of the data of the finished product for the end of use – life cycle application, uses also identified in the literature, although some mention was given to facilities management (FM).

The second highest number of passages is recorded against the low level theme, ***on what, by whom*** *(*13). With CQS recording the majority (7) and COQS (2). All three CQS1, CQS2 and CQS3 unanimously agree that the use of BIM is not just dependant on the market sector (public or private); with CQS2 saying it is much less specific as its use "*differs: project to project, client to client*." COQS2 agrees with this and states *"we have to react to* *some extent to what we're given on projects."*

BIM can be applied by any stakeholder within the construction project and as previously highlighted at any stage. COQS2 affirming "*BIM is not just for the contractor, it's not just for the sub-contractor. It's very much for the whole of the supply chain from conception right through to the building management*." CQS1 agrees and supports the potential of BIM and calls for "an evolutionary *approach in terms of seeking out opportunities to work with BIM*."

Project characteristics recorded the lowest number of passages 5. With once again the CQS recording the majority (4) against the COQS (1). All three CQS claiming that they are seeing more models on more projects. However, CQS1voiced his frustration in terms of the numbers *"we have quite a healthy number of BIM projects but it is by no means the majority of the projects that we work on."* A view supported and further clarified by CQS2 claiming it is still early days for BIM asserting *"none of our BIM projects have moved from CAPEX in to OPEX yet."*

Of the three sets, it is the BE and the COQS that are pioneering in their use of BIM, ensuring its relevance to both their current and future business. In contrast, the CQS set are only utilising BIM in their traditional role and do not appear to have linked its use to the project lifecycle and value creation, as do their counterparts.

6.2.2. Theme 2: Critical Success Factors

The discussion within the theme ***Critical Success Factors*** considers the benefits and barriers to BIM adoption and implementation. This produced a total of 134 passages which involved a contribution from all 8 interviews. This theme is then further broken down into 2 mid-level themes, both with associated low level themes as illustrated in the thematic model shown in Figure 6.5

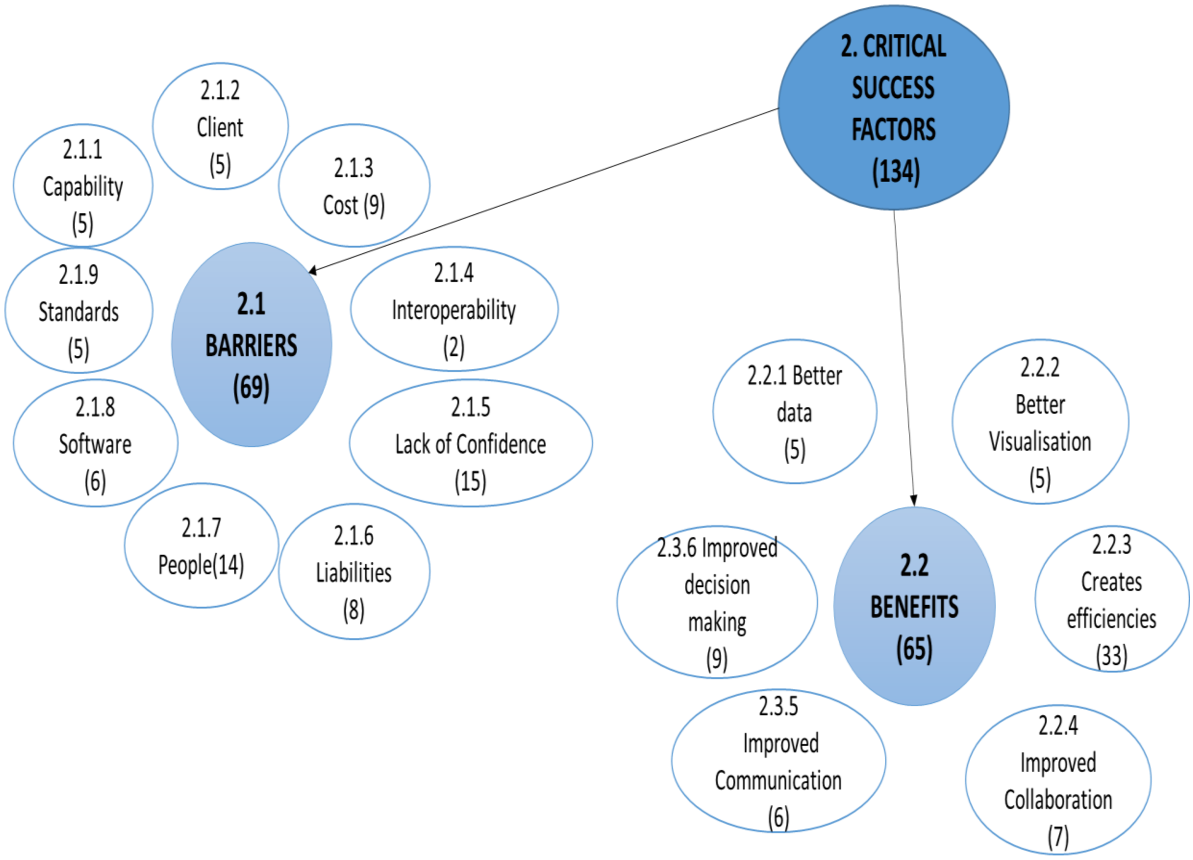


Figure 6-5 Thematic Model 2: Critical Success Factors

The differences of responses amongst the classification sets and the themes are shown in Table 6.5.

Table 6-5 Thematic profile theme 2 - Critical success factors

	BE	CQS	COQS
2.1 Barriers	13	27	29
2.1.1 Capability	0	1	4
2.1.2 Client	3	2	0
2.1.3 Cost	3	2	4
2.1.4 Interoperability	0	2	0
2.1.5 Lack of confidence	0	9	6
2.1.6 Liabilities	0	1	7
2.1.7 People	5	4	5
2.1.8 Software	0	5	1
2.1.9 Standards	2	1	2
2.2 Benefits	16	24	25
2.2.1 Better data	1	3	1
2.2.2 Better Visualisation	1	0	4
2.2.3 Creates efficiencies	7	14	12
2.3.4 Improved Collaboration	0	2	5
2.3.5 Improved Communication	3	3	0
2.3.6 Improved descision making	4	2	3
Overall	**29**	**51**	**54**

6.2.2.1. Barriers

This mid-level theme ***barrier*** produced 69 related passages. The COQS recording the most (29), the CQS recording a similar number (27) and the BE the least (13) as illustrated in Table 6.6. The interviews identified a number of low level themes within the sub theme of ***barriers*** identifying specific issues that could impact on BIM adoption and implementation. The low level themes identified included: ***capability, client, cost, interoperability, lack of confidence, liabilities, people, software and standards***.

Figure 6-6 Division of the low level themes associated with the barriers to the adoption and implementation of BIM, according to set.

A total of nine low level themes identified issues relating to BIM adoption and implementation. The division of these low level themes are illustrated in Figure.6.6. The majority of the passages (15) refer to ***lack of confidence*** as being a barrier, although it must be noted, that neither of the BE contributors made reference to this. Passages recorded for CQS(9) and COQS(6).

The ***lack of confidence*** is generally concerned with the inability to define BIM and to understand what it means to the business as CQS2 asserts "*no one knows what it is yet."* A view shared by COQS3 who adds "there's still a massive knowledge and experience gap of people not fully knowing what the system is, what the process is." COQS1 provides justification for this confirming *"there's a lot of smoke and mirrors around BIM and I think it's taken individual companies time, just to get through that mist and to do it properly."* CQS2 believes the industry needs examples of BIM to show what it is and to build up the confidence in the industry and explains *"that's why the governments has its early adopter project so it can generate that evidence."*

The other concern recognised is the ***lack of confidence*** in the model claims CQS2 "*contractors are saying they won't know if there's any mistakes that* *are inherent from the design team."* CQS2 arguing its linked to the procurement choice especially with the popularity of *"two stage design and build. We are asking contractors to take over the models at a certain stage of the design and then they've got to complete and co-ordinate the remainder of the design, so you can understand why they're doing it."* COQS1 representing the contracting side agrees claiming *"I'm uncomfortable with breaking down that core of four people responsible for the general arrangement model with 150 different supply chain people."*

Interestingly the literature review did not identify lack of confidence as being a barrier although lack of trust, in the quality of the model, was identified by Shen and Isa,(2010), Smith et al (2014) and Harrison & Thurnell,(2014).

The issue that recorded the second highest number of passages (14) refers to ***people*** as being a barrier, with a fairly equal distribution amongst all sets. Passages recorded for BE(5), CQS(4) and COQS(5). This in itself could relate back to lack of confidence, either in their understanding of BIM and what it represents, or the lack of training, to enable them to use BIM effectively.

BE1 claims *"there is still a cultural challenge out there."* COQS2 believes it to be *"the biggest barrier."* The concern is around the behavioural side of change and the resistance of people to change. CQS2 stating *"resistance to change is a big one"* especially as BE2 compares the construction industry with "*the dinosaur industry with many people who you know being resistant to change."*

The biggest challenge to ***people*** seems to be around software, training and retraining. *COQS2* believes *"it's getting people to think differently, to think with that common goal, to move away from the silo mentality and to think in a digital world and trust the software."* CQS2 warns it will take time to change *"as it takes time for people to learn to do things in a different way and learn to optimise the use of software and trust it."* The more evidence people are provided with the more accepting they will be of the change. CQS3 asserts:

“*I think we can change people but they need a lot of support and they need evidence.”*

Cultural resistance was identified in the literature, as was reluctance to change, particularly in relation to the software, however, in general people were not identified as the main barrier.

The next low level issue is ***cost*** which recorded (9) passages, the allocation recorded for BE (3), CQS (2) and COQS(4). The main issue appears to be around the perception of cost as opposed to the actual cost. BE2 claiming “*it’s not actually that expensive it’s just perceived to be expensive,”* although COQS3 identifies that “*it’s a struggle for some subcontractors to access electronic drawings let alone being able to invest in hardware and software*.” However, CQS2 argues that you have to look beyond the perceived ***costs*** and “*turn that on its head and look at what the benefit is.”* The perceived cost around hardware, software, training, that is, the traditional costs, are not the only concerns. As BE2 explains *“an architectural practice I know don’t do BIM yet and are afraid of the cost to them, in terms of the learning curve.” More importantly COQS3 asks “who pays for it? Ultimately the client pays for it.”* COQS2 cautions on the transferring of ***costs*** to the client stating *“if they’re asking for a BIM deliverable then we price it in and we have to be sensible about what we price.”*

The literature placed a much greater emphasis on cost particularly in relation to set up, software updating and training (Harrison & Thurnell,(2014), Stanley and Thurnall, (2014),Goucher and Thurairajah (2013), Olatunji, (2011),Howell and Batcheler, (2012), Smith et al (2014), Zhoui et al, (2010), whilst the contributors emphasised the perception of cost and identified that the learning curve and once again people need to be seen as barriers to adoption.

Liabilities recorded 8 passages, the distribution was skewed with BE (0), CQS (1) and COQS(7). This is clearly an issue for the contracting set as all 3 COQS contributed to the passages, in stark contrast to the BE set who did not. COQS3 asserts there are "*issues of licensing, ownership and responsibility for the model, there's still lots of grey areas on that side."* A view supported by COQS2 who argues *"I don't think it's been nailed down yet. The insurances and the contractual side needs to be quite different."* The consensus being that there is concern around the untested nature of BIM both in reality and in the courts. In addition, COQS3 expresses concern in terms of tracking back liabilities for the quantities in the model, and asks *"who is liable for the quantities that the model manager provides which is a result of inputs from the structural guys frame and the architectural guys fabric and the surfaces guys and so on."* Ultimately it will all come down to insurances as CQS2 asserts *"the contractors' insurance comes on line at construction."* A view supported in the literature, Harrison and Thurnell, (2014), Smith et al, (2014) and Zhoui et al, (2010) all identified the lack of contractual framework as a key issue when implementing BIM. The contractor's liabilities extend beyond that of the consultancy organisation, the degree of which is dependent upon the project procurement route and risk.

Software recorded 6 passages, the distribution was skewed but this time the majority of passages were recorded by the CQS (5) with minimal contribution from COQS (1) and once again none from BE (0). CQS1 recognises that there are issues with software in relation to complexity, firewalls and access but demonstrates a commitment to work through these issues by "working with our software vendors." However, CQS2 argues *"the technology still hasn't caught up"* as it still requires checking *"it's not 100%."* COQS3 adds to this, and asserts it's not just about the software, it is the infrastructure that poses a bigger problem *"as a company we aren't geared up sufficiently for everyone to even run a model."* Consultant QS's are experiencing greater difficulty with the software than the contractors QS, which would explain why previously the consultants did not recognise the benefit of automated quantities.

The next low level themes ***standard's, capability and client*** all recorded 5 passages each.

The division of the passages for ***standards*** was similar for all sets with BE (2), CQS (1) and COQS (2). The issues recorded for this theme are around the availability of a coherent and consistent set of standards both in the UK and around the globe. BE2 argues that the volume of information is massive and often difficult to understand being "*full of acronyms."* Particularly as the protocols relate to estimating as identified by Harrison and Thurnell, (2014)and Stanley and Thurnall, (2014).

The division of the passages for ***capability*** was once again skewed with the majority being recorded against COQS (4) and CQS (1) and BE (0). The issues recorded for this theme are around the variance in competence levels within the organisation and also within the industry. CQS1 claims that capability will only come with experience and *"the projects haven't got that far yet to provide the experience."* COQS1 is not too sure that all people will gain the experience as *"some people want to go traditional and some people wanted to sort of dip in to the capability but probably a bit nervous because it's something new."* Once again this reflects the people barrier. The contributors suggest that individual BIM learning will only be created via the experience gained from a BIM project, (Inocencia,2011). It could be concluded therefore that knowledge provides confidence, which, in turn increases capability.

The division of the passages for ***client*** was between CQS (2) and BE (3) with no contribution from COQS. The client is identified as being key to the successful adoption and implementation of BIM*.* CQS1 claiming *"it's the same old story with any kind of change and any kind of initiative in our industry where the client's behind it and passionately behind it, it works like a dream."* However, BE1 argues it is more to do with educating the client and "m*aking sure a client understands how to procure using BIM."* In contrast, CQS2 argues it is more about educating the clients in terms of benefits that can come from BIM as *"we've taken BIM to the client and said we think that* *your project is right for BIM because it's such a high end project, but they decided not to adopt." The contributors*

The final low level them is ***interoperability***, which recorded only 2 passages both of these from CQS. The main issue being the inability of the software to talk to other software as CQS2 states *"even with REVIT drawings bits drop out of the model when it's converted to NAVISWORK."*

6.2.2.2. Benefits

This mid-level theme ***benefits*** produced 65 related passages. The COQS set recording the most (25), CQS recording a similar number (24) and the BE the least (16) as illustrated in Table 6.5 . The interviews identified a number of low level themes within the sub theme of ***benefits,*** identifying the benefits that could arise as a consequence of BIM adoption and implementation. The low level themes identified included: ***better data, better visualisation, creates efficiencies, improved collaboration, improved communication, improved decision making*.**

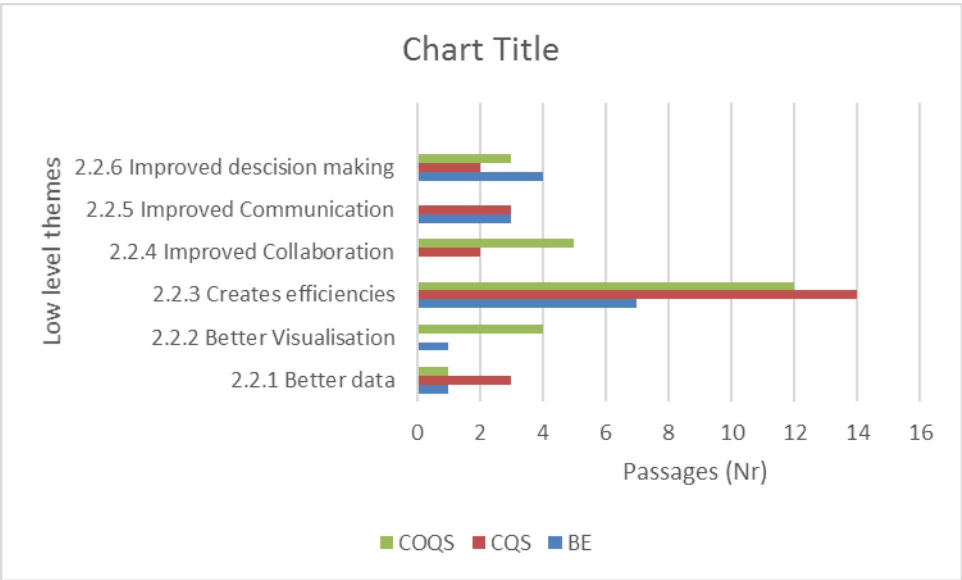


Figure 6-7 Division of the low level themes associated with the benefits of BIM adoption and implementation, according to set.

A total of six low level themes identified the ***benefits*** relating to BIM adoption and implementation. The division of these low level themes are illustrated in Figure 4.7. The majority, over half, of the passages (33) refer to the benefit accruing from ***creating efficiencies.*** The distribution of passages was similar for CQS and COQS, with CQS (14) and COQS (12) and recording the lowest BE (7).

The purpose of BIM asserts BE1 is *"to be much more efficient."* It is concerned with creating efficiencies in the process of a project but more importantly COQS2 argues *"it is the creation of efficiencies in the sectors of industry that offer real benefits."* An increase in efficiency will bring with it a decrease in cost as BIM has the potential for better risk management. BE1 arguing *"it takes out the waste."* BIM offers certainty through design and consistency therefore COQS2 claims "*we should be spending less of the risk money and if we're spending less of the risk money then it means BIM is working."* In addition, BE2 claims "collaboration isn't a benefit but the outcomes are: reduced waste and reduced cost."

Furthermore, CQS3 claims *"BIM increases predictability and performance*" enabling the industry to build better before its built, thereby reducing the number of abortive works. COQS3 asserts predictability can be further increased by the *"ability to extract data direct from the BIM model straight in to fabrication drawings for offsite manufacture in a controlled environment."* BIM improves coordination, which argues BE1 enables *"performance optimisation*" and BE1 *"reduces rework."*

Efficiencies created by the ability to extract data from the model is highlighted by all contributors, but it is the capacity to generate automatic quantities that will create sector efficiencies, particularly for the QS. COQS3 asserting that the capability to "*very quickly get quantities from BIM models*" will create efficiencies within the QS role, especially claims CQS2 in ***"****cost planning and quantity take off."*

Generally, the creation of efficiencies stemmed from the processing of information as the information flows faster (Marsh, 2014) although COQS1 warned there is a "*big caveat around that, because what we find is, that where the project has been set up well and where there's agreed structures and protocols around how the model would be developed then its considerably more efficient."*

The creation of efficiencies was identified as a major benefit by the contributors and interestingly, by the literature as it identified that automated quantities would create efficiencies at budget estimate stage, cost plan stage (Harrison and Thurnell,(2014),Stanley and Thurnall, (2014) Zhou et al, (2010), Shen and Isa, (2010), Sabol (2008), Haque and Mishra,, (2007). Popov et al (2006) and improves the efficiency of the Bill of Quantities. Harrison and Thurnell, (2014).

The remaining low level themes all recorded considerably less passages against them in comparison to creating efficiencies with the next highest ***Improved decision making*** only recording 9. This low level theme identified that BIM has the potential to provide a greater understanding of the project thereby enabling the key stakeholders "*to make better business decisions",* argues BE1. By utilising collaborative decision making points and working together to reach decisions COQS2 argues it creates *"innovation in the supply chain."* CQS2 affirms that the client would ultimately experience the most benefit in terms of the speed and accuracy of decisions made. COQS2 argues that BIM provides contractors with a real understanding of the client's needs which they can in turn *"use to solve problems and make decisions."*

Improved collaboration recorded a total of 7 passages, the division of the passages was between CQS (2) and COQS (5), with no contribution from BE. CQS3 asserts that BIM offers *"more potential for collaboration."* CQS1 is much more specific stating collaboration brings a huge benefit in *"terms of establishing the project culture and the team dynamics and understanding of how they are going to deliver the project."* As a consequence of BIM, COQS3 asserts *"you're less likely for disciplines to be working independently from* *each other."* Whilst the contributors did not see that Collaboration would be as beneficial as the potential to create efficiencies, previously they identified BIM being used in the main, for collaboration. It could be concluded therefore that collaboration has the potential to create efficiencies.

Improved communication recorded a total of 6 passages, the division of the passages was between BE(3) and CQS (3) with no contribution from COQS. BE 2 believes that initially BIM was adopted as means of communication as *"in the early days' small architectural practices adopted 3D CAD to communicate to their clients." BE1* believes with BIM it is easier and better communication. A view supported by CQS1 who asserts *"because with BIM we find that people talk to each other and set out the project better from the beginning, this results in better project outcomes.*" The fact that the contractors QS did not contribute may suggest that they do not see the potential of BIM in improving communication as much as the consultant QS. The literature suggests however that BIM improves communication and access to information in the project team, (Harrison and Thurnell, (2014), Goucher and Thurairajah (2013), Sabol (2008), Haque and Mishra, (2007) and Popov et al (2006).

The final two low level themes, ***better data*** and ***better visualisation*** each recorded a total of 5 passages.

Better data recorded passages from each set with CQS (3) recording the most. CQS2 claims the benefit accrues from being able to reuse the data whereas CQS3 believes it *"drives a longer term view of information."* However, BE1 believes it is the ability to *"see none graphical information"* that will most benefit the industry.

Better visualisation recorded passages from BE(1) and COQs(4), with no contribution from CQS. Visualisation benefits all parties as they can walk through the project before it is constructed. COQS3 asserts, "*I think from a client perspective it will be quite good but also from a construction* *perspective in terms of being able to see things that you can't always pick up off drawings."*

The benefits of BIM to the organisation are centred around the creation of efficiencies around the QS role and the potential to add value. Collaboration, is also recognised as a significant benefit as this too has the potential to change the QS role as it brings with it a change in workflow and patterns.

6.2.3. Theme 3: The Quantity Surveyor

The discussion within the theme ***Quantity Surveyor*** concentrated on the current perception of BIM and its impact on the QS role in terms of the barriers and benefits of BIM adoption and implementation, the function of the QS and the application and future potential of BIM. This produced at total of 156 passages which involved a contribution from all 8 interviews. This theme is then further broken down into 5 mid-level themes, some with associated low level themes as illustrated in the thematic model shown in Figure 6.8.

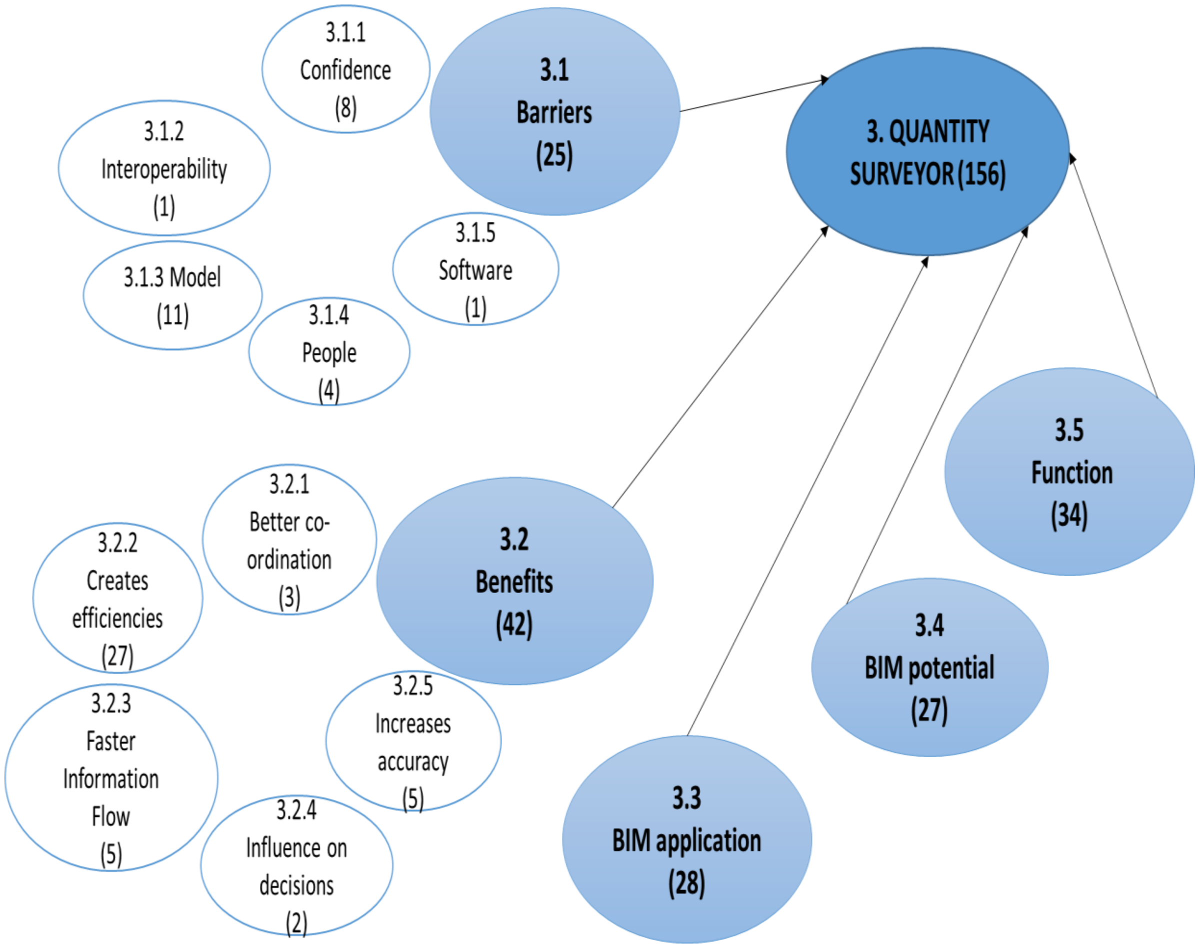


Figure 6-8 Thematic Model 3: Quantity Surveyor

The differences of responses amongst the classification sets and the themes are shown in Table 6.6

Table 6-6 Thematic profile 3- Quantity Surveyor

3. Quantity Surveyor	BE	CQS	COQS
3.1 Barriers	3	14	8
3.2 Benefits	10	22	10
3.3 BIM application	3	16	9
3.4 BIM potential	4	17	6
3.5 Function	6	14	14
Overall	26	83	47

6.2.3.1. Barriers

This mid-level theme barrier produced 25 related passages. The CQS recording the most (14), the COQS recording (8) and the BE the least (3) as illustrated in Table 6.6. The interviews identified a number of low level themes within the sub theme of barriers, identifying specific issues that could impact on BIM adoption and implementation specifically in relation to the QS. The low level themes identified included: ***confidence, interoperability, model, people*** and ***software.***

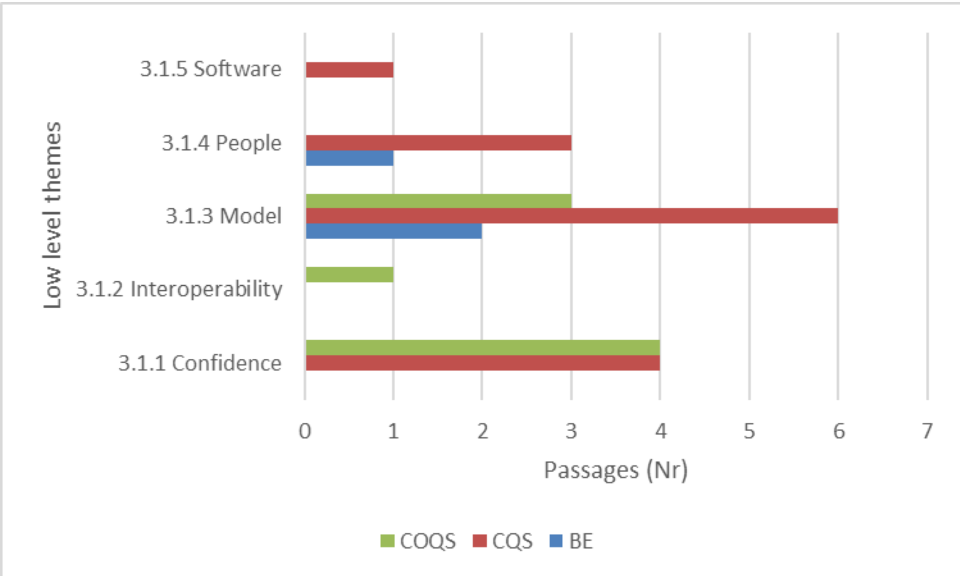


Figure 6-9 Division of the low level themes associated with the barriers of BIM adoption and implementation specific to the QS, according to set.

A total of five low level themes relating to BIM adoption and implementation were identified as being specific to the QS. The division of these low level themes is illustrated in Figure 6.9. The majority of the passages (15) refer to the ***model*** as being a barrier, with all 3 sets making reference to this. Passages recorded for BE (2), CQS (6) and COQS (3).

The low level theme ***model*** is generally concerned with the quality of the model and the data within it. CQS1 asserts "*you've got to have a lot of clarity very early to make sure that everybody who is working on the project is putting the right data in, in the right format and the right structure at the right* *time."* Otherwise the QS role will become a *"checking role"* warns COQS1. All sets raise concerns around models not being fit for purpose to support the QS. BE1 highlights that, *"models aren't often set up for cost purposes."* A view supported by BE2 who claims *"in order to do full element costing a QS needs a decent model."* The accuracy of the data within the models can also present the QS with serious output deficiencies. CQS1 claims *"we've had a huge number of situations where elements of the model have been duplicated on the same co-ordinates so if you take off a quantity it can be measured more than once*." In contrast, CQS2 refers to under measurement rather than over measurement being an issue identifying that *"some bits might not be drawn and hence your quantities could be deficient."* All sets agreed that, the priority is to ensure that the information is set up correctly, it is structured properly in the model, and available at the appropriate depth of information and level of detail to allow the QS to undertake their role.

The next highest number of passages was recorded against ***confidence,*** with a total of 8 being logged. The passages were equally distributed between CQS (4) and COQS (4), with none recorded against BE.

There appears to be a time issue in relation to ***confidence***. COQS2 claims, *"we go through a period of gaining the trust in the model"* although CQS2 adds *"we are speeding up but it is not as smooth as it should be, I don't think."* In addition, there is a lack of confidence in the information the QS is given, such that COQS 3 claims *"I would rather use my own initiative to come to a valuation figure rather than relying on a model."* To overcome this the QS must increase their role and "*introduce different checks and balances,"* affirms CQS3. However, it is not only the QS's confidence that can be a barrier to the QS. Other stakeholders not having the confidence to know what they want from the model can prevent the QS from fulfilling their obligations, particularly as it impacts life cycle costing. CQS2 confirming "*we are quite heavily in discussion with the FM team, and asking them what outcomes they want in relation to lifecycle decisions and what information they want from the model at handover. And, some of them don't really know."*

The QS confidence barrier is not people centric as previously discussed in section 6.2.2.1., but this time specific to data, models and information and associated with lack of trust in these areas.

The next 3 low level themes had a minimal number of passages recorded against each, people (4), software (1) and interoperability (1) suggesting that these barriers were less significant than ***model*** and ***confidence***.

The low level theme ***People*** is concerned with the impact other members in the project team have on the QS role. It relies on the QS being forward thinking and asking for the information in a certain way as CQS3 asserts "*we're getting more intelligent about how we tell, for example engineers, to identify steel sections, defining them by weight categories, so we can easily filter the data for different NRM categories."* CQS3 further expresses concern in relation to the client and how they view QS fees in the light of BIM stating. *"I would like to think that we can retain the levels of fees that we're getting paid."* In contrast to the generic people barrier identified in section 6.2.2.2, which focussed on lack of confidence and cultural resistance, the people barrier to the individual QS relates more to communication and relationships with the project stakeholders.

Software *and* ***interoperability*** may appear insignificant themes due to the low number of passages, however the maturity of the software and the inability of some to talk to others is seen to be stifling innovation. CQS1 claims they need to be in a position where the software is driving innovation but *"rather than helping us innovate at the moment, it is acting as buffer."* Interestingly software was rated highly in terms of a generic barrier to BIM, as discussed in section 6.2.2.1, with the consultants QS experiencing greater difficulty, which appears to be supported here, in relation to QS specific software.

6.2.3.2. Benefits

This mid-level theme barrier produced 42 related passages. The CQS recording the most (22), the COQS recording (10) and the BE the least (10) as illustrated in Table 6.6. The interviews identified a number of low level themes within the sub theme of barriers identifying specific benefits that could be gained by the QS by adopting and implementing BIM. The low level themes identified included***: better coordination, creates efficiencies, faster information flow, greater influence on decisions*** and ***increases accuracy.***

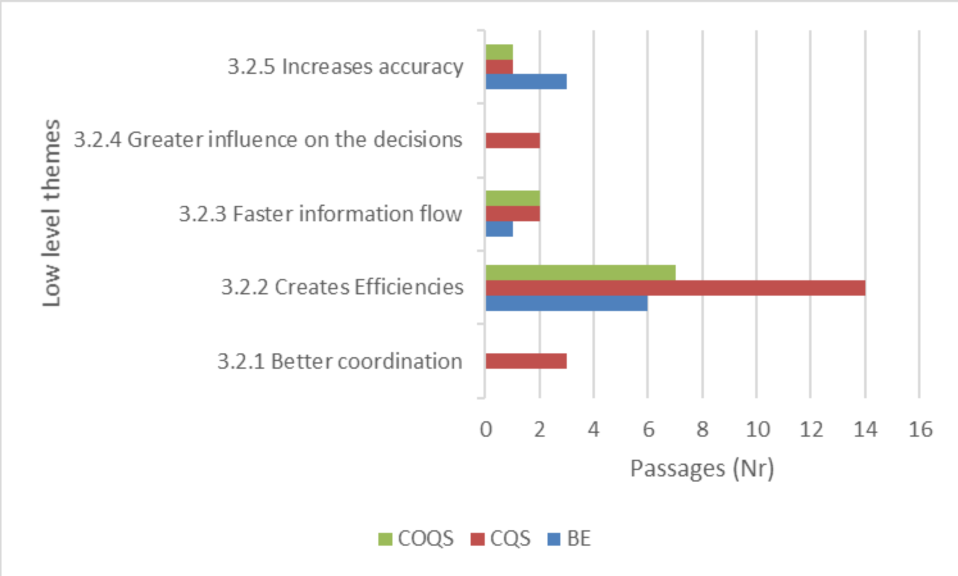


Figure 6-10 Division of the low level themes associated with the benefits of BIM adoption and implementation specific to the QS, according to set.

A total of five low level themes relating to BIM adoption and implementation were identified as being specific to the QS. The division of these low level themes are illustrated in Figure 6.10. The majority of the passages (27) refer to the ***creation of efficiencies*** as being of benefit to the QS, with all 3 sets making reference to this. Passages recorded for BE (6), CQS (14) and COQS (7).

The ***creation of efficiencies*** is associated with increasing the speed of quantification "*enabling a reduction in time on the take off and in generating revisions to the cost plan*", claims CQS1. As the QS process becomes more efficient, the QS can add further value to the project. BE2 argues *"not having to measure and do manual take off enables the QS to spend more time concentrating on the areas that you can't measure."* BE1 supports this argument stating it is an opportunity for the QS to move away from measurement and to *"concentrate on doing the professional job."* As a consequence, these traditionally labour intensive QS roles will release resources that can then allow *"more senior resources to evaluate further opportunities for the client to gain value and improve their profit margins,"* claims CQS2. Consideration being given to the total expenditure of the client, life cycle costs, BE1 advising the QS will be "*making more lifecycle decisions rather than just Capex decisions."* COQS1 agrees, emphasising the QS role is best suited to resolving longer term commercial issues and making commercial decisions rather *"than digging in to the detail of quantity assessment*." In addition, greater collaboration with the QS attending federation meetings is identified as creating efficiencies and adding value to the project team as it will allow the *"QS more time to do what's not in the model, to see the gaps, to understand where things are missing,"* claims COQS2.

The contributors identifying, that in creating efficiencies, the QS will create value, by spending time on other activities such as life cycle costing. A view previously identified in the literature, (Azar and Brown, 2009, Jiang, 2011). All contributors agreeing that the QS would add value to the project team as a result of implementing BIM, linking this theme with the generic benefit of BIM, collaboration, as identified in section 6.2.2.2.

The next two low level themes of ***increases accuracy*** and ***faster information*** both recorded 5 passages each.

The low level theme ***increases accuracy*** recorded the following passages: BE (3), CQS (1) and COQS (1). Both BE contributors claimed that the data that the QS is receiving is better and more trustworthy although CQS 3 argues it is perceived to be more accurate in that it "*feels more accurate"*

The low level theme ***faster information*** recorded 5 passages distributed as follows: BE (1), CQS (2) and COQS (2). Faster information flow enables the QS to make more accurate, validated decisions in areas not traditionally linked to quantification. The QS role is becoming more heavily involved in *"optioneering scenarios, value engineering and lifecycle costs,"* claims CQS3. Faster information also produces faster decisions from the QS asserts CQS1, as the QS interrogates the model or the data base *"they can quickly react to any commercial variants in the project."* This theme is linked with the previous creation of efficiencies as efficiency is created by the speed of information supporting accurate decision making.

The two low level themes ***better co-ordination*** recorded 3 passages and **greater influence,** 2. These two themes are intrinsically linked in that the contributors identified that better coordination relied on earlier involvement of the QS and that this earlier involvement allowed the QS to have greater influence on project team decisions. CQS2 asserts early involvement with the project team affords the QS *"early access to the design, enabling greater QS influence over its development."*

6.2.3.3. BIM application

The third mid-level theme identifies the ***application*** of BIM in the QS role producing 28 related passages, as shown previously in Table.6.6. The distribution of passages was skewed with the most recorded by CQS (16) , followed by COQS(9) and finally BE(3).

Both the CQS and the COQS set agree that the application of BIM in their role is very much dependant on what information they receive and its format. CQS3 asserts *"we're very reactionary to what information we get as Quantity Surveyors."* CQS2 agrees with this affirming *"if models come to us and they've got BIM measure capability then we will use it."* However, this is not typical as CQS2 believes it only applies to 5- 10% maximum of the projects they are currently working on. A view supported by COQS 3 who asserts "*whilst we are trialling it on this project, I don't think a single QS has used it* *elsewhere in the business!"* It can be concluded therefore, that, BIM is not commonly adopted by the QS and that the QS is reactive in its adoption.

The experience of BIM application is typically around take off, cost planning and bill production, all functions traditionally associated with quantification. CQS3 claiming *"we do use models where they are generated for cost planning and bill production purpose."* However, it is more in relation to checking warns COQS3 as "we extract the data from the models to go into the cost plans and to go into the bills, but we would always supplement that by checking." A view supported by COQS1 who further claims it is the early access to the quantities that *"allows us to test the validity of our cost plan much earlier."* The checking can be testing the manual quantities against the model or using the model to validate the manual take off, either way checks are undertaken, resulting in duplication of effort. COQS 3 asserting *"at the last bid stage of the project we did our own quantity take off and then we used the REVIT model outputs as a cross check."* This links with the previous theme of **barriers to the QS,** as discussed in section 6.2.3.,1, which identified lack of confidence in the model as being the key barrier. The contributors are now saying that the need to validate the data restricts BIM adoption.

More recently the QS is becoming more involved in less traditional roles with CQS 1 claiming the QS is becoming more involved in the information management role *"in terms of understanding the model and how it needs to be structured."* The COQS set confirmed that QS's were providing invaluable contributions at coordination meetings with COQS2 asserting *"key conversations happen in the co-ordination meetings and as a business we encourage the QS's into that environment so they can feed in to it."* The timing of QS involvement is seen as critical. COQS2 affirms it is far better to have the QS interrogating the model with the project team, contributing to a robust solution *"rather than being given the design solution the day after, only to knock it back."* The QS is also able to make more life cycle costing decisions as a consequence of adopting BIM. BE1 claims because the data is better the QS is "making more whole life cost decisions up front as well"

Where BIM is currently underutilised is in the area of change management as CQS2 claims its only application is pre contract. A view supported by COQS2 who asserts *"none of the contractors are coming forward with any of their change management through any models."* Another area of underutilisation is in the QS legal and contractual environment claims CQS1 although at this stage he question the potential benefits of application.

Interestingly the contributors have identified that BIM has the potential to change the QS role from a traditional measurement one, to one, that adds value and leads to greater collaboration with the project team, as identified by Mitchell, (2012). Furthermore, this can be linked to the generic benefit of BIM identified of collaboration identified previously in Section 6.2.2.2.

6.2.3.4. BIM potential

The fourth mid-level theme identifies the ***potential*** that BIM brings to the QS role producing 27 related passages, as shown previously in Table 6.6. All sets recording a similar number of passages with BE (4), CQS (17) and COQS (6).

BIM has the potential to support and transform the QS role, but just how and to what extent is unclear at the moment. CQS1 asserting *"it is going to be quite an interesting evolution; I don't quite know how it is all going to fit together in terms of individual responsibilities at the moment."* However, there is always going to be a strong role around quantification and cost, procurement routes and advice around forms of contract, adds CQS1. In addition, COQS1 advises there will still be a need for checking things *"in the usual sort of QS style through the developing design and as you go in to procurement and construction."*

Several potential opportunities for the QS are identified in the areas of optioneering, whole life costs, facilities management, designing to cost and environmental quantification. BE 1 asserting that the QS *"can actually start to think more in terms of optioneering and thinking actually what if,"* a view supported by CQS2 expressing excitement at engaging in optioneering. Whole life costs and FM are moving in new directions as the QS helps support the delivery of Soft Landings. CQS3 claiming there is a potential for QS to manage the data through our project's lifecycles, possibly extending our role post contract and beyond. Although CQS2 cannot see any evidence currently and warns, *"I don't think our lifecycle costing team have used any models as yet*." BE1 upholding *"it is just a matter of when, but I believe one of the things that will be automated in a few years is design,"* thereby enabling a radical shifting of the traditional QS approach to include *"planning and design to cost,"* affirms COQS1. Therefore, suggesting, that, as part of the cost planning process, the QS function should involve the production of more detailed targets and the creation of a menu of cost parameters. Finally, environmental quantification offers huge potential opportunities for the QS over the next three to five years with *"carbon becoming much more part something that the QS quantifies,"* claims CQS1. In addition to embodied carbon and operational carbon CQS1 asserts *"people are talking about embodied water and operational water."* Furthermore, he questions whether these too could be subject to quantification by the QS.

The contributors all agree the BIM has the potential to change the QS role, extend current services whilst transforming and developing new services, as previously identified, in section 6.2.3.2. This furthermore supports the ability of BIM to create added value in terms of its services.

6.2.3.5. QS Function

The final and fifth mid-level theme considers the current ***functions*** undertaken by the QS in their role producing 34 related passages, as shown previously in Table 6.6. An equal number of passages were recorded for CQS (14) and COQS (14) with less than half for BE (6).

This low level theme identifies disparities between the various sets especially between the consultant QS(CQS) and the Contracting QS (COQS). The QS roles are each unique to the set.

The title quantity surveyor is even seen as challenge as BE1 exerts *"they're not really Quantity Surveyors I would say the shift is more towards Cost Management."* Whilst CQS3 supports this change in title CQS2 questions refers to the QS as built asset consultants.

BE1 defines the QS function as being concerned with cost management and cost control in effective procurement, not about measurement. CQS1 agrees asserting "*there are far fewer examples of full bill of quantities being prepared these days and that's been a trend in the industry over the last probably five years they've been very much in the decline."* CQS2 defines the QS role as being able *"to understand the requirements of the client and the project and then to deliver to that."* In contrast, CQS3 defines the role in relation to supporting the decision making process purporting, *"it is all about facilitating the development of affordable and beneficial solutions and proving that affordability; generating that confidence."* A clear division in function exists in the role of the consultant QS between pre-contract work which includes feasibility, cost planning and tendering and post contract which is the contract documents, valuations, final accounts, and change management. In addition, CQS2 stresses that the QS function will vary depending on where the individual sits within the organisational structure *as "we've got a set of role profiles so obviously each person has got their individual job description which relates to their kind of project role."* CQS1 argues that "the QS brings substantially more to a project than a database of costs with CQS3 asserting *"I wouldn't actually say it was to manage the cost because you could be managing really inefficient cost well."* It can be concluded therefore that the consultant QS function is rich and varied and includes lifecycle costing, capital tax, project management, change management, facilities management in additional to traditional measurement services, thereby adding value throughout the whole life of a project.

The QS function in the contracting sector is also divided with estimators or cost planners depending on the project, responsible for the figures pre contract in terms of the cost plan or the bid or the estimate. COQS1 claiming "*we would not generally see a Quantity Surveyor involved during the early* *stages of a bid."* It would mainly be driven by the design management and estimating and cost planning function. COQS2 asserting that *"within our business the QS is in charge of the commercial administration of a project post contract."* These post contact duties are quite extensive as the QS is responsible for managing both value and cost, managing the client, managing its supply chain in terms of money, contracts, payments, risk and, the design team as well. COQS2 succinctly defines it as *"project cost management".*

COQS3 argues that the QS will probably transfer to the forefront of their role "*when we move into the main contract and then into the management of the subcontracts on site."* This post contact role is more concerned with managing the administration commercially of project work packages; through the valuation programme all the way to completion on site, final account and sign off. This role is different initially to that of the consultant QS as COQS2 explains the QS needs to *"scope the works, convert programmes into durations and programme requirements"* but the tender process following reflects that of the consultant as the *package "goes out to tender, analyse the returns, complete a sub contract with the selected contractor."* COQS1 confirming that the QS will lead the procurement management and delivery of those packages to the completion of the contract. Interestingly, COQS 2 describes the consultant QS role as facilitating a design to cost process, setting cost targets with the designers and manage those costs through the project.

It can be concluded therefore that the QS role for the consultant is totally different to that of the consultant. The consultant's role is rich and varied from pre contract to post contract, whilst that of the contractor is focussed on post contract financial management and procurement of sub contracts.

6.2.4. Theme 4: Knowledge and skills

The discussion within the theme ***knowledge and skills*** focuses on how the organisations transfer BIM knowledge and facilitate the development of skills within the organisation. This produced at total of 31 passages which involved a contribution from the 6 QS interviews with no comments from the BE's. both BE's declined to comment, possibly because they were unaware how BIM knowledge was gained in a QS organisation as neither were employed in one. The differences of responses amongst the classification sets and the themes are shown in Table 6.7. The passages were generally evenly distributed between CQS9 (15) and COQS (16).

Table 6-7 Thematic profile- Knowledge and Skills

	BE	CQS	COQS
4. Knowledge and skills	0	15	16

The passages demonstrate a deep division between the current practice within organisations in relation to the dissemination of BIM knowledge and training. The disunion is not between set but within sets, there is no common approach to BIM learning or skill development by either the consulting or contracting organisation. CQS1 demonstrates some excellent practice within his organisation and affirms, *"We are building our internal capability and making sure that all of our Quantity Surveyors, Project Managers, Building Surveyors understand what BIM is, have got access to the right training and support, so that when a BIM opportunity comes along they are able to deliver that effectively."* However, in complete contrast, COQS3 proclaims *"there's certainly no formal training or formal briefing at the moment regarding BIM, other than we have a strategy."* The BIM message is being delivered but it lacks consistency in communication. CQS1 believes communication is key to BIM success, proclaiming*, "just having that conversation can open up an opportunity to develop some mutual skills. So first of all it's about developing an internal capability, secondly about raising our profile around."* A view seconded by COQS2 who urged *"Get out there, communication and feedback will help deliver an understanding of what BIM. We involve our sub-contractors and communicate to them our protocols and our process to working in a BIM environment."* However, COQS3 found internal communication in his organisation poor and claims he found out about the

BIM strategy when it appeared on the front page of the organisations intranet site, claiming *“there hasn’t been any other formal kind of communication within the business about BIM.”* However, COQS2 claims it is important to spread the BIM gospel and pitch BIM phrases and BIM terminology out into the world, as a gradual dispersion is likely to have more impact than a sudden explosion.

Developing networks, talking to clients, industry stakeholders and not least internal staff appear to be positive behaviours associated with the transfer of knowledge exhibited by CQS1 and COQS2. Growth and the sharing of BIM knowledge is associated positively with business growth and development and those that demonstrate good practice strive for excellence. CQS1 further proclaims *“whilst I’ve got a BIM network that’s quite rich already, increasingly I’m building on those areas to try and join up our BIM delivery and best practice and knowledge around our business.”* Communication takes many formats including running breakfast seminars, half day conferences, publishing articles, and simply talking to clients in public and private sectors CQS3 reports, they have a BIM steering group and *“we’ve got BIM papers being released every month.”* All strategies with the aim of selling the benefits of BIM.

COQS2 and CQS1 believe that knowledge management is pivotal in the development of innovation and the sharing of best practice and knowledge. CQS” claims it’s *about “encouraging curiosity amongst staff and encourage them to talk openly to other staff, partners on project teams and to clients about their experience*” COQS2 further claims “I *think this is a key driver, its involving people from the business and not just the bright young things who are keen for BIM.”* COQS2 and CQS1 have identified BIM champions to run trials, develop process, share BIM experiences, and then share it across the business. CQS3 claims they have appointed an Information Manager who will support the sharing of knowledge and experiences, not just internally, but externally as “there is a role for the companies to help designers and contractors to become clearer in terms of the benefits. However, CQS1 warns “*despite a huge amount of effort that we put in to educating people* *you know we've still got people in the business who haven't yet worked on their first BIM project."*

Software training is identified as an essential BIM skill by all sets, but once again, it is the management and organisation of the training that is random and disorganised. CQS2 asserts *"software training doesn't usually happen with new staff for months."* Whilst COQS3 declares he is self-taught and has not *"had any training or briefing whatsoever from within the company."* COQS1 urges practical BIM is essential and should be encouraged, "*get on site and engage and start working in a 3D environment. Start using and sharing data."* A view supported by CQS3 who claims to be *"using project models for training purposes and for software testing."*

COQS2 claims it's about taking BIM incremental steps and planning for BIM implementation. All sets agree that it is about creating a vison and putting together a team and the resource needed to start making incremental changes in the culture and the systems of the organisation. Engagement with the client in the process is essential in order to, CQS3 asserts, *"to identify their BIM or their asset requirements and end user needs."*

Finally, COQS 2 advises *"communicate the message and provide practical demonstration, but form the longer term vision of where the business wants to be in the five-year plan, the ten-year plan, and then start looking at the incremental steps to you there."*

It can be concluded that the QS organisation needs to formulate a business plan in terms of BIM, address the capacity and capability within the QS organisation in terms of BIM, create a vison for its implementation and effect change within the organisation support success.

6.2.5. Theme 5: Survival

The discussion within the theme ***survival*** centres on the QS role and whether or not the implementation of BIM will question its very existence and hence that of the organisation that supports it. This produced at total of 44 passages which involved a contribution from all 8 interviews. This theme is then further broken down into 3 mid-level themes as illustrated in the thematic model shown in Figure 6.11.

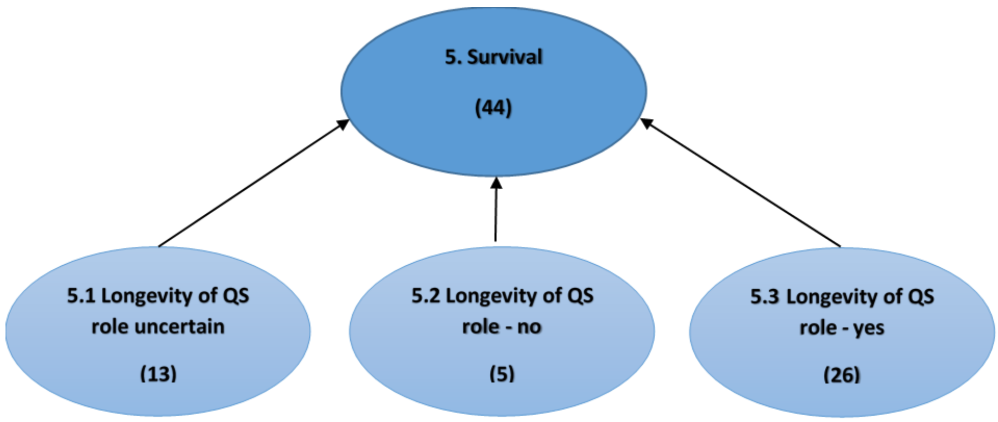


Figure 6-11 Thematic Model 5: Survival

The differences of responses amongst the classification sets and the themes are shown in Table 6.8. The passages produced a skewed distribution with generally evenly distributed between CQS (22), COQS (15) and BE (7).

Table 6-8 Thematic profile- Survival

5. Survival			
5.1 Longevity of QS role uncertain	2	9	2
5.2 Longevity of QS role - no	2	2	1
5.3 Longevity of QS role - yes	3	11	12
	7	22	15

6.2.5.1. Longevity of QS role uncertain

This mid-level theme ***longevity of QS role uncertain*** produced 13 related passages, the CQS recording the most (9), with the COQS and the BE recording (2) each, as illustrated in Table 6.8. The comments recorded in relation to this mid-level theme are generally around the attitude of the QS and *"how positively the profession embrace BIM,"* asserts CQS1, a view supported by COQS1 who argues if the QS is smart enough BIM should present *“an opportunity rather than a displacement of their function.”* However, it is a proactive process and the more positive and constructive the QS is, in the adoption of BIM, the stronger the role can become. However, claims CQS1 “*if QS’s are negative or resistant or conservative about BIM then there is a potential that other members of the project team, architects and structural engineers will go ahead and find different ways to deliver their projects.”* COQS 2 further warns of similar threats to the QS role but this time from contractors *as “they are trying to offer one stop shops.”* Furthermore, the perception of the QS is not clear as its title does not best define what it is they essentially do, COQS3 proclaims, suggesting that BIM may bring about a change in title as CQS1 questions *“Whether they will still be called Quantity Surveyors at the end of it I don’t know.”* A view supported by BE1 who asserts *“the term of QS is a patronising term I think we will see the next generation as Commercial Asset Managers.”* The lack of certainty in the survival of the QS can be summarised as being associated with attitude, competition from the project team and the title itself.

6.2.5.2. Longevity of QS role – no

This mid-level theme ***Longevity of QS role – no*** produced only 5 related passages, the CQS recording and the BE recording (2) each, with the COQS (1), as illustrated in Table 6.8. The comments recorded in relation to this mid-level theme do not support the longevity of the QS role. CQS1 affirms that the analysis of the information can be broadly achieved by anybody in a project environment with BIM, not just the QS, *“in that sense the QS’s role could be diminished.”* COQS1 believes that BOQ’s will diminish, which in turn will negatively impact on traditional QS firms offering this capability which BE1 argues, *“might be the final nail in the coffin for those traditional firms that are left.”*

6.2.5.3. Longevity of QS role – yes

This mid-level theme ***longevity of QS role - yes*** produced 26 related passages, the CQS recording (11), BE (3) and COQS (12), as illustrated in Table 6.8. The comments recorded in relation to this mid-level theme fully support the permanence of the QS role. All contributors with the exception of BE1 agreed and supported the evolution of the QS. Initially the observations highlighted the need for someone to undertake the QS function in relation to making commercial decisions. CQS1 affirming *"the whole thing still requires someone to look at the raw data and make some analysis and make some recommendations so someone will still need to do that process."* Cost is always going to be a key driver around the business case of a project. As such, CQS3 claims *"It's always going to have to be managed and you're always going to have to be able to demonstrate value."* COQS3 stresses that that person should be a QS as they are unique as a profession "*bringing that whole mind set and way of thinking and understanding or the project."*

Recognition however is given to the need for change. BE2 confidently expressing *"the role will grow, it will survive and it will change!"* Furthermore, COQS3 comments on the fact that the QS is not averse to change as *"we have changed anyway, we're probably more of an accountant now than we ever were." The* QS profession are *"actually quite adaptable, we can easily adapt and we've adapted over time,"* supports, CQS2. The change will be "*in how the work is done not the work itself,"* argues COQS3. It is an evolutionary process claims CQS2 *"it's no different than going from paper to CAD, this is just another evolution."*

The QS has an opportunity to have a significant degree of influence on the project team if they can demonstrate they can add value, asserts CQS1. COQS3 agrees and asserts *"I think potentially we might have to add some more strings to our bow. I think we'll have to become a bit more technologically proficient."* In addition, it is argued, some of the traditional processes might fade effecting change. Single stage competitive tendering might disappear over time or might reduce down but CQS3 claimed "*you will* *still need to measure the value around those projects*." In addition, subcontractors may be able to price the package straight from the model but argues COQS2 *"we've still got the payment mechanisms in place, their valuation needs to be validated, somebody's got to be involved in that process and it is a QS."* COQS 1 believes that changes in roles will be most evident at the front end of a project identifying that in early bid work the QS *"will need to focus more around cost planning and design to cost."*

There is overwhelming support for the survival of the QS. BE2 asserts *"completely the QS will survive!"* because *"we have"* proclaims CQS3. BIM brings with it major potential for the QS as *"quantity generation is only a small part of what we do,"* argues CQS 3. COQS 3 agrees, *"I don't see that the QS is on the endangered list just yet!"*

The contributors therefore, fully support the survival of the QS role, identifying, that purposeful change management is required to secure a changing role, capable of creating and adding value to the organisation.

6.2.6. Summary of the interviews

As previously disclosed, the outcome of the analysis of the interviews will highlight issues requiring particular attention in the design process of the questionnaire and inform the design for the potential framework to be validated by the focus group. The contribution from the 8 interviews provided a vital insight into BIM and the QS. The analysis produced 5 high level themes and associated mid-level and low levels themes as illustrated in Table 6.4. These interviews assisted in enhancing the depth and breadth of understanding of BIM, whilst at the same time, identifying the impact that BIM may have on the future role of the QS. The five high level themes identified are (1) BIM, (2) Critical Success Factors, (3) Knowledge and Skills, (4) Quantity Surveyor and (5) Survival. The interviews provided definitions of ***BIM***, identified the current level of BIM adoption and the strategies for implementation along with its current applications and utilisation. In addition, the ***critical success factors*** for its adoption were identified, demonstrating the benefits that can come from BIM and the barriers that exist within the industry to its adoption. These two high level themes provide a generic background to BIM adoption and implementation in the construction industry, whilst the additional themes considered specifically the impact on the QS. The interviews clarified the current ***QS*** role and provided an insight into the current application of BIM by the QS. In addition, it identified the particular critical success factors to the adoption and implementation of BIM by the QS and identified the potential QS applications of BIM. The importance of extending and enhancing ***knowledge and understanding*** of BIM is considered and the variety of methods for its dissemination identified. Finally, the discussion around the survival of the QS resulted in the contributors affirming the continued evolution of the QS, not its annihilation, although, not without reservation. The essence of survival is further reflected by a tag cloud generated utilising NVivo. The 100 most frequently used words from the discussions within the survival theme are illustrated in Figure 5.12. The essential keywords that occurred most frequently within the 8 interviews were: still (256), project (193), might (189), going (186), BIM (156), role (145), see (144) and commercial (139), all words supporting the continued growth of the QS role.

Figure 6-12 Word frequency tag cloud Survival

These findings have been derived from a systematic and rigorous data analysis and synthesis of the rich information provided by the 8 interviews, contributing to the achievement of the objectives 2, 3 and 4 of this ‘study. Building on the literature review and these exploratory findings the questionnaire was derived, the analysis if which is discussed in the next chapter.

7. Findings: Questionnaire

This section presents the results of the questionnaire. The questionnaire considers QS services, BIM, organisational development and BIM and BIM learning and associated socio demographic information. The section concludes by summarising the key findings of the questionnaire and the implications for the framework development. The outcome of the analysis will highlight issues requiring particular attention in the design process of the framework and inform the design for the potential framework to be validated by the focus group.

7.1.1. The reliability of the sample size

The sample size affects whether a difference between samples is deemed significant or not. Generally, large samples have more power to detect effects than small sample sizes (Field, 2013). The power of this survey was tested with a population of 45,000 quantity surveyors in the UK (CITB, 2016) and the survey return of 183. Field, (2013) suggests that normally the confidence level is set at 95% and the confidence interval at 8 to calculate the number of participants needed to detect effect. This test was undertaken and a sample size of 150 was identified. However, when the test was undertaken again to calculate the interval expected from our population size of 45000 at a 95% confidence limit, the sample returned a 7.23 margin of error, therefore there could be a difference of 7.23% either side of the mean. It is recognised that this is 2% lower than the benchmarking standard and as such an exploratory factor analysis(EFA) was undertaken using SPSS23. EFA is a statistical technique that is used to reduce data to smaller sets of summary variables and, used to, identify the structure of the relationship between the variable and the respondent. 15 of the survey questions (constructs) and a total of 189 variables were tested by applying the Kaiser-Meyer-Olkin Measure of Sampling Adequacy to confirm or otherwise the validity of the sample. In all instances, the results exceeded the minimum criterion of 0.5 (Kiaser, 1974), ranging from 0.907 to 0.699and as such confirmed confidence in the sample size. See Appendix 3 tables 1- 3 for sample tests.

7.1.2. The reliability of the data

Research data must be reliable, as reliability, refers to the repeatability of the findings (Field, 2013). It is important therefore to assess the reliability of the questionnaire. Factor analysis is adopted to ensure that the questionnaire "consistently reflects the construct that it is measuring" (Field, 2013, p.706).

The factorability of the following questions in this research was considered Generally, correlations exceeding .30 provide enough evidence to indicate that there is enough commonality to justify comprising factors (Tabachnick& Fidell, 2001).

- Benefits of BIM to the QS
- BIM definition
- Benefits of BIM adoption to the organisation
- Barriers of BIM adoption to the organisation
- Organisational characteristics
- Criteria used by the organisation when adopting BIM.
- Impact on organisations as a consequence of adopting BIM
- Changes made by organisations as a consequence of BIM adoption.
- BIM learning mode
- Factors influencing resistance to change by organisations when implementing BIM

Benefits of BIM to the QS

Initially, the factorability of 11 benefits of BIM to the QS was examined. Several well-recognised criteria for the factorability of a correlation were used. Firstly, 8 of the 11 benefits correlated at least 0 .3 with at least one other item, suggesting reasonable factorability. Secondly, the Kaiser-Meyer-Olkin measure of sampling adequacy was 0.78, above the recommended value of 0.6 and as such indicates that patterns of correlations are relatively compact and that factor analysis should yield distinct and reliable results (FIeld, 2013, p684). Finally, the communalities were all above 0.3 further confirming that each item shared some common variance with other items. Given these overall indicators, factor analysis was conducted with all 11 items.

Principal components analysis was used because the primary purpose was to identify and compute benefits of BIM to the QS. The initial eigen values showed that the first factor explained 37% of the variance, the second factor 13% of the variance, and a third factor 10% of the variance. The remaining factors recorded values less than 1. During several steps, a total of two factors, “No impact on the QS” and “Death of the QS” were eliminated because they did not contribute to a simple factor structure and failed to meet a minimum criteria of having a primary factor loading of 0.4 or above, and cross-loading of 0.3 or above. Factorability is the assumption that there are at least some correlations amongst the variables so that coherent factors can be identified. The tests indicate inter-item reliability of the constructs. The scree tests showed inflexions that justified retaining two factors as illustrated in Figure 1 in Appendix 3. Table 4 illustrates the factor loadings after rotation, see Appendix 3.

As the research adopted factor analysis to validate the questionnaire it is essential that the scale adopted in the questionnaire is also reliable. Finally, the internal consistency for each of the scales was examined using Cronbach’s alpha. Cronbach’s alpha coefficient is a measure used to determine the internal consistency of the measurement scale in the questionnaire, which rates the importance of the variables. George and Mallery (2003 p.231) identified a rule of thumb in determining how reliable the measurement scale is in relation to the construct: “> .9 – Excellent, _ > .8 – Good, _ > .7 – Acceptable, _ > .6 – Questionable, _ > .5 – Poor, and _ < .5 – Unacceptable”. The alphas were acceptable at 0.769 for “No Impact on the QS” and questionable at 0.605 for “measurement of water”. However, there was no evidence to suggest that substantial increases in alpha would occur for any of the scales by eliminating more items. The scale adopted for these constructs: 5=Strongly Agree, 4=Agree, 3=Neutral, 2=Disagree, 1=Strongly Disagree; can be deemed to be internally consistent.

BIM definition

Initially, the factorability of 5 definitions of BIM was examined. Several well-recognised criteria for the factorability of a correlation were used. Firstly, all of the 5 definitions correlated at least 0.3 with at least one other item, suggesting reasonable factorability. Secondly, the Kaiser-Meyer-Olkin measure of sampling adequacy was 0.71, above the recommended value of .6 and as such indicates that patterns of correlations are relatively compact and that factor analysis should yield distinct and reliable results (FIeld, 2013, p684). Finally, the communalities were all above 0.3 further confirming that each item shared some common variance with other items. Given these overall indicators, factor analysis was conducted with all 5 items.

Principal components analysis was used because the primary purpose was to identify and compute the definitions of BIM. The initial eigen values showed that the first factor explained 47% of the variance and the second factor 23% of the variance. The remaining factors recorded values less than 1. Factorability is the assumption that there are at least some correlations amongst the variables so that coherent factors can be identified. The tests indicate inter-item reliability of the constructs. The scree tests showed inflexions that justified retaining two factors as illustrated in Figure 2 in Appendix 3 Table 5 illustrates the factor loadings after rotation, see Appendix 3.

Finally, the internal consistency for each of the scales was examined using Cronbach's alpha. The alphas ranged from acceptable at 0.752 for BIM definition 1(BIM is an Information Technology (IT) enabled approach that allows design integrity, virtual prototyping, simulations, distributed access, retrieval and maintenance of the building data) to poor/questionable at 0.582 for BIM definition 3(BIM is a multi-dimensional, historically evolving, complex phenomenon). However, there was no evidence to suggest that substantial increases in alpha would occur for any of the scales by eliminating more items. The scale adopted for these constructs: 5=Strongly Agree, 4=Agree, 3=Neutral, 2=Disagree, 1=Strongly Disagree; can be deemed to be internally consistent.

Benefits of BIM adoption to the organisation

Initially, the factorability of 15 benefits of BIM adoption to the organisation was examined. Several well-recognised criteria for the factorability of a correlation were used. Firstly, all of the 15 benefits to the organisation correlated at least 0.3 with at least one other item, suggesting reasonable factorability. Secondly, the Kaiser-Meyer-Olkin measure of sampling adequacy was 0.888, above the recommended value of 0.6 and as such indicates that patterns of correlations are relatively compact and that factor analysis should yield distinct and reliable results (Field, 2013, p684). Finally, all but one of the items, “visualisation” when the communalities were considered were above 0.3 further confirming that each item shared some common variance with other items. Given these overall indicators, factor analysis was conducted with all 15 items.

Principal components analysis was used because the primary purpose was to identify and compute the benefits of BIM to the organisation. The initial eigen values showed that the first factor explained 33% of the variance and the second factor 27% of the variance. The remaining factors recorded values less than 1. Factorability is the assumption that there are at least some correlations amongst the variables so that coherent factors can be identified. The tests indicate inter-item reliability of the constructs. The scree tests showed inflexions that justified retaining two factors as illustrated in Figure 3 in Appendix 3   Table 6 illustrates the factor loadings after rotation, see Appendix 3.

Finally, the internal consistency for each of the scales was examined using Cronbach’s alpha. The alphas ranged were all found to be excellent from

0.932 for visualisation to 0.924 for improving efficiencies. However, there was no evidence to suggest that substantial increases in alpha would occur for any of the scales by eliminating more items. The scale adopted for these constructs: 3= Major benefit of BIM 2= Minor benefit of BIM 1= No benefit; can be deemed to be internally consistent.

Barriers of BIM adoption to the organisation

Initially, the factorability of 17 barriers of BIM adoption to the organisation was examined. Several well-recognised criteria for the factorability of a correlation were used. Firstly, all of the 17 barriers to the organisation correlated at least 0.3 with at least one other item, suggesting reasonable factorability. Secondly, the Kaiser-Meyer-Olkin measure of sampling adequacy was 0.826, above the recommended value of 0.6 and as such indicates that patterns of correlations are relatively compact and that factor analysis should yield distinct and reliable results (FIeld, 2013, p684). Finally, the communalities were all above 0.3 further confirming that each item shared some common variance with other items. Given these overall indicators, factor analysis was conducted with all 17 items.

Principal components analysis was used because the primary purpose was to identify and compute the barriers of BIM to the organisation. The initial eigen values showed that the first factor explained 36% of the variance, the second factor 12% of the variance, the third factor 9% of the variance and the fourth factor 8% of the variance. The remaining factors recorded values less than 1. Factorability is the assumption that there are at least some correlations amongst the variables so that coherent factors can be identified. The tests indicate inter-item reliability of the constructs. The scree tests showed inflexions that justified retaining five factors as illustrated in Figure 4 in Appendix 3 Table 7 illustrates the factor loadings after rotation, see Appendix 3.

Finally the internal consistency for each of the scales was examined using Cronbach’s alpha. The alphas ranged were all found to be good from 0.882

for contractual liability to 0.871 hardware and software costs. However, there was no evidence to suggest that substantial increases in alpha would occur for any of the scales by eliminating more items. The scale adopted for these constructs: 3= No barrier of BIM 2= Minor barrier 1= Major barrier; can be deemed to be internally consistent

Organisational characteristics

Initially, the factorability of 11 organisational characteristics was examined. Several well-recognised criteria for the factorability of a correlation were used. Firstly, all of the 11 organisational characteristics correlated at least 0.3 with at least one other item, suggesting reasonable factorability. Secondly, the Kaiser-Meyer-Olkin measure of sampling adequacy was 0.86, above the recommended value of .6 and as such indicates that patterns of correlations are relatively compact and that factor analysis should yield distinct and reliable results (FIeld, 2013). Finally, the communalities were all above 0.3 further confirming that each item shared some common variance with other items. Given these overall indicators, factor analysis was conducted with all 11 items.

Principal components analysis was used because the primary purpose was to identify and compute the organisational characteristics. The initial eigen values showed that the first factor explained 51% of the variance and the second factor 15% of the variance. The remaining factors recorded values less than 1. Factorability is the assumption that there are at least some correlations amongst the variables so that coherent factors can be identified. The tests indicate inter-item reliability of the constructs. The screen tests showed inflexions that justified retaining two factors as illustrated in Figure 5 in Appendix 3 Table 8 illustrates the factor loadings after rotation, see Appendix 3.

Finally, the internal consistency for each of the scales was examined using Cronbach’s alpha. The alphas ranged from good at 0.84 for “Trust” To excellent at 0.900 for “organisational structure”. However, there was no evidence to suggest that substantial increases in alpha would occur for any of the scales by eliminating more items. The scale adopted for these constructs: 5=Strongly Agree, 4=Agree, 3=Neutral, 2=Disagree, 1=Strongly Disagree; can be deemed to be internally consistent.

Criteria used by the organisation when adopting BIM.

Initially, the factorability of 11 organisational characteristics was examined. Several well-recognised criteria for the factorability of a correlation were used. Firstly, all of the 11 organisational characteristics correlated at least 0.3 with at least one other item, suggesting reasonable factorability. Secondly, the Kaiser-Meyer-Olkin measure of sampling adequacy was 0.93, above the recommended value of 0.6 and as such indicates that patterns of correlations are relatively compact and that factor analysis should yield distinct and reliable results (Field, 2013, p684). Finally, the communalities were all above 0.3 further confirming that each item shared some common variance with other items. Given these overall indicators, factor analysis was conducted with all 11 items.

Principal components analysis was used because the primary purpose was to identify and compute criteria used by the organisation when adopting BIM. The initial eigen values showed that the first factor explained 56% of the variance and the second factor 10% of the variance. The remaining factors recorded values less than 1. Factorability is the assumption that there are at least some correlations amongst the variables so that coherent factors can be identified. The tests indicate inter-item reliability of the constructs. The scree tests showed inflexions that justified retaining two factors as illustrated in Figure 6 in Appendix 3 Table 9 illustrates the factor loadings after rotation, see Appendix 3.

Finally, the internal consistency for each of the scales was examined using Cronbach's alpha. The alphas were all in the excellent range with the lowest recording being 0.911 for "Support the business" to 0.921 for "Response to Government push".

However, there was no evidence to suggest that substantial increases in alpha would occur for any of the scales by eliminating more items. The scale adopted for these constructs: 5=Strongly Agree, 4=Agree, 3=Neutral, 2=Disagree, 1=Strongly Disagree; can be deemed to be internally consistent.

Impact on organisations as a consequence of adopting BIM

Initially, the factorability of 14 impact on organisations as a consequence of adopting BIM was examined. Several well-recognised criteria for the factorability of a correlation were used. Firstly, all of the 14 impacts correlated at least 0.3 with at least one other item, suggesting reasonable factorability. Secondly, the Kaiser-Meyer-Olkin measure of sampling adequacy was 0.93, above the recommended value of .6 and as such indicates that patterns of correlations are relatively compact and that factor analysis should yield distinct and reliable results (FIeld, 2013, p684). Finally, the communalities were all above 0.3 further confirming that each item shared some common variance with other items. Given these overall indicators, factor analysis was conducted with all 14 items.

Principal components analysis was used because the primary purpose was to identify and compute the impact on organisations as a consequence of adopting BIM. The initial eigen values showed that the first factor explained 59% of the variance, the second factor 9% of the variance and the third factor 7% of eth variance. The remaining factors recorded values less than 1. Factorability is the assumption that there are at least some correlations amongst the variables so that coherent factors can be identified. The tests indicate inter-item reliability of the constructs. The scree tests showed inflexions that justified retaining three factors as illustrated in Figure 7 in Appendix 3 Table 10 illustrates the factor loadings after rotation, see Appendix 3.

Finally, the internal consistency for each of the scales was examined using Cronbach’s alpha. The alphas were all in the excellent range with the lowest recording being 0.928 for “roles less varied” to 0.922 for “increased revenue”.

However, there was no evidence to suggest that substantial increases in alpha would occur for any of the scales by eliminating more items. The scale adopted for these constructs: 5=Strongly Agree, 4=Agree, 3=Neutral, 2=Disagree, 1=Strongly Disagree; can be deemed to be internally consistent.

Changes made by the organisation as a consequence of BIM adoption.

Initially, the factorability of 14 organisational changes to the organisation was examined. Several well-recognised criteria for the factorability of a correlation were used. Firstly, all of the 14 changes to the organisation correlated at least 0.3 with at least one other item, suggesting reasonable factorability. Secondly, the Kaiser-Meyer-Olkin measure of sampling adequacy was 0.905, above the recommended value of 0.6 and as such indicates that patterns of correlations are relatively compact and that factor analysis should yield distinct and reliable results (FIeld, 2013, p684). Finally, the communalities were all above 0.3 further confirming that each item shared some common variance with other items. Given these overall indicators, factor analysis was conducted with all 14 items.

Principal components analysis was used because the primary purpose was to identify and compute the benefits of changes made by the organisation as a consequence of BIM adoption.The initial eigen values showed that the first factor explained 55% of the variance and the second factor 9% of the variance. The remaining factors recorded values less than 1. Factorability is the assumption that there are at least some correlations amongst the variables so that coherent factors can be identified. The tests indicate inter-item reliability of the constructs. The scree tests showed inflexions that justified retaining five factors as illustrated in Figure 8 in Appendix 3 Table 11 illustrates the factor loadings after rotation, see Appendix 3.

Finally, the internal consistency for each of the scales was examined using Cronbach's alpha. The alphas ranged were all found to be excellent from 0.934 for "software" to 0.928 "processes". However, there was no evidence to suggest that substantial increases in alpha would occur for any of the scales by eliminating more items. The scale adopted for these constructs: 3= Major change 2= Minor change 1= No change; can be deemed to be internally consistent.

BIM learning mode

Initially, the factorability of 11 BIM learning modes was examined. Several well-recognised criteria for the factorability of a correlation were used. Firstly, all of the 11 learning modes correlated at least 0.3 with at least one other item, suggesting reasonable factorability. Secondly, the Kaiser-Meyer-Olkin measure of sampling adequacy was 0.783, above the recommended value of 0.6 and as such indicates that patterns of correlations are relatively compact and that factor analysis should yield distinct and reliable results (FIeld, 2013, p684). Finally, the communalities were all above 0.3 further confirming that each item shared some common variance with other items. Given these overall indicators, factor analysis was conducted with all 11 items.

Principal components analysis was used because the primary purpose was to identify and compute BIM learning mode. The initial eigen values showed that the first factor explained 40% of the variance, the second factor 20% of the variance and the third factor 10% of the variance. The remaining factors recorded values less than 1. Factorability is the assumption that there are at least some correlations amongst the variables so that coherent factors can be identified. The tests indicate inter-item reliability of the constructs. The scree tests showed inflexions that justified retaining three factors as illustrated in Figure 9 in Appendix 3   Table 12 illustrates the factor loadings after rotation, see Appendix 3.

Finally, the internal consistency for each of the scales was examined using Cronbach’s alpha. The alphas were all in the good range with the lowest recording being 0.814 for “professional journals” to 0.845 for “by doing”. However, there was no evidence to suggest that substantial increases in alpha would occur for any of the scales by eliminating more items. The scale adopted for these constructs: 5=Strongly Agree, 4=Agree, 3=Neutral, 2=Disagree, 1=Strongly Disagree; can be deemed to be internally consistent.

Factors influencing resistance to change by organisations when implementing BIM

Initially, the factorability of 10 Factors influencing resistance to change by organisations when implementing BIM was examined. Several well-recognised criteria for the factorability of a correlation were used. Firstly, all of the 10 factors correlated at least 0.3 with at least one other item, suggesting reasonable factorability. Secondly, the Kaiser-Meyer-Olkin measure of sampling adequacy was 0.847, above the recommended value of .6 and as such indicates that patterns of correlations are relatively compact and that factor analysis should yield distinct and reliable results (FIeld, 2013, p684). Finally, the communalities were all above 0.3 further confirming that each item shared some common variance with other items. Given these overall indicators, factor analysis was conducted with all 10 items.

Principal components analysis was used because the primary purpose was to identify and compute the factors influencing resistance to change by organisations when implementing BIM. The initial eigen values showed that the first factor explained 55% of the variance, the second factor 13% of the variance and the third factor 11% of the variance. The remaining factors recorded values less than 1. Factorability is the assumption that there are at least some correlations amongst the variables so that coherent factors can be identified. The tests indicate inter-item reliability of the constructs. The scree tests showed inflexions that justified retaining three factors as illustrated in Figure 10 in Appendix 3 Table 13 illustrates the factor loadings after rotation, see Appendix 3.

Finally, the internal consistency for each of the scales was examined using Cronbach's alpha. The alphas ranged from excellent range with 0.928 for "inadequate management support" to good 0.894 for "staff reluctant to adopt new methods" However, there was no evidence to suggest that substantial increases in alpha would occur for any of the scales by eliminating more items. The scale adopted for these constructs: 5=Strongly Agree, 4=Agree, 3=Neutral, 2=Disagree, 1=Strongly Disagree; can be deemed to be internally consistent.

7.1.3. The Normality of the Data

In order to check the normality of the distribution of the scores the Kolmogorov-Smirnov test is used. The test compares a theoretically normally distributed set of scores with the same mean and standard deviation, to the scores in a given sample (Field, 2015). If the test result has a significant value of <0.05 that means the distribution of the sample is significantly different from a normal distribution, if the result has a non-significant value of >0.05 this mean the results are normally distributed. Appendix 3 Table 14 illustrates that the KS Sig. for the all of the variables has a significant value of <0.05 and therefore the data in the questionnaire is nonparametric and as such non-parametric tests must be used for analysis.

7.2. Demographic features of the sample

A number of demographic variables were obtained from the participants these can be separated into personal and organisational.

7.2.1. Personal

The age of the respondents ranges from 16 – 67 years, with 70% in the age range 22-40 years, 19% 41- 54 years, 5.5% 16-21 years and 5.5% 55-67 years as illustrated in Figure 7.1.

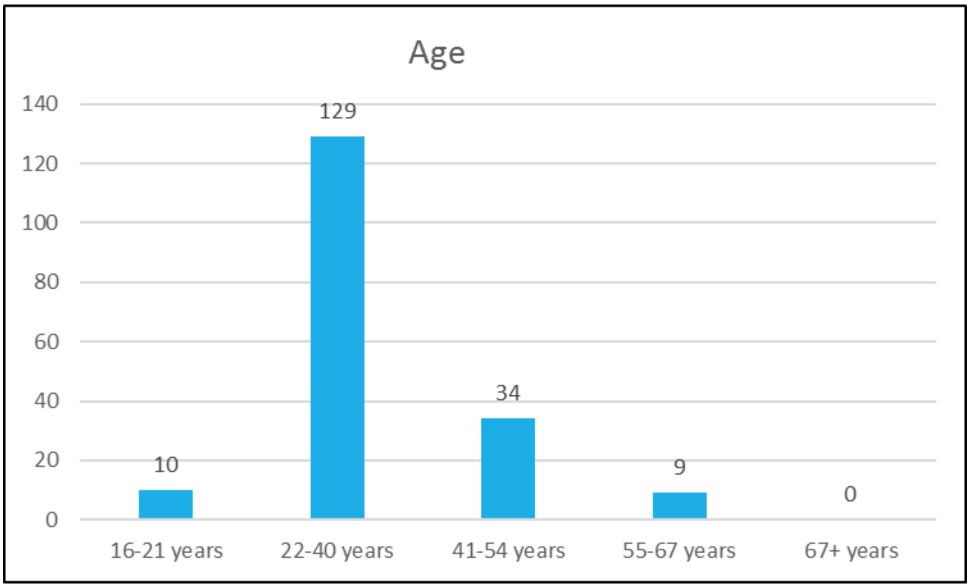


Figure 7-1 Age profile of respondents

60 % of the respondents are employed as a quantity surveyor with 30% in a trainee role and 10% as other. Those in the other category included 6 commercial directors, 1 Commercial BIM lead, 2 academics, 4 associate partners, 1 estimator, 1 senior consultant, 1 Bid manager, 1 senior Project manager, 1 lifecycle assistant and 1 building surveyor. Of these 19, 14 titles represent a senior position within the organisation, as illustrated in Figure 7.2.

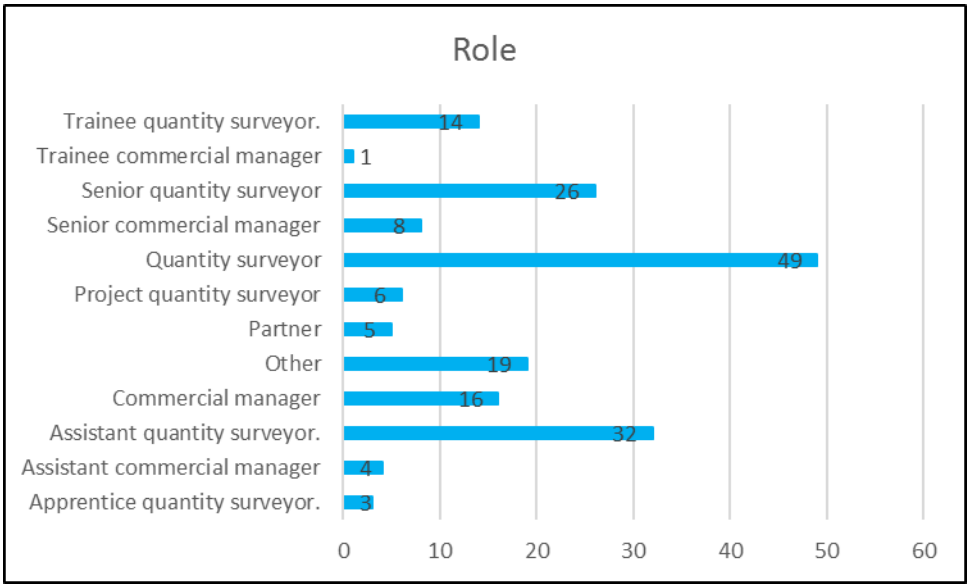


Figure 7-2 Role profile of the respondents

7.2.2. Organisational

The majority of the respondents are employed in a Contracting organisation with the second highest being employed in a consultant organisation. Academic, housing association, sub-contractor and developer were the organisations identified as “other”. As illustrated in Figure 7.3.

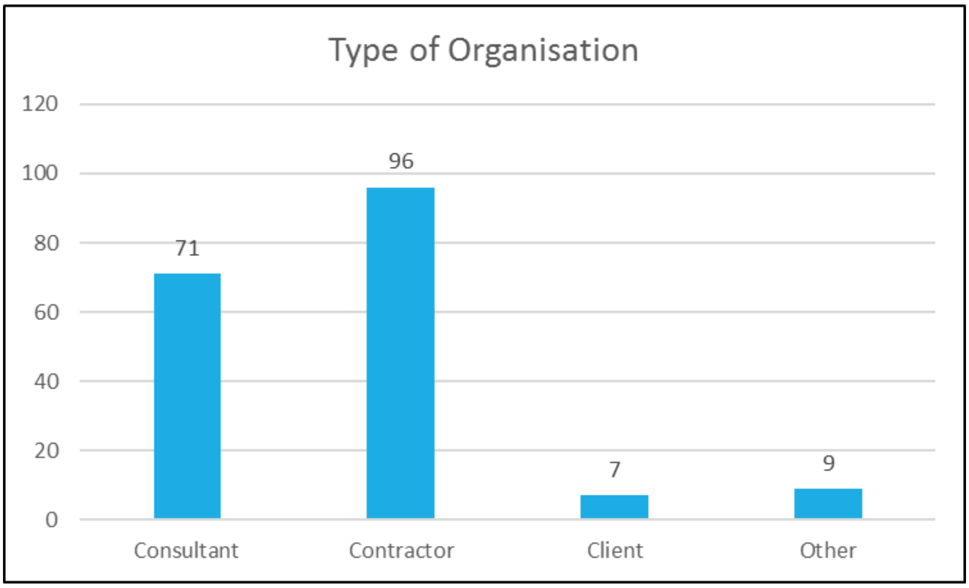


Figure 7-3 Organisational type

In addition, 32.8 % of the respondents are employed in a small and medium sized enterprise(SME) as defined in the EU recommendation 2003/361; with 67.2% employed in a large enterprise, employing over 250 employees. 64.1% of the respondents work in organisations which are UK based only, with the remaining 35.9% being International. 33% of the respondent’s organisations work out of 1-5 offices whilst 32% work out of 50+ offices. In terms of the number of years the organisations have been in operation, 40.4% have existed for over 51 years, 24%, 21-50 years; 27.4%, 6-20 years and 8.2%, 1-5 years. The sectors to which the organisations belong predominantly 50.3 % Building, 28.5% Civil Engineering, 13.6% Engineering and 7.6% identified “other”. The nuclear, rail, and infrastructure sectors were identified as being in the “other” category.

7.3. BIM and the QS

7.3.1. The service provided by the QS

The list of services identified as being offered by the QS provided a range of responses, with the least offered service being insolvency (31%) and the most offered service being procurement and tendering (87%). The services showing the highest adoption of BIM is cost modelling services and design economics and cost planning each with 34% and the service that adopts BIM the least is insolvency with 4%. Interestingly, only 26% of the respondents adopted BIM when offering the service, procurement and tendering. The services offered, offered with BIM, and not offered by the respondents are illustrated in Figure 7.4.

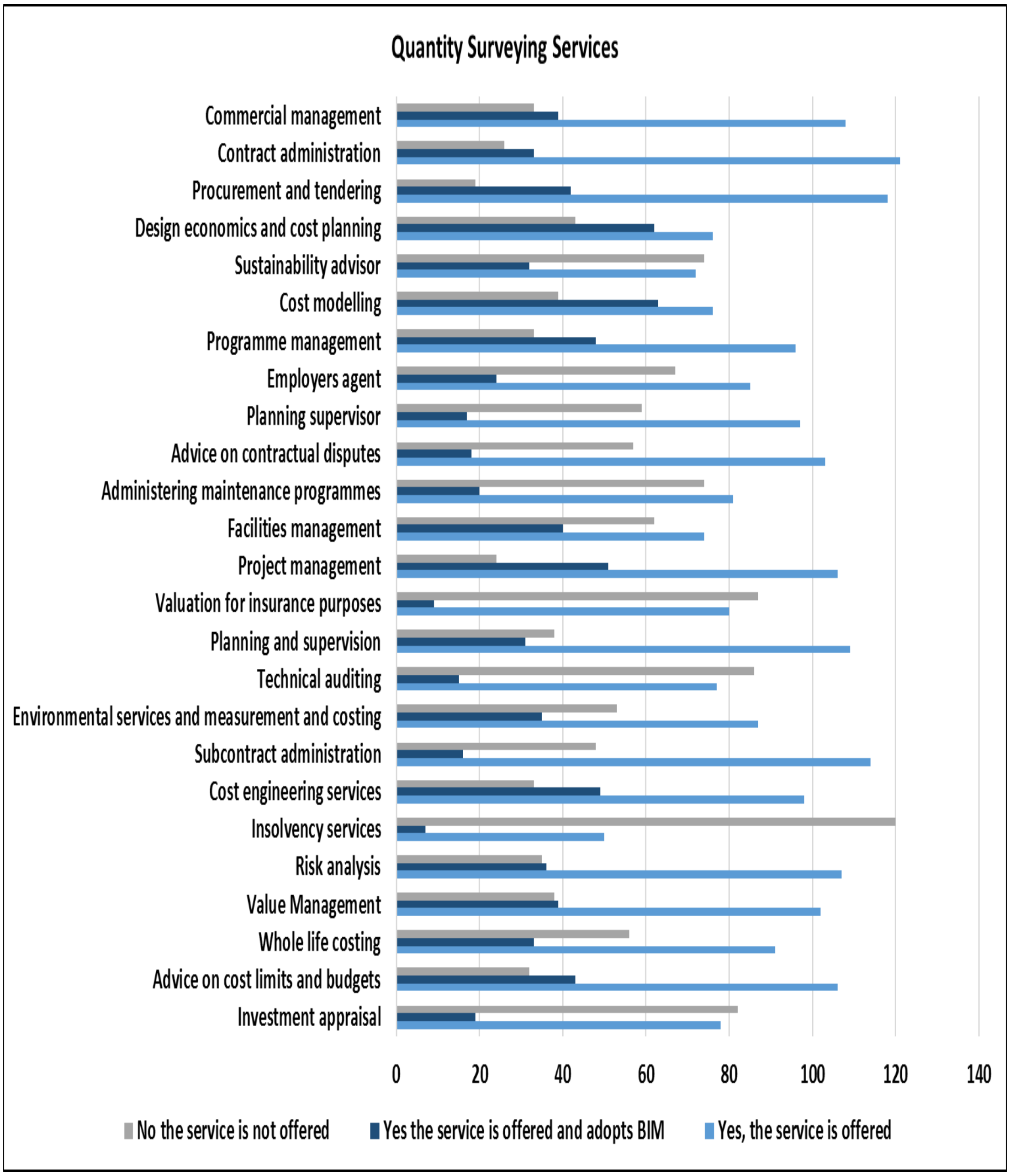


Figure 7-4 Quantity Surveying Services

The contractor (COQS) and the consultant (CQS) represent 91% of the total respondents with the remaining 9% being client and other. The focus of the study is on the contracting and consulting organisations. The services offered with BIM specifically by these groups is illustrated in Figure 7.5. The service that the consultant adopts BIM the most for is design economics and cost planning (48%) followed closely by cost modelling (45%) with the least adoption of BIM being insolvency (1%). Similarly, the service the Contractor adopts BIM the most for is cost modelling (31%) closely followed by project management (30%) and programme management (30%), design economics and cost planning (28%) is the 4th most popular service to adopt BIM. As with the consultant, the contractor adopts BIM the least with insolvency, 3%. BIM is therefore adopted by both the COQS and CQS at an early stage in the project development where it would be expected the greatest influence could be made to the project in terms of creating efficiencies with cost modelling and design economics.

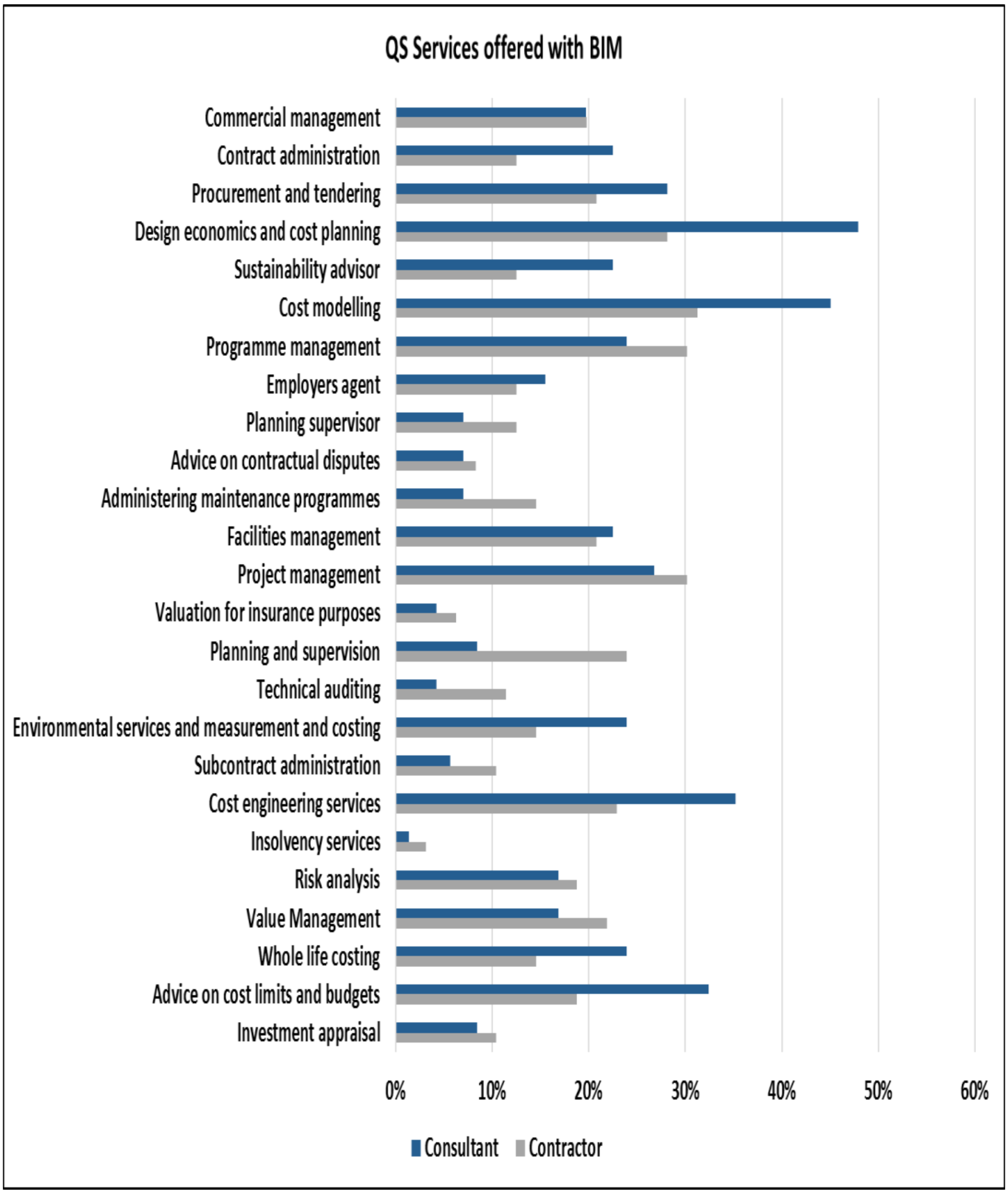


Figure 7-5 QS services offered with BIM

7.3.2. RIBA stage at which the QS adopts BIM

The RIBA plan of work represents the stage in a project life cycle, from stage 0, strategic definition to 7, in use. The stage when the respondents are more likely to adopt BIM is at developed design stage 3 with 21% of respondents indicating that they will always adopt BIM at this stage. The stage when they are least likely to adopt BIM is at stage 7, in use, with 51% indicating that they never adopt BIM at this stage. Stage 2, concept design, is the stage that the respondents may consider using BIM with 59% confirming that they sometimes adopt at this stage.

The contractor is more likely to always adopt at Stage 0 than the consultant, with the client group indicating that they are the least likely to adopt at this stage. 13% of contractors always adopt BIM at this stage in comparison to 6% of consultants. This is illustrated in Figure 7.6.

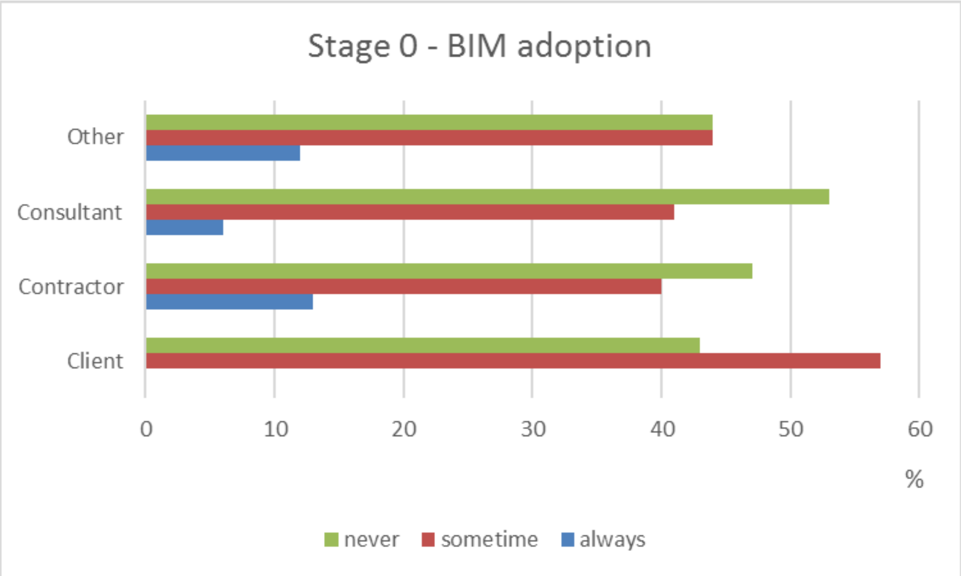


Figure 7-6 Stage 0 BIM adoption

Once again at Stage 3 the contractor is more likely to always adopt BIM than the consultant with 24% of contractors always adopting at this stage, compared with 11% of consultants. Both the client and the contractor are twice as likely to always adopt BIM at Stage 3 than Stage 0, as illustrated in Figure 7.7.

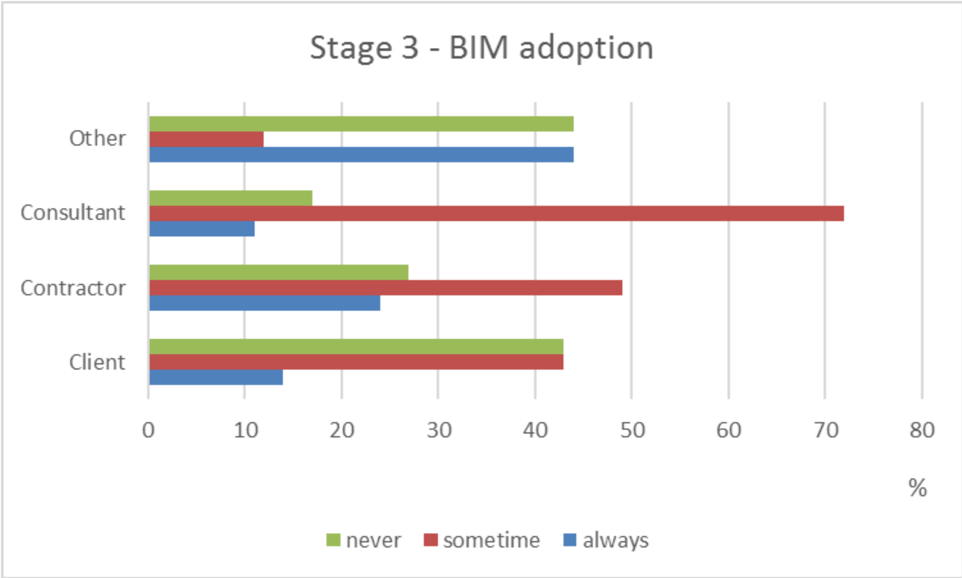


Figure 7-7 Stage 3 - BIM adoption

The variance in the stage of adoption between the CQS and the COQS could be explained in terms of the predominant procurement route that each group are appointed under. Design and Build procurement offering the COQS an opportunity to engage with BIM at stage 0 whereas normally the CQS appointment would be much later, at stage 3.

7.3.3. Impact on the QS role

The participants were asked to indicate their opinions on a total of 10 variables. These variables range from a negative perspective, i.e. the “death of the QS” to the positive impact in terms of process and technology. BIM, when considered as a technology, was associated with the automation of quantities and creating efficiencies in terms of time and accuracy. In contrast when BIM was considered as a process, the impact was associated with an increase in collaborative working to support decision making and diversification of services, particularly in relation to whole life costing and new areas of sustainable measurement. The participants were asked to rate their level of agreement or disagreement in relation to each variable. This is identified in Table 7.1 complete with the standard deviation and its ranking in relation to impact.

Table 7-1 Frequency data, Impact of BIM on the QS

	Strongly disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly Agree 5	Mean	Std. Deviation	Rank
	N(%)	N(%)	N(%)	N(%)	N(%)			
Greater involvement in a collaborative project team environment	0(0)	3(1.7)	29(16.1)	75(41.7)	73(40.6)	4.21	0.77	1
Less time spent on quantification	6(3.3)	11(6.1)	40(22.2)	58(32.2)	65(36.1)	3.92	1.06	2
Greater involvement in whole life costing	3(1.7)	6(3.4)	41(22.9)	86(48)	43(24)	3.89	0.86	3
Smarter faster decisions	1(0.6)	12(6.7)	54(30)	63(35)	50(27.8)	3.83	0.93	4
Greater involvement in quality assurance	0(0)	12(6.7)	58(32.2)	69(38.3)	41(22.8)	3.77	0.88	5
More time for the QS to spend looking for gaps in the model	2(1.1)	14(7.8)	55(30.6)	67(37.2)	42(23.3)	3.74	0.94	6
Greater involvement in post occupancy evaluation	6(3.4)	15(8.4)	66(37.1)	70(39.3)	21(11.8)	3.48	0.93	7
Measurement moving into embodied and operational carbon	5(2.8)	26(14.4)	73(40.6)	51(28.3)	25(13.9)	3.36	0.98	8
Measurement moving into embodied and operational water	6(3.3)	27(15)	75(41.7)	47(26.1)	25(13.9)	3.32	1	9
Death of the QS	92(51.1)	44(24)	23(12.8)	16(8.9)	5(2.8)	1.88	1.11	10

The greatest impact perceived by the participants on the role of the QS as represented by the highest mean is identified as "*greater involvement in a collaborative project team environment*", the second highest impact is *"less time spent on quantification"* and the third highest *"greater involvement in whole life costing".* The participants perceived that BIM would have the least impact, as represented by the lowest mean, on *“the death of the QS”.* Rather surprisingly the QS participants did not express any negative concerns in relation to their roles. Moreover, they recognised the positive outcomes in relation to both the process (collaborative working) and technology (automation and speed of quantification). Therefore, it can be concluded that the QS would survive and that BIM provided the QS with the opportunity to create value and provide new services, in a collaborative project team environment.

7.3.4. BIM definitions

The literature and the exploratory interviews identified that BIM has many different interpretations each with its own fundamentally different perspective ranging from the constantly evolving and complex to others founded on process or technology based. The respondents were asked to consider 5 definitions of BIM and to confirm their level of agreement or disagreement. The results are illustrated in Table 7.2.

T able 7-2 Mean and Standard deviation for BIM definitions.

	Strongly disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly Agree 5	Mean	Std. Deviation	Rank
	N(%)	N(%)	N(%)	N(%)	N(%)			
BIM definition 2 BIM is concerned with information about the entire building and a complete set of design documents stored in an integrated database, where the information is parametric and thereby interconnected.	8(4.4)	15(8.2)	37(20.2)	70(30.83	51(27.9)	3.78	1.08	1
BIM definition 5 BIM is a language of collaboration with people and communication at its centre.	8(4.4)	15(8.3)	44(24.4)	56(31.1)	57(31.7)	3.77	1.12	2
BIM Definition 1 BIM is an Information Technology (IT) enabled approach that allows design integrity, virtual prototyping, simulations, distributed access, retrieval and maintenance of the building data.	10(5.5)	14(7.7)	33(18.2)	80(44.2)	44(24.3)	3.74	1.08	3
BIM definition 4 BIM is the coming together of policy, process and technology.	6(3.4)	22(12.4	48(27)	57(32)	45(25.3)	3.63	1.09	4
BIM definition 3 BIM is a multi-dimensional, historically evolving, complex phenomenon.	14(7.8)	45(25)	46(25.6)	54(30)	21(11.7)	3.13	1.15	5

Definition 2 defines BIM as *"information about the entire building and a complete set of design documents stored in an integrated database, where the information is parametric and thereby interconnected."* This scored the highest mean and as such is the definition which the majority of the participants agree with: the client, 71.43%, the contractor, 69.15%, the consultant, 64.79%, and "other", 55.55%, recording the least.

Definition 5 defines BIM as *"a language of collaboration with people and* *communication at its centre."* The mean score was only 0.1% lower than definition 2 and as such must be given high consideration. All 4 groups agreed with this definition the “other” groups 88.88%, the client, 85.71%, the consultant, 56.34%, and the contractor, 63.44%. This definition achieves the second highest overall level of support from the total of all groups.

Definition 3 defines BIM as *"a multi-dimensional, historically evolving, complex phenomenon."* recorded the lowest score and was the one that the majority did not relate to. 3 of the groups did not agree with this definition recording their agreement as consultant, 34.62%, contractor, 45.16% and “other”, 44.44%, although in contrast the client, 57.15%, did agree with the definition.

Interestingly, the participants did not focus on technology in terms of definition and recognised that BIM was concerned first and foremost with information and that it was the method of collection and storage that could support integration that was important. Presumably, collaboration ranked second highest, as collaboration could provide the conduit through which the information could be exchanged. The fact that BIM could change over time was not well received by the participants, perhaps this was because, BIM is a new concept and as such the participants are grappling with its interpretation. They do not want it to change and as such cannot see beyond this initial stage. However, in section 7.3.3 it was identified that the QS role would change and bring with it added value, therefore as the QS role changes, there would be a change in BIM definition, as presumably, BIM experience would influence perceptions, particularly as it pertains to benefits.

7.3.5. Benefits to the QS organisation

The literature and exploratory interviews identified many benefits to the QS organisation by adopting BIM. These benefits were identified at both project level (Bryde et al, 2013) and organisational level (Lindblad and Vass, 2015) with the ultimate aim of all benefits being to improve productivity by the creation of efficiencies and a more effective service. The project level benefits are created within each individual project and can be different depending on the characteristics of the project. These project level benefits can create and support organisational level benefits in terms of how the project level benefits transfer into the organisation. The participants considered both types of benefits and were asked to identify if they were a *major benefit (3), minor benefit (2)* or of *no benefit (1)* to their organisation as illustrated in Table 7.3.

Table 7-3 Mean, standard deviation and rank for the benefits of BIM to the organisation

	Major benefit 3	Minor benefit 2	No benefit 1	Mean	Std. Deviation	Rank
	N(%)	N(%)	N(%)			
Improved visualisation	158	16	6	2.84	0.446	1
Improved communication across the project team	127	43	10	2.65	0.584	2
Faster quantification and measurement	116	54	10	2.59	0.596	3
Improved efficiency	113	51	16	2.54	0.655	4
More accurate updating of changes	114	47	18	2.54	0.673	5
Faster updating of changes	107	57	15	2.51	0.648	6
Improved processes	101	67	12	2.49	0.621	7
More accurate quantification and measurement	102	60	18	2.47	0.672	8
Improved productivity	102	56	22	2.44	0.703	9
Faster decision making	100	56	23	2.43	0.711	10
Increased competitive advantage	93	59	28	2.36	0.738	11
Increased sustainable competitive advantage	90	60	29	2.34	0.743	12
More accurate decision making	87	63	28	2.33	0.734	13
Improve the quality of delivery	85	70	25	2.33	0.709	14
Increased global competitive advantage	90	53	37	2.29	0.789	15

The *major benefit* that achieves the highest overall level of support from the total of all groups, with the highest mean is *improved visualisation*. In addition, it scored the highest with the consultant,87.32%, and the contractor,87.1%, and joint highest with client,85.71%, and other,100%.

Improved communication across the project team achieves the second highest level of support from the total of all groups, the client,85.71% and other,100% scored this joint highest with *improved visualisation* and the consultant,69.01%, scored it second highest and the contractor,67.74%, joint second highest with *faster quantification and measurement*. The third highest level of support was faster quantification and measurement. The *increases global competitive advantage* recorded the lowest mean (2.29) and was perceived to be the least benefit to the organisation with all groups recording their lowest score against this.

Interestingly, it was the project benefits that were ranked higher than the organisational ones with the participants relating to the benefits of BIM at this level as opposed to the transfer of these to the organisation, the link between improved efficiency not being made, with increasing the competitive advantage of the organisation. The participants are perhaps closer to the project needs, than those of the organisation, and hence, it is these benefits that they perceive to be more important. Finally, BIM was not perceived as improving the quality of delivery although in relation to the government push for BIM to create efficiencies and cut costs this may be hardly surprising.

7.3.6. Barriers to the QS organisation

In addition to benefits, several barriers to the adoption of BIM were identified in the literature and the exploratory interviews. The barriers centred on the technology, process and protocols and people. In respect of technology, barriers were identified as relating to the type of software, costs, integration of data and lack of trust (Goucher and Thurairajah, 2013, Stanley and Thurnall, 2014); whereas process identified issues around industry standards and protocols, QS specific formats, contracts and the fragmented nature of the construction industry (Harrison and Thurnell, 2014, Smith et al, 2014). In contrast, the people barrier presented itself in relation to lack of trained staff, cultural resistance to change and lack of confidence (Shen and Isa, 2010, Stanley and Thurnall, (2014) and even represented as a threat to survival of the QS role (Olatunji, 2011). In contrast to benefits being presented at project level in section 7.3.5, the barriers presented themselves now at an institutional level, external to the organisation particularly in terms of the lack of new entrants into the industry and the lack of private demand mainly at an organisational level which could then be transferred down this time to project level, for example lack of suitably qualified staff. The participants were asked to consider the barriers and to identify if they were a *major barrier (1), minor barrier (2)* or *no barrier (3)* to their organisation, as illustrated in Table 7.4.

Table 7-4 Mean, standard deviation and rank for the barriers of BIM to the organisation

	Major barrier 3	Minor barrier 2	No barrier 1	Mean	Std. Deviation	Rank
	N(%)	N(%)	N(%)			
Lack of suitably skilled and experienced staff	114(63.3)	51(28.3)	15(8.3)	2.55	0.65	1
The ageing workforce and the undersupply of new entrants.	101(56.1)	58(32.2)	21(11.7)	2.44	0.69	2
Cost of training	90(50.6)	73(40.6)	16(8.9)	2.40	0.65	3
Cost of hardware	87(50.6)	75(42.2)	18(10)	2.38	0.66	4
Lack of private client demand	91(53.9)	67(37.2)	16(8.9)	2.35	0.65	5
Cost of network	89(47.8)	79(44.6)	18(10.2)	2.35	0.66	5
Lack of shared knowledge banks available to the QS	76(42.2)	87(48.3)	17(9.4)	2.33	0.64	7
Cost of Software	91(50.6)	76(42.2)	13(7.2)	2.29	0.63	8
Lack of confidence in the selection of appropriate software	83(46.4)	67(37.4)	29(16.2)	2.29	0.73	9
Inadequate professional body training provided by professional bodies	71(39.4)	87(48.3)	22(12.2)	2.27	0.67	10
The isolation of the QS from key decision makers and clients	73(40.6)	66(36.7)	41(22.8)	2.18	0.78	11
Lack of certainty of added value to the client	63(35.4)	78(43.80	37(20.8)	2.15	0.74	12
Lack of certainty of added value to the QS role	63(35.2)	73(40.8)	43(24)	2.11	0.76	13
Contractual liability concerns	51(28.8)	86(48.6)	40(22.6)	2.06	0.72	14
Reduction in fees charged	42(23.60)	98(55.1)	38(21.3)	2.02	0.67	15
Increased competition	34(19)	102(57)	43(24)	1.95	0.66	16
Fear of extinction of the QS role	37(20.6)	51(28.3)	92(51.1)	1.69	0.79	17

The highest mean recorded was against *lack of suitably skilled and experienced staff* presenting itself as the biggest barrier, over all groups. In addition, this is also the biggest barrier for the consultant, 63.84% and the contractor, 63.44%. This was closely followed by, *the ageing workforce and the undersupply of new entrants,* the largest two barriers being in relation to people barriers. The contractor recorded this as the second highest barrier but the consultant only ranked it as fourth, whilst the client did not see it as much of barrier as it appeared joint second lowest in this group. The current shortage of QS's must be impacting the contracting organisation more than the consultant organisation causing them to identify people as a major barrier. It is hardly surprising, that, the client does not identify with this, as they do not appoint the QS as an individual, they appoint their services from an organisation. The next major barrier identified with the third highest mean is *the lack of private client demand for BIM*. *Increased competition* did not appear to be a major barrier to the organisations as all groups recorded this as the lowest barrier to adoption. The barrier that is now identified as being the least significant with the lowest recorded mean is *fear of extinction of the QS role* all participants perceiving this to be not a major barrier. This could perhaps be interpreted as the QS being willing to embrace BIM as they do not see it as a threat to their role. It also supports the findings in section 7.3.3 that the QS role would survive.

Interestingly it is the people barrier that is evidenced to be the biggest issue facing BIM implementation. Whilst it is recognised as being an institutional level issue, it does presents itself as an issue, at both organisational and project level. Similarly, barriers in relation to process, all appear to be at an institutional level. As the process of an organisation is normally driven top down through the organisation, this is not to be unexpected. In contrast, the majority of the IT issues are at an organisational level with the exception of those around interoperability which remain an institutional problem.

7.3.7. BIM maturity

Level 2 BIM maturity is the level set by the UK Government for all public procured projects and as such is the target against which organisations can measure their performance. The participants were asked what BIM maturity level they were currently working at. The results are as illustrated in Figure 7.8.

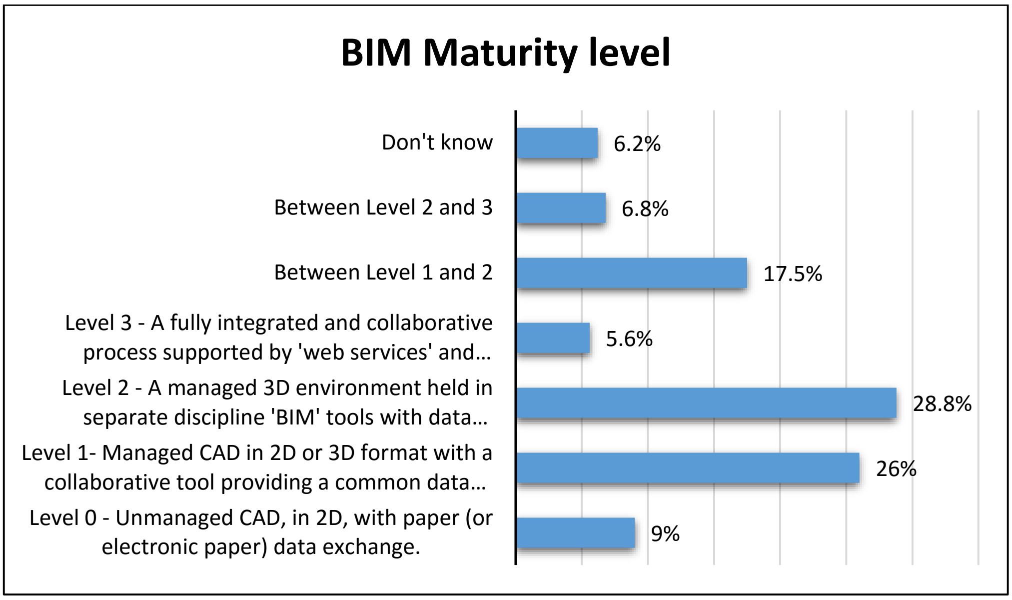


Figure 7-8 BIM Maturity Level

57.14% of clients agreed that they were working at Level 2 compared with only 25% of consultants, 30.11% of contractors and 22.22% of others. Interestingly the client did not claim to be working at level 3 although 5.88% of consultants, 5.38% of contractors and 11.11% others did and a further 5.88% of consultants, 7.53% of contractors, and 11.11% of others claimed to be working between Level 2 and 3. All groups claimed to be working at Level 1 with the other, 55.56%, consultant 25%, contractor 24.73% and other at 55.56%. Overall, 43.02% of contractors believe they are working at Level 2 or above, in comparison to 36.76% consultants, although 6.45% of contractors do not know what level they are working at, in comparison to 5.88%, of consultants. Overall. In terms of hitting the government's target of Level 2 BIM maturity, 52.5% of all those surveyed were performing below government expectations. Therefore, in terms of BIM performance only 35.6% of the QS participants were working at or above Level 2 maturity.

In terms of the documentation, 8 pillars of BIM represent the documentation that should be considered when working in a BIM environment with the BIM protocol and PAS1192.2 being synonymous with BIM Level 2. Rather worryingly, 29.4% of the participants did not know what documents were used in their organisations. Only 12.6% claimed to be adopting the BIM protocol and 14.90%, PAS1192.2, the two most common BIM documents. Surprisingly 8.4% claimed to be using none of the BIM documents. Which leads to the conclusion how can 35.6% claim to be working at or above BIM level 2, if only 12.6 % were using the BIM protocol, a document requisite for level 2 BIM? Conflicting results. As illustrated in Figure 7.9.

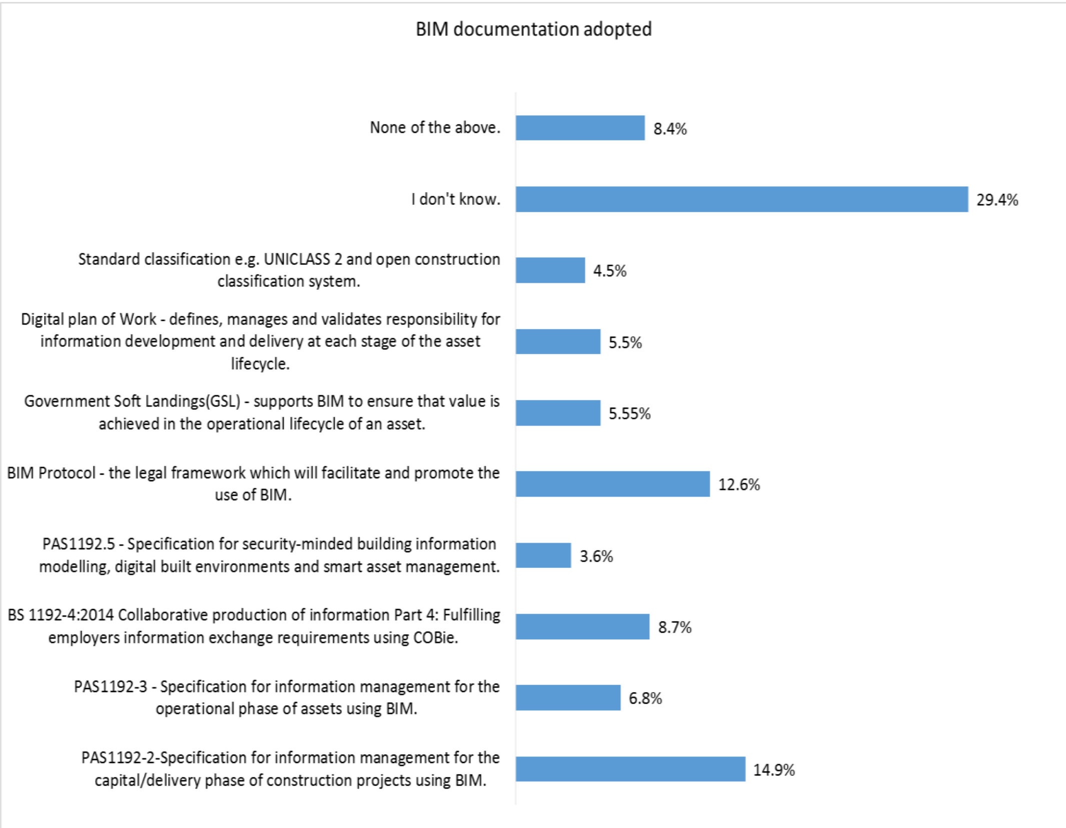


Figure 7-9 BIM documentation in use

The group with the largest *don't know* with 55% is the contractors, followed closely by the client group with 50%, then 47% of consultants and 45% of other. 40% of consultants adopted the BIM protocol either in isolation or along with an assortment of the other documents in comparison to 11% of contractors. Similarly, 46% of consultants adopted PAS 1192.2 either in isolation or along with other BIM documents including the BIM protocol in comparison to only 24% of contractors. These two documents were the main documents adopted by both groups. The lowest adoption of documents recorded included, PAS119.5 with 6.5% of consultants and 2% of contractors, GSL, with 11.5% of consultants and 4% of contractors, and DPOW 6% of consultants and 4% of contractors. The CQS's are currently therefore adopting the 8 pillars of BIM more frequently than COQS's, perhaps being influenced by the client requirements especially in terms of OPEX and PAS1192.3. It must be said with less than 50% adopting PAS119.2 and the BIM protocol, only approximately a third of QS's are working at BIM Level 2 or above.

Another mechanism for measuring BIM maturity could be considered in terms of the number of years' organisations have adopted BIM. The questionnaire identified that 60.1% of the participants have adopted BIM in the last two years, although 30.3% claim to have adopted BIM between 3 and 5 years, and less than 10% over 6 years. Interestingly, the consultant group have been adopting BIM polices, processes or technologies for a longer time period than the contractor with 47.15% of consultants claiming to have been adopting BIM for three years and over in comparison to the contracting organisation at 40.21%. Clients and the other group, however, have only recently adopted BIM with 85.71% clients and 100% of other adopting within the last two years. Overall, the majority of those surveyed have adopted BIM within the last two years with only 10% leading the adoption of BIM within the QS organisation. The majority of QS organisations being laggards in term of innovation and adoption of BIM.

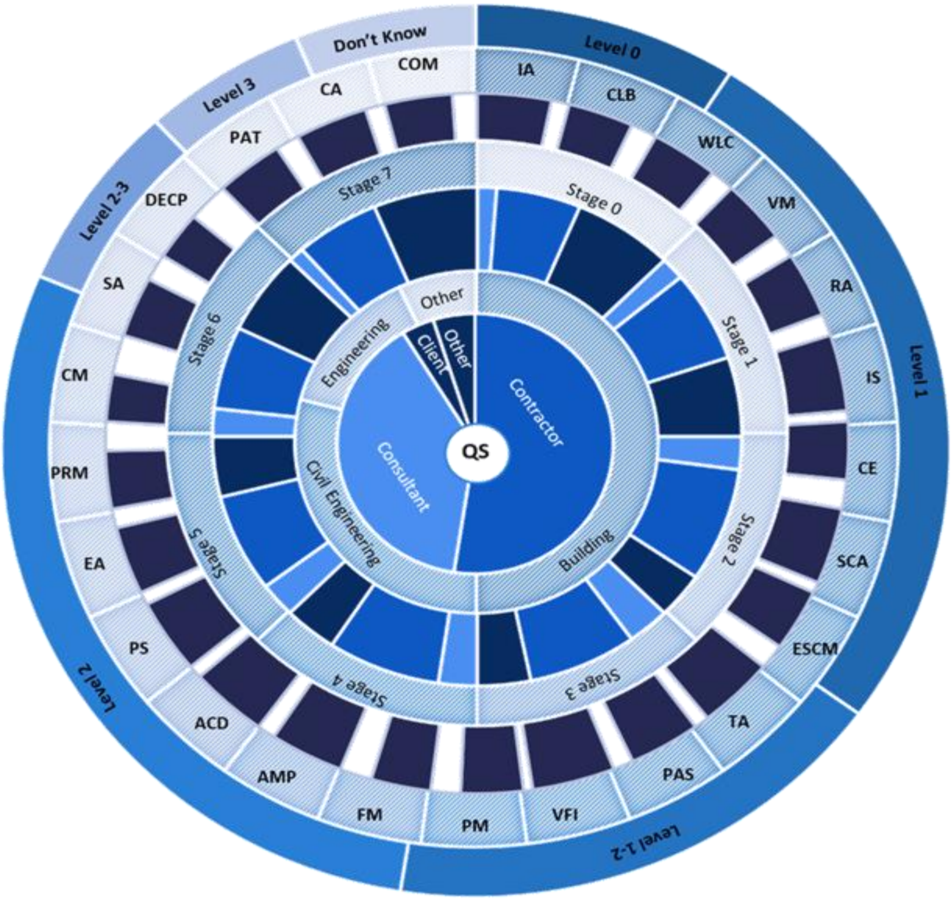
7.3.8. BIM adoption criteria

If QS organisations are adopting BIM, then how are they implementing it? What criteria are they using to select the projects that they apply BIM to?

The participants applied a variety of selection criteria when implementing BIM although the most common criteria was *"the type of client"* as identified by 60.9% of the participants identified that was used when determining which project to use BIM on. This was followed by *"type of project"* with 55.1% of participants confirming their agreement. Interestingly, the *“value of the project”* is given the least consideration with only 36% of agreement from the participants. In contrast 10.2% of all participants claim that BIM is used on all projects whilst 19.2% claim not to use BIM at all. It can be concluded therefore, that the client is leading the adoption of BIM and the potential benefits of BIM to the organisation are being driven top down from the client to the organisation.

7.3.9. Summary of BIM and the QS

The outcomes from these two sections of the questionnaire provide some interesting results as summarised in Figure 7.10. Working from the centre outwards, it can be seen that the majority of those surveyed were COQS and that the field, that the majority of the participants worked in was building. In terms of the RIBA 2013 stage of BIM adoption, it can be seen that at all stages, the COQS is more likely than the CQS to adopt BIM. However, when the QS services provided by the CQS and COQS were considered it can be seen that the majority of services are less likely to adopt BIM than to adopt. Finally, the outer layer reveals that the CQS and the COQS are more likely to be working at below Level 2 than they are to be at Level 2 or above BIM maturity.



Layer 1 QS type	Contractor Consultant Client Other
Layer 2 Organisation type	Building Civil Engineering Engineering Other
Layer 3 RIBA stage of BIM adoption	Contractor Consultant Client and other
Layer 4 QS Function	Service offered Service offered and adopts BIM
IA - Investment appraisal CLB - Advice on cost limits and budgets WLC - Whole life costing VM - Value management RA - Risk analysis IS - Insolvency services CES - Cost engineering services SCA - Subcontract administration ESCM - Environmental services and measurement and costing TA - Technical auditing PAS - Planning and supervision VFI - Valuation for insurance purposes PM - Project management	FM - Facilities management AMP - Administering maintenance programmes ACD - Advice on contractual disputes PS - Planning supervisor EA - Employers agent PRM - Programme management CM - Cost modelling SA - Sustainability advisor DECM – Design economics and cost planning PAT – procurement and tendering CA – contract administration CM - Commercial management
Layer 5 BIM maturity	Contractor Consultant Client and other

Figure 7-10 Summary of QS services and BIM

7.4. Organisational development and BIM

In order to understand how BIM can be positively employed by an organisation it is necessary to establish how the organisation has prepared, planned and reorganised its activities. The literature suggests that there is a close relationship between the type of organisation and its capacity to create a learning environment that will support BIM (Lee, Courtney, and O'Keefe 1992).

7.4.1. Organisational characteristics

The participants were asked to consider the organisational characteristics of their organisation. The growth characteristics identified by the literature as being typical of an organisation able to respond positively to change are numerous and include: flat organisational structure (Nicholas, (1994), open lines of communication (Goldsmith and Clutterbuck, 1985) and positive promotion of innovation (Germain,1996).

Only 38.8% of the participants considered their organisational structure to be flat, whilst 43.9% disagreed with this, leading to the conclusion that for 43.9% of the participants the organisational structure contains multiple layers of management. 39.3% of the participants perceived their organisation to have a decentralised decision making structure, which is often associated with a flatter organisational structure. The majority, 50.5% of the participants, felt empowered although 33.7% remained neutral. Open lines of communication were perceived to be positive with 71.4% of the participants agreeing that this was true for their organisations with only 10.7% disagreeing. In addition, 60.6% agreed that their organisation positively promotes staff and 68.4% believed it positively promotes innovation. Only 14.1% of the participants considered that the organisation did not positively promote innovation. There was also a strong positive response from the participants confirming that the organisation supports team based decision making with 69.1% agreeing with this and only 7.8% in disagreement. 52.2% of the participants agreed that individuals were given time to reflect although 23.6% remained neutral. The organisations were generally supportive of change as 64.6% of the participants agreed with this and 59.9% of the participants also agreed that the organisations provided a supportive environment conducive to learning. Finally, 58.2% considered that their organisation adopts a philosophy of trust an openness, although 26.6% remained neutral and 15.3% disagreed. Overall, the majority of the participants associated their organisation with the characteristics typical of a learning organisation, which encourages creativity, openness and innovation, which in in turn is symbolise growth.

7.4.2. Criteria used for adopting BIM for the organisation

The literature also suggests that in terms of organisational survival it is necessary to understand why changes are made and new technologies/innovations are employed. The participants were asked to indicate their agreement on a total of 11 variables, which were identified as potential criteria for adoption of BIM by QS organisations. These variables represented the opportunities to the QS organisation and could be grouped into: market/competition, capability/capacity, recognition/relevance, and information/communication/technology (Frei et al, 2015). The strength of agreement or disagreement of the respondents in relation to each variable is identified in Table 7.5 complete with the standard deviation and its ranking in relation to the criteria.

Table 7-5 Criteria used for adopting BIM for the organisation

	Strongly disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly Agree 5	Mean	Std. Deviation	Rank
	N(%)	N(%)	N(%)	N(%)	N(%)			
To keep pace with similar organisations who have adopted	9(5.3)	11(6.5)	25(14.8)	64(37.9)	60(35.5)	3.92	1.11	1
To maintain position in the market place	8(4.7)	7(4.1)	37(21.60	61(35.7)	58(33.9)	3.90	1.07	2
To respond to client demand	8(4.8)	12(7.1)	33(19.6)	59(35.1)	56(33.3)	3.85	1.11	3
To respond to Government push	11(6.5)	11(6.5)	31(18.3)	64(37.9)	52(30.8)	3.80	1.14	4
To improve performance	10(5.9)	10(5.9)	32(18.9)	73(43.2)	44(26)	3.78	1.08	5
To improve the use of technology	9(5.4)	13(7.8)	27(16.2)	84(50.3)	34(20.4)	3.72	1.05	6
To demonstrate leadership and innovation	10(5.9)	15(8.9)	35(20.7)	65(30.5)	44(26)	3.70	1.13	7
To support the existing business	10(6)	13(7.7)	35(20.8)	82(48.8)	28(16.7)	3.63	1.04	8
To maintain stakeholder relationships	10(5.9)	12(7.1)	51(30.2)	56(33.1)	40(23.7)	3.62	1.10	9
To improve the management processes within the business	10(6)	17(10.1)	37(22)	71(42.3)	33(19.6)	3.60	1.10	10
To diversify service provision	8(4.8)	26(15.5)	40(23.3)	68(40.5)	26(15.5)	3.46	1.08	11

The major justification for the organisation adopting BIM was perceived to *be "to keep pace with their competitors" (ranked 1)* and *"to maintain their existing position in the market place." (ranked 2)* The participants also perceived their organisations responded to client demand (ranked 3) and government push (ranked 4). This supports the findings in section 7.3.6, in that, the client was found not to be a barrier to implementation. Therefore, it could be concluded that the client is extremely influential in terms of BIM adoption. The participants did not perceive their organisations were proactively attempting to diversify service provision (ranked 11) or to improve management processes within the business (ranked 10). Interestingly the first criteria for improvement was ranked at 5 with the participants perceiving the organisation considered *"improving performance"* when adopting BIM. The criteria recording the highest means are reactive responses to the adoption of BIM. The participants perceived that their organisations were less proactive in response to BIM, as the criteria representing a more proactive approach generally resulted in the lowest means. Overall the results indicate that QS organisations are adopting BIM in order to maintain equilibrium in terms of market share and position and not as a mechanism for improvement or to demonstrate leadership or innovation in the field. The QS organisation is not leading the way in BIM implementation, they are adopting a cautious approach and implementing change slowly to keep pace with their competitors, as opposed to being driven by innovation.

7.4.3. Impact on organisations as a consequence of adopting BIM

The introduction of innovation or technologies is associated with organisational growth (DeSmet et al, 2007), which in turn, ignites organisational change (Sundbo,1997). A total of 14 variables were identified from the literature as being negative organisational characteristics in relation to organisational growth. The participants were asked to indicate the impact on the organisation in relation to these variables as a consequence of adopting BIM. The strength of agreement or disagreement of the participants in relation to each variable is identified in Table 7.6 complete with the standard deviation and its ranking in relation to the criteria.

Table 7-6 Impact on organisations as a consequence of adopting BIM

	Strongly disagree 1 N(%)	Disagree 2 N(%)	Neutral 3 N(%)	Agree 4 N(%)	Strongly Agree 5 N(%)	Mean	Std. Deviation	Rank
Roles have become highly specialised	22(12.6)	25(14.4)	55(31.6)	52(29.9)	20(11.5)	3.13	1.18	1
Greater formalisation in organisation	17(9.3)	33(18)	69(37.7)	45(24.6)	7(4.1)	2.95	1.01	2
Greater centralisa - tion in the organisation	20(11.7)	32(17.5)	74(40.4)	38(20.8)	7(4.1)	2.88	1.02	3
Roles have reduced autonomy	23(13.2)	37(20.2)	77(42.1)	23(13.2)	14(8)	2.82	1.08	4
Increase in revenue	34(19.5)	22(12.6)	79(45.4)	29(16.7)	10(5.7)	2.76	1.12	5
Roles have less variety	21(12.1)	48(27.6)	73(42)	20(11.5)	12(6.6)	2.74	1.04	6
Decrease in risk taking by the organisation	43(25.3)	43(25.3)	57(33.5)	17(10)	10(5.9)	2.59	1.01	7
Roles have less task identity	22(12.9)	61(35.7)	66(38.6)	13(7.6)	9(5.3)	2.57	0.99	8
Decrease in employee participation in decision making in the organisation	31(18)	51(29.7)	57(33.1)	30(17.4)	3(1.7)	2.55	1.03	9
Decrease in innovation in organisation	32(18.6)	57(33.1)	51(29.7)	25(14.5)	7(4.1)	2.52	1.08	10
Greater secrecy in organisation	35(20.2)	59(34.1)	52(30.1)	16(9.2)	11(6.4)	2.47	1.11	11
Decrease in long term planning	43(25.3)	43(25.3)	57(33.5)	17(10)	10(5.9)	2.46	1.15	12
Greater conflict in the organisation	29(17)	65(38)	60(35.10)	10(5.8)	7(4.1)	2.42	0.98	13
Decrease in leader influence	47(27.3)	52(30.2)	46(26.7)	21(12.2)	6(3.5)	2.34	1.11	14

The major impact to the organisation as a consequence of adopting BIM identified that roles were *"becoming highly specialised" (ranked 1)* and that *"roles have reduced autonomy" (ranked 4).* The participants also perceived that the organisational structure was impacted as a consequence of adopting

BIM and that there is “*greater formalisation in the organisation*” (ranked 2) and “*greater centralisation*” (Ranked 4), thereby reducing the potential for autonomy in decision making and empowerment of the individual. The participants did not perceive there was a “*decrease in leader influence*” (ranked 14) within their organisations, nor did they perceive there to be an increase in “*conflict”* (ranked 13) or *“secrecy”* (ranked 11). Interestingly in relation to innovation, which BIM is, they do not perceive that there has been a significant decrease in innovation within the organisation (ranked 10). The results indicate that the impact of adoption relates more specifically to roles and structures than it does to leadership, innovation and long term planning.

In order to facilitate change it is essential that organisations have a strategy for BIM adoption and implementation (Frei et al, 2013). The strategy should consider the health of an organisation with the aim of identifying the organisations capacity for BIM adoption. A total of 11 variables were recognised as indicators of the capacity of the QS organisation to adopt BIM. The results identified that little consideration was given *“to existing workload”* (ranked 10) with only 4.3% of organisations considering this at the pre planning stage, in contrast to, 8.4% of organisations who considered their *“existing BIM maturity”* (ranked1), 7.5% *“their existing software capability”* (ranked 2) and 7% *“the existing skills”* (ranked 3).

Following consideration of the business audit (existing organisation position) the QS organisation moves onto the strategic planning stages (new organisation position (NBS, 2014). The results identified that *“training”* was given the greatest consideration with 53.2% of participants recording strongly agree/agree. The second highest consideration was the “*budget”* with 47.3%. The assessment of “*BIM maturity level”* was third (44.4%) with and consideration of the “*definition of BIM deliverables*” fourth (48.8%). The factors the participants perceived to be given the least consideration was “*cash flow”* (ranked 14, 34.9%) and the next three highlighted the perception that “*the impact of BIM on people*” was given little consideration with,” *impact on project teams”* (ranked 13, 39.3%), “*new ways of working”* (ranked 12, 41.3%) and “*impact on work load”* (ranked 11, 40.3%).

7.4.4. Changes made by organisations as a consequence of BIM adoption.

On completion of the strategic plan, the organisation may need to change in order to accommodate BIM adoption. A total of 11 variables were identified as areas of potential change (Kaseem et al,2015, Jung and Joo,2010) and the participants were asked confirm if the variables resulted in major/minor/no change, illustrated in Table 7.7.

Table 7-7 Changes made by organisations as a consequence of BIM adoption.

	Major change 3	Minor change 2	No change 1			
	N(%)	N(%)	N(%)	Mean	Std. Deviation	Rank
Software	67(39.9)	80(47.6)	21(12.5)	2.27	0.681	1
Training	65(38.7)	79(47)	24(14.3)	2.24	0.692	2
Information Management	53(31.7)	81(48.5)	33(19.8)	2.12	0.701	3
Work processes and procedures	59(35.1)	70(41.7)	39(23.2)	2.12	0.754	3
Hardware	45(26.8)	81(48.2)	42(25)	2.02	0.722	5
Policies	38(22.6)	88(52.4)	42(25)	1.98	0.696	6
Protocols	43(25.9)	76(45.8)	47(28.3)	1.98	0.734	6
Staffing	32(19)	87(51.8)	49(29.2)	1.90	0.696	8
Performance management	29(17.4)	92(55.1)	46(27.5)	1.90	0.675	8
Fees	42(25)	67(39.9)	59(35.1)	1.90	0.779	8
Contract Documents	31(18.6)	74(44.30)	62(37.1)	1.81	0.722	11
Structure	21(12.6)	90(53.9)	56(33.5)	1.79	0.750	12
Professional indemnity insurance	27(16.2)	66(39.5)	74(44.30	1.72	0.727	13
Copyright	26(15.6)	61(36.5)	80(47.9)	1.68	0.723	14

The major change identified by the participants are changes to the "*software"* (ranked 1) and "*training"* (ranked 2). The next two variables scoring the same mean value were "*changes to information management"* and "*work processes and procedures*." The participants perceive the greatest change to be therefore in the type of software and associated training and the manner of information and work flows management. The least changes perceived by the participants are in relation to copyright, scoring the lowest mean, and professional indemnity, scoring the second lowest mean. Organisational structure also appears to have minimal change despite changes to work processes and procedures being identified as having major change. Interestingly fees, performance management and staffing all tie at eight in the ranking with little evidence of major change in these variables. The change being effected through people, process and information.

7.4.5. Impact of BIM on the organisation

As a consequence of adopting BIM 23.8% of the participants affirmed that their organisations have increased the level of expertise in BIM and 22.8% recorded that the organisation had greater experience of working on BIM projects. Only 14.8% of participants perceived that the organisation had become more efficient as a consequence of adopting BIM, a contrasting view to that identified in section 6.2.2.2, where the creation of efficiencies was believed to be greatest to the organisation. 7.6% of participants believed that their organisations had become more dominant in a specific niche market as a result of BIM, with 11% confirming BIM has enabled expansion into new markets with a further 6.3% claiming expansion into global markets. Interestingly, only 7% of participants perceive that the organisation has increased its revenue as result of adopting BIM, as previously identified, in section 7.4.4. However, if the organisations level of expertise has increased in terms of BIM, then they will have an increased confidence in bidding for BIM projects and presumably an increase in revenue will result. This in turn will bring with it a change in QS role and the added value of new BIM services, e.g. life cycle costing.

7.4.6. BIM learning environment

The literature identified the need for a supportive BIM learning environment to support individual learning and for strong leadership to develop processes for the storage and transfer of BIM knowledge throughout the organisation. 37% of participants identified that their organisation had appointed a BIM champion to lead the development of BIM within the organisation and a further 25.6% perceived senior management to be driving the learning forward. It was a minority of participants, 14.2%, that recorded individuals or groups of individuals as leading the development of BIM learning. Interestingly, 14.2% claim BIM is not being developed by the organisation. The literature suggested that BIM learning could originate from a variety of sources both internal and external. The participants were asked to indicate their agreement as to how their individual learning on BIM has been achieved. A total of 11 variables were identified as being BIM learning sources available to the participants. They were also provided with an option *"other"* to include any additional sources that they have adopted to facilitate their BIM learning. The strength of agreement or disagreement of the participants in relation to each variable is identified in Table 7.8 complete with the standard deviation and its ranking in relation to the criteria.

Table 7-8 BIM learning mode

	Strongly disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly Agree 5	Mean	Std. Deviation	Rank
	N (%)	N (%)	N (%)	N (%)	N (%)			
Learning by doing	17(10)	13(7.6)	29(17.1)	54(31.8)	57(33.5)	3.71	1.29	1
Personal reading in professional body journals	22(12.7)	16(9.2)	36(20.8)	53(30.6)	46(26.6)	3.49	1.32	2
Personal reading of academic journals	27(15.5)	16(9.2)	41(23.6)	43(24.7)	47(27)	3.37	1.39	3
Attendance at University led events	31(18)	23(13.4)	33(19.2)	35(20.3)	50(29.1)	3.31	1.46	4
Personal reading on the Government BIM Group Task Forum site	33(19.3)	16(9.4)	38(22.2)	42(24.6)	42(24.6)	3.28	1.43	5
Problem solving techniques	25(14.8)	25(14.8)	60(35.5)	45(26.6)	14(8.3)	3.04	1.22	6
Debriefing	29(17.1)	21(12.4)	72(42.4)	38(22.4)	10(5.9)	2.99	1.16	7
Personal reading on the NBS webpage	37(21.6)	22(12.9)	49(28.7)	36(21.1)	27(15.8)	2.96	1.36	8
Attendance at CPD events organised internally within the organisation	40(23.3)	24(14)	39(22.8)	53(31)	15(8.8)	2.87	1.31	9
Learning by following organisation best practice	30(17.5)	16(9.4)	61(35.7)	46(26.9)	18(10.5)	2.86	1.11	10
Attendance at CPD events organised by the RICS	46(26.7)	30(17.4)	35(20.3)	45(26.2)	16(9.3)	2.74	1.34	11
Other	26(32.9)	3(3.80)	32(40.5)	9(11.4)	9(11.4)	2.66	1.35	12

The most common method of BIM learning employed by the participants in terms of their own individual learning was perceived to be *"learning by doing" (ranked 1)* and *"personal reading"* in *"professional journals" (ranked 2) and "academic journals" (ranked 3).* Surprisingly attendance at *"university led events" (ranked 4)* was ranked higher than attendance *"at CPD events organised by the RICS" (ranked 11),* one of the professional bodies representing quantity surveyors. Suggesting that industry perceives universities to have greater BIM knowledge than professional bodies. Other sources of learning identified include online tutorials, web pages, watching you tube videos, training events offered by BRE and software providers and university undergraduate and post graduator degree programmes. In fact, one participant stated "anything I can get my eyes on!!!Twitter, LinkedIn!"

7.4.7. Impact of BIM adoption on the QS

The participants were asked to comment on their personal experience as a consequence of adopting BIM. 49.2% of the participants *"were made aware of the benefits of BIM to their role, prior to adoption"* but only 36.5% were *"aware of the likely changes to their role."* In terms of support offered by the organisation, 42.5% of the participants agreed that they "*had been provided with appropriate training to use the technology"*, which was similar to those who perceived that they had been *"provided with sufficient knowledge in relation to BIM process and policy*" at 40.8%. In terms of meeting expectations, only 35.5% of the participants agreed that the *"technology did what they expected it."* Hardly surprising as 52.4% were *"told which technology to use"* and only 23.2% "*experimented with technology to find the most appropriate to satisfy their needs*". 35.3% of participants *"found the technology made their role easier"*, with 46.1% agreeing it "*facilitated improved collaboration with the other stakeholders".* Only 27.2% of the participants found the *"technology complex".* Participants, however, perceived *"they were more competent with BIM technologies than processes*" with 42.8% recording their agreement that they "*are competent with BIM technologies"* as opposed to 34.8% with *"BIM policies and processes."* Can it be assumed therefore that organisations are still viewing BIM as a technology, rather than a process?

7.4.8. BIM knowledge

"*BIM knowledge"* was accepted by the participants as being valuable with 61.7% recognising its value. 36.3% of the participants were *"encouraged to* *share their BIM knowledge"* and 63.4% were "*happy to share this knowledge."* In order to support BIM learning the literature suggests that BIM projects should be reviewed and evaluated. The participants identified that "*time spent on BIM projects"* was given the greatest priority closely followed by *"mistakes and discrepancies"* with *"the level of waste generated"* given the least priority. If knowledge creates value, then surely organisations should encourage staff to share their BIM knowledge throughout the organisation in order to improve the organisations performance in terms of maturity. An increase in BIM maturity will therefore bring with it an increase in value creation.

The participants were asked how their organisation captured BIM knowledge with the majority 22.8% confirming that the BIM champion took responsibility for its capture. 12.9% of the participants held a lessons learnt data base and 13.5% had BIM projects written up as case studies. Only 6.7% of the participants recorded BIM evaluations/feedback during the project with 7.3% recording evaluations /feedback at the end of the project. Interviews were used the least to capture BIM knowledge, with 2.9% interviewing stakeholders on all projects and 5% of stakeholders interviewed on specific project. Disappointingly 10.8% of participants confirmed that their organisation does not capture BIM knowledge at all.

In addition, the participants were asked to consider how BIM knowledge was transferred within their organisation. Once again, the BIM champion is identified as the person responsible for sharing good practice, 29.4%, although 20.1% confirmed that BIM knowledge is not shared as an organisation other methods of transfer include peer tutoring (14.9%), internal CPD event (13%), regular team briefings and meetings (12.6%) and supervision/monitoring system (10%).

7.4.9. Change management

The literature identified that how organisations deal with change is significant to the successful adoption of BIM. The participants were asked to indicate their agreement to statements describing the resistance to change by the organisation when implementing BIM. A total of 10 variables were identified as impacting the resistance to change. The strength of agreement or disagreement of the participants in relation to each variable is identified in Table 7.9 complete with the standard deviation and its ranking in relation to the criteria.

Table 7-9 Factors influencing resistance to change by organisations when implementing BIM

	Strongly disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly Agree 5			
	N(%)	N(%)	N(%)	N(%)	N(%)	Mean	Std. Deviation	Rank
Staff unaware of the benefits of BIM to their role	11(6)	21(11.5)	40(21.9)	56(30.6)	42(23)	3.57	1.18	1
Lack of knowledge of the software available	9(4.9)	23(12.6)	40(20.9)	61(33.3)	38(20.8)	3.56	1.13	2
Inadequate component data base	4(2.2)	24(13.1)	60(32.8)	57(31.1)	26(14.2)	3.45	0.99	3
Inadequate reference material within the organisation	7(3.8)	28(15.3)	50(27.3)	60(32.8)	26(14.2)	3.41	1.06	4
Lack of staff involvement in the decision making process to implement BIM	8(4.4)	29(15.8)	49(26.8)	56(30.6)	29(15.8)	3.40	1.10	5
Reluctance of staff to adopt new work flow practices	11(6)	43(23.5)	45(24.6)	42(23)	28(15.3)	3.20	1.18	6
Reluctance of staff to adopt new methodologies	12(6.6)	42(23)	44(24)	48(26.2)	24(13.1)	3.18	1.16	7
Reluctance of staff to adopt new IT technologies	11(6)	49(26.8)	38(20.8)	45(24.6)	27(14.8)	3.16	1.20	8
Inadequate top management support for implementation	19(10.4)	38(20.8)	44(24)	42(23)	27(14.8)	3.12	1.24	9
Poor leadership from senior management	18(9.8)	48(26.2)	46(25.1)	30(16.4)	23(12.6)	2.95	1.21	10

The factor identified as having the greatest impact on resistance to change when implementing BIM is *"staff being unaware as to the benefits of BIM to* *their role" (ranked 1) and "lack of knowledge of software's available" (ranked 2).* Surprisingly,the reluctance of staff to "*adopt new work flow practices, methodologies and IT technologies" (ranked 6,7 and 8) a*re not perceived by the participants to be major factors in resistance to change. Furthermore, they had a positive perception of the role senior management had played when implementing BIM ranking *"poor leadership from senior management",* (ranked10), and *"inadequate top management support for implementation"* (ranked 9).

7.5. Hypotheses.

7.5.1. The development of the hypotheses

The findings discussed in chapters 6 and 7 have been derived initially from a systematic and rigorous data analysis and synthesis of the literature review, the exploratory interviews and finally, the questionnaire.

The rich information provided by these findings were further interrogated, to establish if any relationship exists, between the main themes identified. For example, could it be established that the benefits of BIM perceived by the QS organisation would bring about a change to the QS role? The process of formulating the hypotheses, involved triangulating the findings from the literature review, with the themes identified from the interview and the questionnaire. The signposting of the development of the hypotheses are illustrated in Table 7.10.

Table 7-10 Signposting of the hypotheses development

	Hypothesis	Development
H1	There is a relationship between the benefits of BIM to the organisation and the role of the QS	**Key Sections** Section 6.2.2.2 Section 6.2.3.4 Section 6.2.5.3 Section 7.4.3 Section 7.4.5 **Key References** (Haque and Mishra, 2007; Meadati, 2009; Samphaongoen, 2010; Saint, 2012; Saxon, 2013; Whatmore, 2012, Smith 2014 and Wu et al, 2014)
H2	There is a relationship between the benefits of BIM to the organisation and its adoption.	**Key Sections** Section 6.2.2.2 Section 7.3.5 Section 7.3.8 Section 7.4.2 Section 7.4.3 Section 7.4.5 **Key References** Jung and Joo,2011; Lu and Korman, 2011; Khosrowshahi, and Arayici, 2012; Frei et al, 2013;Bryde et al, 2013 and Lindblad and Vass, 2015
H3	There is a relationship between the barriers of BIM to the organisation and its adoption.	**Key Sections** Section 6.2.2.1 Section 7.3.6 Section 7.3.8 Section 7.4.2 Section 7.4.5 **Key References** Woo, 2007; Boon and Prigg, 201; Klein 2012 Frei et al, 2013; Olatunji, 2010; Harrison and Thurnell, 2014 and Smith et al 2014
H4	There is a relationship between BIM maturity level and organisational planning.	**Key Sections** Section 6.2.1.3 Section 7.3.7 Section 7.4.3 **Key References** Succar 2009; Young et al., 2009; Smith and Tardif, 2012 Kaseem et al, 2015;

	Hypothesis	Development
H5	There is a relationship between BIM maturity level and knowledge management.	**Key Sections** Section 6.2.4 Section 7.3.7 Section 7.4.3 Section 7.4.8 **Key References** Stata,1989; Maqsood and Finegan, 2009; Taylor and Bernstein 2009 and Inocencia, 2011.
H6	There is a relationship between organisational characteristics and the learning organisation.	**Key Sections** Section 6.2.4 Section 7.4.1 Section 7.4.6 **Key References** Fiol and Lyles, 1985; Lee, Courtney and O'Keefe,1992; Dodgson, 1993; Garvin, 1993 Germain, 1996; Bapuji and Crossan, 2004;, Miettininen and Paavola, (2014).
H7	There is a relationship between organisational change and BIM impact.	**Key Sections** Section 6.2.1.3 Section 6.2.1.4 Section 6.2.5.3 Section 7.3.3 Section 7.4.3 Section 7.4.4 Section 7.4.5 **Key References** Cameron and Whetton, 1983); Cannon, 1994; Succar, 2009; Froese, 2010; Olatunji et al, 2010; Begat et al 2015 and Kaseem et al, 2015.
H8	There is a relationship between resistance to change and benefits.	**Key Sections** Section 6.2.2.1 Section 6.2.3.2 Section 6.2.5.1 Section 7.3.6 Section 7.4.7 Section 7.4.9 **Key References** Kennett, 2010, Rendall, 2011 and Harrison and Thurnell, 2014.

	Hypothesis	Development
H9	There is a relationship between BIM definition and benefits and maturity.	**Key Sections** Section 6.2.1.1 Section 6.2.1.2 Section 7.3.4 Section 7.3.7 **Key References** Hardin, 2009; Succar, 2009 Race, 2012; Miettinen and Paavola, 2014.

Furthermore, the result of the investigation identified that potential relationships may also exist within these themes. As a result of this, sub themes were identified within some of the main themes, from which, the following hypothesis and sub hypotheses were developed.

H1 **There is a relationship between the benefits of BIM to the organisation and the role of the QS**

H2 **There is a relationship between the benefits of BIM to the organisation and its adoption**

H2.1 There is a correlation between benefits and criteria for organisation adoption

H2.2 There is a correlation between benefits and stage of adoption

H2.3 There is a correlation between benefits and project adoption

H3 **There is a relationship between the barriers of BIM to the organisation and its adoption**

H4 There is a relationship between BIM maturity level and organisational planning.

H4.1 There is a correlation between BIM maturity level and business audit

H4.2 There is a correlation between BIM maturity level and BIM planning

H4.3 There is a correlation between BIM maturity level and BIM lead

H4.4 There is a correlation between BIM maturity level and years adopted

H4.5 There is a correlation between BIM maturity level and the stage of BIM adoption

H5 There is a relationship between BIM maturity level and knowledge management

H5.1 There is a correlation between BIM maturity level and knowledge capture

H5.2 There is a correlation between BIM maturity level and knowledge transfer

H5.3 There is a correlation between BIM maturity level and knowledge review

H6 There is a relationship between organisational characteristics and the learning organisation

H6.1 There is a correlation between organisational characteristics and benefits to QS role.

H6.2 There is a correlation between organisational characteristics and individual learning

H7 There is a relationship between organisational change and BIM impact

H7.1 There is a correlation between organisational change and benefit to the QS role.

H7.2 There is a correlation between organisational change and benefits to organisation.

H7.3 There is a correlation between organisational change and criteria for BIM adoption.

H8 There is a relationship between resistance to change and benefits

H8.1 There is a correlation between resistance to change and benefit to the QS role.

H8.2 There is a correlation between resistance to change and benefits to organisation.

H8.3 There is a correlation between resistance to change and barriers to adoption.

H9 There is a relationship between BIM definition and benefits and maturity

H9.1 There is a correlation between BIM definition and maturity.

H9.2 There is a correlation between BIM definition and benefits to the QS.

H9.3 There is a correlation between BIM definition and benefits to organisation.

H9.4 There is a correlation between BIM definition and BIM pre plan

7.5.2. Testing the hypotheses

This section reports the results in relation to the hypotheses developed in the 7.5.1, measuring the relationship between the main variables. It will consider the relationship between the following:

- BIM benefits and the QS organisation.
- Benefits of BIM to the organisation and its adoption.
- Barriers of BIM to the organisation and its adoption
- BIM maturity levels and organisational planning.
- BIM maturity level and knowledge management.
- Organisational characteristics and the learning organisation.
- Organisational change and the benefits of BIM.
- Resistance to change and the benefits of BIM
- BIM definition, benefits and maturity.

The data is non parametric and the test used to determine the relationship between the variables is Spearman's correlation coefficient. A two-tailed significance test was adopted, in order to test for the possibility of the relationship in both directions. This test will provide two values, the correlation and the significance.

7.5.2.1. BIM benefits to the organisation with BIM benefits to the QS role (H1)

A Spearman rank-order correlation test was conducted in order to determine if there were any relationship between the benefits of BIM to the organisation and the benefits of BIM to the QS role as identified by the respondents of the questionnaire. A two-tailed test of significance indicated the there was a significant negative relationship between the benefits of BIM to the organisation and the QS role: N (171), $r_s = -0.546$, $p < 0.05$. This correlation coefficient is considered large, indicating that there is strong evidence that, as the ranking in benefits of BIM increase for the organisation the ranking of benefits decreases to the QS role.

The results of the Spearman's correlation test in relation to H1 are shown in table 7.11.

Table 7-11 Correlation coefficients (H1)

		Benefit to organisation	Benefit to QS role
Benefit to organisation	Correlation Coefficient	1.000	-.546**
	Sig. (2-tailed)		0.000
	N	171	171
Benefit to QS role	Correlation Coefficient	-.546**	1.000
	Sig. (2-tailed)	0.000	
	N	171	171
**. Correlation is significant at the 0.01 level (2-tailed).			

7.5.2.2. Benefits of BIM to the organisation and its adoption (H2)

A series of Spearman rank-order correlations were conducted in order to determine if there were any relationship between the benefits of BIM to the organisation, the criteria for project adoption, the criteria for organisation adoption and the RIBA stage of adoption. Firstly, a two-tailed test of significance indicated the there was a significant negative relationship between the benefits of BIM to the organisation and the criteria for BIM adoption: QS role: N (143), $r_s = -0.323$, $p < 0.05$. This correlation coefficient is considered medium, indicating that there is moderate evidence that suggests, as the ranking of the benefits of BIM to the organisation increase the ranking for the criteria for BIM adoption decrease and vice versa. Next, a two-tailed test of significance indicated that there was a significant positive relationship between the benefits of BIM to the organisation and the RIBA stage at which the organisation adopts BIM: N (172), $r_s = 0.254$, $p < 0.05$. This correlation coefficient is considered small, indicating that there is minimum evidence that suggests, as the ranking of the benefits of BIM increase the ranking for the stage at which the organisation adopts BIM increases. Finally, a two-tailed test of significance indicated that there was not a significant relationship between benefits of BIM to the organisation and criteria used for project adoption: N (161), $r = 0.152$, $p > 0.05$. The results of the Spearman's correlation test in relation to H2 are shown in table 7.12.

Table 7-12 Correlation coefficients (H2)

Spearman's rho **. Correlation is significant at the 0.01 level (2-tailed).		Benefit to organisation	Criteria for project adoption	Criteria for organisation adoption	RIBA Stage adoption
Benefit to organisation	Correlation Coefficient	1.000	0.152	-.0.323**	0.254**
	Sig. (2-tailed)		0.083	0.000	0.003
	N	175	161	143	172
Criteria for project adoption	Correlation Coefficient	0.152	1.000	-0..389**	-0.039
	Sig. (2-tailed)	0.083	166	0.000	0.655
	N	161	131	131	163
Criteria for organisation adoption	Correlation Coefficient	-.323**	-.389**	1.000	0.041
	Sig. (2-tailed)	0.000	0.000		0.643
	N	143	138	148	146
RIBA Stage adoption	Correlation Coefficient	.254**	-0.039	0.041	1.000
	Sig. (2-tailed)	0.003	0.655	0.643	
	N	172	163	146	179
**. Correlation is significant at the 0.01 level (2-tailed).					

7.5.2.3. Barriers of BIM to the organisation and its adoption (H3)

A Spearman rank-order correlation test was conducted in order to determine if there was any relationship between the barriers of BIM to the organisation and the criteria used for adoption as identified by the respondents of the questionnaire. A two-tailed test of significance indicated that there was not a significant negative relationship between the benefits of BIM to the organisation and the QS role: N (148), rs = 0.010, p > 0.05. Therefore, it can therefore be assumed that there is no significant relationship between barriers to BIM and the criteria for adoption.

The results of the Spearman's correlation test in relation to H3 are shown in table 7.13.

Table 7-13 Correlation coefficients (H3)

		Criteria for adoption	Barriers to organisation
Criteria for adoption	Correlation Coefficient	1.000	0.010
	Sig. (2-tailed)		0.906
	N	148	148
Barriers to organisation	Correlation Coefficient	0.010	1.000
	Sig. (2-tailed)	0.906	
	N	148	183
Correlation is not significant at the 0.01 level (2-tailed).			

7.5.2.4. BIM maturity level and organisational planning (H4)

A series of Spearman rank-order correlations were conducted in order to determine if there were any relationship between BIM maturity level, the BIM business audit, BIM planning, BIM leadership, the number of years BIM adopted and the RIBA stage of adoption. Firstly, a two-tailed test of significance indicated the there was a significant negative relationship between BIM maturity level and business audit: N (166), $rs = - 0.182$, $p < 0.05$. This correlation coefficient is considered small, indicating that there is minimum evidence that suggests, as the ranking of BIM maturity increases the ranking for the business audit decreases and vice versa. Secondly, a two-tailed test of significance indicated that there was a significant positive relationship between BIM maturity level and BIM planning: N (156), $rs = 0.246$, $p < 0.05$. This correlation coefficient is considered small indicating that there is minimum evidence that suggests, as the ranking of BIM maturity increases, the ranking for BIM planning increases. Thirdly, a two-tailed test of significance indicated the there was a significant negative relationship between BIM maturity level and BIM lead: N (175), $rs = - 0.158$, $p < 0.05$. This correlation coefficient is considered small, indicating that there is minimum evidence that suggests, as the ranking of BIM maturity increases, the ranking for the BIM lead decreases and vice versa. Next, a two-tailed test of significance indicated that there was a significant positive relationship between BIM maturity level and years adopted: N (175), $rs = 0.194$, $p <$

0.05. This correlation coefficient is considered small, indicating that there is minimum evidence that suggests, as the ranking of BIM maturity increases the ranking for the years of adoption increases. Finally, a two-tailed test of significance indicated that there was not a significant relationship between BIM maturity level and the stage of adoption, N (174), $r = 0.133$, $p > 0.05$.

It can therefore be assumed that there is a significant relationship between BIM maturity level, the BIM business audit, BIM planning, BIM leadership and the number of years BIM adopted.The results of the Spearman’s correlation test in relation to H4 are shown in table 7.14.

Table 7-14 Correlation coefficients (H4)

Spearman's rho	BIM Maturity Level	Pre BIM planning	Pre BIM Business Audit	BIM Lead	Years BIM Adoption	RIBA Stage adoption
Correlation Coefficient	1.000	.246**	-.182*	-.158*	.194*	0.133
Sig. (2-tailed)		0.002	0.019	0.038	0.010	0.080
N	177	156	166	172	175	174
Correlation Coefficient	.246**	1.000	0.079	-0.117	.349**	0.029
Sig. (2-tailed)	0.002		0.334	0.145	0.000	0.716
N	156	158	153	156	157	156
Correlation Coefficient	-.182*	0.079	1.000	-0.035	-0.063	-.164*
Sig. (2-tailed)	0.019	0.334		0.652	0.423	0.034
N	166	153	169	167	166	167
Correlation Coefficient	-.158*	-0.117	-0.035	1.000	-0.099	-.221**
Sig. (2-tailed)	0.038	0.145	0.652		0.194	0.004
N	172	156	167	176	173	173
Correlation Coefficient	0.133	0.029	-.164*	-.221**	0.029	1.000
Sig. (2-tailed)	0.080	0.716	0.034	0.004	0.704	
N	174	156	167	173	175	179
Correlation Coefficient	.194*	.349**	-0.063	-0.099	1.000	0.029
Sig. (2-tailed)	0.010	0.000	0.423	0.194		0.704
N	175	157	166	173	178	175
Correlation is significant at the 0.01 level (2-tailed).**						

7.5.3. BIM maturity level and knowledge management. (H5)

A series of Spearman rank-order correlations were conducted in order to determine if there was any relationship between BIM maturity level, knowledge capture, knowledge transfer and knowledge review. Firstly, a two-tailed test of significance indicated the there is no significant relationship between BIM maturity level and knowledge capture: N (166), $rs = - 0.058$, $p > 0.05$. Next, a two-tailed test of significance indicated that there was a significant positive relationship BIM maturity level and knowledge transfer: N (165), $rs = - 0.156$, $p < 0.05$. This correlation coefficient is considered small, indicating that there is minimum evidence that suggests, as the ranking of BIM maturity increases the ranking for knowledge transfer increases. Finally, a two-tailed test of significance indicted there is a significant negative relationship between BIM maturity level and knowledge review: N (139), $rs = - 0.188$, $p < 0.05$. This correlation coefficient is considered small, indicating that there is minimum evidence that suggests, as the ranking of BIM maturity increases the ranking for the knowledge review decreases and vice versa

It can therefore be assumed that there is a significant relationship between BIM maturity level, knowledge transfer and knowledge review. The results of the Spearman’s correlation test in relation to H5 are shown in table 7.15.

Table 7-15 Correlation coefficients (H5)

Spearman's rho		BIM Maturity Level	BIM Knowledge Capture	BIM Knowledge Transfer	BIM Evaluation
BIM Maturity Level	Correlation Coefficient	1.000	-0.058	-.156*	-.188*
	Sig. (2-tailed)		0.456	0.045	0.027
	N	177	166	165	139
BIM Knowledge Capture	Correlation Coefficient	-0.058	1.000	0.130	0.044
	Sig. (2-tailed)	0.456		0.094	0.610
	N	166	169	166	139
BIM Knowledge Transfer	Correlation Coefficient	-.156*	0.130	1.000	0.079
	Sig. (2-tailed)	0.045	0.094		0.358
	N	165	166	168	138
BIM Evaluation	Correlation Coefficient	-.188*	0.044	0.079	1.000
	Sig. (2-tailed)	0.027	0.610	0.358	
	N	139	139	138	142
Correlation is significant at the 0.01 level (2-tailed).**					

7.5.3.1. Organisational characteristics and the learning organisation (H6)

A series of Spearman rank-order correlations were conducted in order to determine if there was any relationship between organisational characteristics, benefits of BIM to the QS and individual BIM learning. Firstly, a two-tailed test of significance indicated the there was a significant positive relationship between organisational characteristics and benefits to the QS role: N (171), r = 0.172, $p < 0.05$. This correlation coefficient is considered small, indicating that there is minimum evidence that suggests

, as the ranking of the benefits of BIM to the QS role increases the ranking for the organisational characteristics increases. Next, a two-tailed test of significance indicated that there was a significant positive relationship between organisational characteristics and individual BIM learning, N (157), r = 0.269, < 0.05. This correlation coefficient is considered small, indicating that there is minimum evidence that suggests, as the ranking of the organisational characteristics increases the ranking for the individual BIM learning increases.

It can therefore be assumed that there is a significant relationship between organisational characteristics, benefits of BIM to the QS and individual BIM learning. The results of the Spearman's correlation test in relation to H6 are shown in table 7.16.

Table 7-16 Correlation coefficients (H6)

Spearman's rho		Individual BIM Learning	Benefits to QS role	Organisational characteristics
Individual BIM Learning	Correlation Coefficient	1.000	.357**	.269**
	Sig. (2-tailed)		0.000	0.001
	N	162	159	157
Benefits to QS role	Correlation Coefficient	.357**	1.000	.172*
	Sig. (2-tailed)	0.000		0.024
	N	159	176	171
Organisational characteristics	Correlation Coefficient	.269**	.172*	1.000
	Sig. (2-tailed)	0.001	0.024	
	N	157	171	175
Correlation is significant at the 0.01 level (2-tailed).**				
Correlation is significant at the 0.05 level (2-tailed).*				

7.5.4. Organisational change and the benefits of BIM (H7).

A series of Spearman rank-order correlations were conducted in order to determine if there was any relationship between organisational change, benefits to the organisation, benefits to the QS and criteria used for BIM adoption. Firstly, a two-tailed test of significance indicated there was a significant negative relationship between organisational change and benefits to the QS: N (161), $r_s = -0.196$, $p > 0.05$. This correlation coefficient is considered small, indicating that there is minimum evidence that suggests, as the ranking of organisational change increases, the ranking for benefits to the QS decreases and vice versa. Secondly, a two-tailed test of significance indicated that there was a significant positive relationship between organisational change and benefits to the organisation: N (159), $r_s = 0.241$, $p < 0.05$. This correlation coefficient is considered small, indicating that there is minimum evidence that suggests, as the ranking of organisational change increases, the ranking for the benefits to the organisation increases. Finally, a two-tailed test of significance indicted there is a significant negative between organisational change and criteria for BIM adoption, N (141), $r = -0.521$, $p < 0.05$. This correlation coefficient is considered large, indicating that there is strong evidence that suggests, as the ranking of organisational change increases the ranking of the criteria for BIM adoption decreases and vice versa.

It can therefore be assumed that there is a significant relationship between Organisational change, benefits to the QS and criteria used for BIM adoption. The results of the Spearman's correlation test in relation to H7 are shown in table 7.17.

Table 7-17 Correlation coefficients (H7)

Spearman's rho		Organisational change	Benefits to the organisation	Criteria for BIM adoption	Benefits to the QS role
Organisational change	Correlation Coefficient	1.000	.241**	-.521**	-.196*
	Sig. (2-tailed)		0.002	0.000	0.013
	N	164	159	141	161
Benefits to the organisation	Correlation Coefficient	.241**	1.000	-.350**	-.546**
	Sig. (2-tailed)	0.002		0.000	0.000
	N	159	175	143	171
Criteria for BIM adoption	Correlation Coefficient	-.521**	-.350**	1.000	.258**
	Sig. (2-tailed)	0.000	0.000		0.002
	N	141	143	148	145
Benefits to the QS role	Correlation Coefficient	-.196*	-.546**	.258**	1.000
	Sig. (2-tailed)	0.013	0.000	0.002	
	N	161	171	145	176
Correlation is significant at the 0.01 level (2-tailed).**					
Correlation is significant at the 0.05 level (2-tailed).*					

7.5.5. Resistance to change and the benefits of BIM (H8)

A series of Spearman rank-order correlations were conducted in order to determine if there was any relationship between resistance to change, barriers to adoption of BIM, benefits to the organisation and benefits to the QS. Firstly, a two-tailed test of significance indicated there was a significant positive relationship between resistance to change and benefits to the QS role: N (160), $r = 0.307$, $p > 0.05$. This correlation coefficient is considered medium, indicating that there is moderate evidence that suggests, as the ranking of resistance to change increases, the ranking for benefits to the QS increases. Secondly, a two-tailed test of significance indicated that there was a significant negative relationship between resistance to change and benefits to the organisation: N (158), $r = - 0.204$,, $p < 0.05$. This correlation coefficient is considered small, indicating that there is minimum evidence that suggests, as the ranking of resistance to change increases, the ranking for the benefits to the organisation decreases, and vice versa. Finally, a two-tailed test of significance indicted there is a significant negative relationship between resistance to change and barriers to adoption, N (163), r = - 0.273, $p < 0.05$. This correlation coefficient is considered small, indicating that there is minimum evidence that suggests, as the ranking of resistance to change increases, the ranking of the barriers to adoption decreases, and vice versa.

It can therefore be assumed that there is a significant relationship between resistance to change, benefits to the QS, benefits to the organisation and barriers to adoption. The results of the Spearman's correlation test in relation to H8 are shown in table 7.18.

Table 7-18 Correlation coefficients (H8)

Spearman's rho		Barriers to adoption	Benefits to the organisation	Benefits to the QS role	Resistance to change
Barriers to adoption	Correlation Coefficient	1.000	0.099	-0.081	-.273**
	Sig. (2-tailed)		0.191	0.283	0.000
	N	183	175	176	163
Benefits to the organisation	Correlation Coefficient	0.099	1.000	-.546**	-.204**
	Sig. (2-tailed)	0.191		0.000	0.010
	N	175	175	171	158
Benefits to the QS role	Correlation Coefficient	-0.081	-.546**	1.000	.307**
	Sig. (2-tailed)	0.283	0.000		0.000
	N	176	171	176	160
Resistance to change	Correlation Coefficient	-.273**	-.204**	.307**	1.000
	Sig. (2-tailed)	0.000	0.010	0.000	
	N	163	158	160	163
Correlation is significant at the 0.01 level (2-tailed).**					

7.5.6. BIM definition, benefits and maturity (H9)

A series of Spearman rank-order correlations were conducted in order to determine if there was any relationship between BIM definition, BIM maturity level, benefits of BIM to the organisation, benefits to the QS and BIM pre plan. Firstly, a two-tailed test of significance indicated there was a significant negative relationship between, BIM definition and maturity level, N (174), $r = -0.163$, $p < 0.05$. This correlation coefficient is considered small, indicating that there is minimum evidence that suggests, as the ranking of BIM definition increases the ranking for maturity level decreases and vice versa. Secondly, a two-tailed test of significance indicated that there was a significant positive relationship between BIM definition and benefits to the QS, N (174), $r = 0.371$, $p < 0.05$. This correlation coefficient is considered medium, indicating that there is moderate evidence that suggests, as the ranking of BIM definition increases, the ranking for the benefits to the QS, increases. Next, a two-tailed test of significance indicated that there was a significant negative relationship between BIM definition and benefits to the organisation: N (173), $r = -0.576$, $p < 0.05$. This correlation coefficient is considered large, indicating that there is strong evidence that suggests, as the ranking of BIM definition increases the ranking for the benefits to the organisation decreases and vice versa. Finally, a two-tailed test of significance indicted there is a significant positive relationship between BIM definition and BIM pre plan: N (157), $r = 0.167$, $p < 0.05$. This correlation coefficient is considered small, indicating that there is minimum evidence that suggests, as the ranking of BIM definition increases, the ranking of BIM pre plan increases. It can therefore be assumed that there is a significant relationship between BIM definition, BIM maturity level, benefits to the QS, benefits to the organisation and the BIM pre plan. The results of the Spearman's correlation test in relation to H9 are shown in table 7.19.

Table 7-19 Correlation coefficients (H9)

Spearman's rho		Benefits to the organisation	Benefits to the QS role	BIM definition	BIM Maturity Level	BIM Pre plan
Benefits to the organisation	Correlation Coefficient	1.000	-.546**	-.350**	-0.043	-.300**
	Sig. (2-tailed)		0.000	0.000	0.577	0.000
	N	175	171	173	171	154
Benefits to the QS role	Correlation Coefficient	-.546**	1.000	.371**	0.008	.180*
	Sig. (2-tailed)	0.000		0.000	0.922	0.025
	N	171	176	174	173	155
BIM definition	Correlation Coefficient	-.350**	.371**	1.000	-.163*	.167*
	Sig. (2-tailed)	0.000	0.000		0.032	0.036
	N	173	174	178	174	157
BIM Maturity Level	Correlation Coefficient	-0.043	0.008	-.163*	1.000	.246**
	Sig. (2-tailed)	0.577	0.922	0.032		0.002
	N	171	173	174	177	156
BIM Pre plan	Correlation Coefficient	-.300**	.180*	.167*	.246**	1.000
	Sig. (2-tailed)	0.000	0.025	0.036	0.002	
	N	154	155	157	156	158

7.5.7. Summary of the results of the hypotheses

A total of 25 sub hypotheses were considered; 9 showed a positive relationship existed between the variables whilst 11 sub hypotheses demonstrated a negative relationship between the variables and 5 showed no significant relationship between the variables. This is illustrated in Table 7.20.

Table 7-20 A summary of the hypothesis after statistical analysis.

Main Hypothesis	Sub Hypothesis		Significant relationship		
			Positive	Negative	No
H1		**There is a relationship between the benefits of BIM to the organisation and the role of the QS**		**x**	
H2		**There is a relationship between the benefits of BIM to the organisation and its adoption**			
	H2.1	There is a correlation between benefits and criteria for organisation adoption		x	
	H2.2	There is a correlation between benefits and stage of adoption	x		
	H2.3	There is a correlation between benefits and project adoption			x
H3		**There is a relationship between the barriers of BIM to the organisation and its adoption**			x
H4		**There is a relationship between BIM maturity level and organisational planning.**			
	H4.1	There is a correlation between BIM maturity level and business audit		x	
	H4.2	There is a correlation between BIM maturity level and BIM planning	x		
	H4.3	There is a correlation between BIM maturity level and BIM lead		x	
	H4.4	There is a correlation between BIM maturity level and years adopted			x
	H4.5	There is a correlation between BIM maturity level and the stage of BIM adoption			x
H5		**There is a relationship between BIM maturity level and knowledge management**			
	H5.1	There is a correlation between BIM maturity level and knowledge capture			x
	H5.2	There is a correlation between BIM maturity level and knowledge transfer	x		
	H5.3	There is a correlation between BIM maturity level and knowledge review		x	
H6		**There is a relationship between organisational characteristics and the learning organisation**			
	H6.1	There is a correlation between organisational characteristics and benefits to QS role.	x		
	H6.2	There is a correlation between organisational characteristics and individual learning	x		
H7		**There is a relationship between organisational change and BIM impact**			
	H7.1	There is a correlation between organisational change and benefit to the QS role.		x	
	H7.2	There is a correlation between organisational change and benefits to organisation.	x		

Main Hypothesis	Sub Hypothesis		Significant relationship		
			Positive	Negative	No
	H7.3	There is a correlation between organisational change and criteria for BIM adoption.		x	
H8		**There is a relationship between resistance to change and benefits**			
	H8.1	There is a correlation between resistance to change and benefit to the QS role.	x		
	H8.2	There is a correlation between resistance to change and benefits to organisation.		x	
	H8.3	There is a correlation between resistance to change and barriers to adoption.		x	
H9		**There is a relationship between BIM definition and benefits and maturity**			
	H9.1	There is a correlation between BIM definition and maturity.		x	
	H9.2	There is a correlation between BIM definition and benefits to the QS	x		
	H9.3	There is a correlation between BIM definition and benefits to organisation.		x	
	H8.4	There is a correlation between BIM definition and BIM pre plan	x		

7.6. Difference in the results between the consultant QS(CQS) and contractors QS(COQS)

The Mann Whitney U Test in SPSS was conducted to compare the results from the two major QS groups participating in the survey: CQS and COQS. A total of 64 variables were considered, of the 64 variables considered, 3 identified a statistically significant difference between the two groups. It can therefore be assumed that for the remaining variables there was no significant difference in the results between the CQS and the COQS. The 3 significantly different variables are considered below.

7.6.1. Stage of adoption

A statistically significant difference was found between the RIBA stage at which the organisation adopts BIM between the CQS (median = 91.19) and COQS (median = 75.90): $U = 25.87$, $z = -2.06$, $p = 0.040$, $r = -0.17$, this represents a small effect. It can be assumed therefore that there are minor differences in terms of, the stage at which, the CQS and the COQS adopt BIM.

7.6.2. Resistance to change

A statistically significant difference was found between the resistance to change when implementing BIM in the organisation between the CQS (median = 59.34) and COQS (median = 83.83): U= 34.61, z= 3.42 , p = 0.001, r= - 0.17, this represents a small effect. It can be assumed therefore that there are minor differences in the CQS and the COQS's resistance to change.

7.6.3. Benefits of BIM to QS role

A statistically significant difference was found between the benefits of BIM to the QS, between the CQS (median = 59.34) and COQS (median = 83.83) in relation to the resistance to change, U= 18.27, z= -2.33 , p = 0.020, r= - 0.17 and represents a small effect. It can be assumed that there are minor differences in the CQS and the COQS's ranking of the benefits of BIM to the QS role.

7.7. Summary of the key findings

Chapter 6 and 7 presented the findings of the analysis of the data, which was systematically and rigorously collected, from the interviews and questionnaires. The findings were presented in a transparent format to provide an overview of the CQS and COQS perceptions of BIM, maturity levels, impact on the QS role and the organisation, organisational learning, organisational change and its adoption. It appears that there is some statistically significant difference in the opinions of the CQS and the COQS albeit it minor in relation to this study. Leading to the development of the framework, a more detailed discussion, of the importance of this difference in opinion along with the findings from both, the interviews and the questionnaire, will be discussed in Chapter 8,

8. CHAPTER 8 - Discussion and framework development

8.1. Introduction

The aim of this chapter is to discuss the findings from both the interviews and the survey, with the intention of developing a framework that can be adopted by the QS organisation to respond positively to the challenges and opportunities set by BIM- enabled construction. This framework incorporates the achievement of Objectives 1-4 of this research as follows:

1. To assimilate the existing literature and theories on BIM implementation and organisational development to provide a comprehensive academic basis for the framework of value creation through BIM.

2. To establish the critical success factors of BIM to the QS that will identify the opportunities and challenges to the quantity surveying organisation when adopting and implementing BIM;

3. To determine the implication of organisation BIM learning in creating and adding value to the quantity surveying organisation.

4. To determine the organisational changes needed to accommodate BIM in a quantity surveying organisation to support the value proposition of BIM.

5. To develop and validate a framework of value creation for a quantity surveying organisation when adopting and implementing BIM.

The first section will consider the key attributes of the framework as defined by the literature and the findings. The second section of this chapter will present the developed structure of this framework including its elements Finally, the last section will present the validation process and its outcome for this framework.

8.2. Framework rationale

Chapter 2 identified that the UK BIM level 2 mandate, along with the Construction 2025 strategy, set, an almost impossible challenge to the industry and its stakeholders, to reduce costs, time and carbon emissions. BIM, whilst vital to support the delivery of these targets, will demand revolutionary and evolutionary changes, to organisations and project teams, if it is to create these efficiencies. The QS, as part of the project team, cannot be excluded from this revolution.

Chapter 2 further discussed the uncertainty around the impact of BIM on the QS (Olatunji, 2009), identifying the need for the QS and the QS organisation to respond swiftly, to increase their knowledge, awareness and usage of BIM (Goucher and Thurairajah, 2013). Frei, 2010a, adding that the QS organisation should respond positively to BIM innovation, and be proactive, not reactive in its adoption. Mamphey (2016), further claims, that BIM does not toll the death of the QS, but proffers to the QS, a further opportunity, to reinvent itself. Chapters 6 and 7 confirmed this positive attitude to BIM adoption and consistently established, that the QS role will survive post BIM. The majority of those surveyed agreed, that BIM presents itself more, as an opportunity to create value, than, as a threat to its survival.

Chapter 3 considered organisational change and change management, identifying that organisations need to manage the change and transformation of its people, polices, processes and technology, if they are to grow and create value. In addition, organisational characteristics typical of organisational survival were identified, along with, the critical success factors (CSF'S) for growth and survival of the QS organisation, as identified by Frie et al (2013). Finally, Garvin (1993) identified the importance of the learning organisation in creating and acquiring knowledge, to the process of value creation. It was found in chapter 6 and 7 that the QS organisation typically presented itself with the characteristics of one that would grow and survive, adding further support, to the ideology of survival of the QS. In addition, the QS organisation presented itself with many of the characteristics of the learning organisation, although there was evidence of considerable variance, in the capture, storage and transfer of knowledge within those organisations surveyed.

The structure for this framework has been developed, based on the activity-theoretical/evolutionary framework, discussed by Miettininen and Paavloa (2014), and, the critical success factors developed by Frei and Mbachu (2013). The theoretical framework drawn upon for development in this study is based on an activity theoretical practical approach founded on effective organisational learning, and the evolution of knowledge. This framework identifies the importance of learning, to improve organisational performance, particularly in relation to BIM implementation. "The learning being gained from conscious experimentation and learning by the practitioners". (Miettininen and Paavloa (2014), p. 22). The framework recognising the importance of capturing information in context, that will inform the evolution of the organisation, in terms of BIM implementation. The critical success factors of the QS firm, as identified by Frei and Mbachu, (2013), provided, the basis for the development of the critical success factors developed in this study, in terms of value creation. Whist Frei and Mbachu identified factors internal and external to the organisation, this framework as the McKinsey 7S factors, will only consider those that are internal and within the control of the organisation.

8.3. The proposed framework

This research has identified BIM as a potential opportunity for growth and value creation. It has considered BIM, the QS and the QS organisation, in order to identify the CSF's to support the QS organisation in managing, the opportunities presented by BIM. This research does not consider CSF to be merely concerned with the benefits and barriers of BIM, but has identified, through detailed analysis of the exploratory interviews and primary data 7 other factors, and sub factors, that must be given careful consideration, if the QS organisation is to respond positively to the opportunities given by BIM. A total of 9 factors were identified, 5 factors being specific to BIM and 4 to the organisation. It is these factors that will constitute the structure of the framework:

- BIM maturity
- BIM definition
- BIM benefits
- BIM barriers
- BIM adoption
- Business planning
- Organisational characteristics
- Organisational learning
- Change management

Further to the discussion around the findings of the research in Chapters 6 and 7 the following framework is proposed, as illustrated in Figure 8.1.

At the foundation of the framework itself lie “Perceptions” on which the Definitions are founded and at the head is “value creation”, the ultimate aim of the framework, which is measured against Maturity. Bounding the framework either side are the External Factors, recognised as being outside of the control and influence of both the QS and the organisation. For the purpose of this research these were not considered as discussed in section 8.2, the focus of the research being what could be influenced internally within the organisation in order to promote value creation. 9 factors are contained within the framework and the relationships previously identified, through correlation analysis in section 7.5.2, are identified by an arrow connecting each component. The CSF’s which inform the components of the framework previously discussed in section 8.2 are summarised in Table 8.1

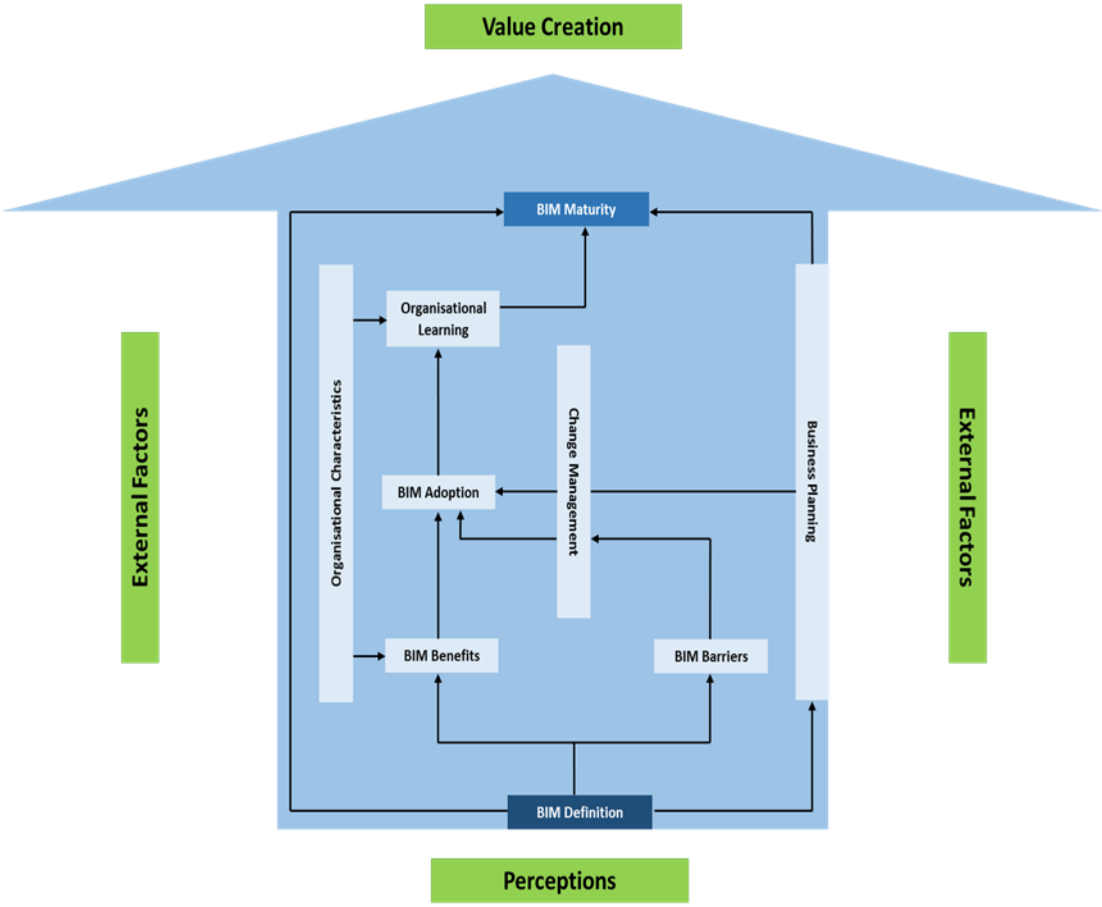


Figure 8-1 Structure of the developed framework for the survival of the QS organisation in a BIM enabled era

Table 8-1 CSF's of the framework

<table>
<tr><th>Factor</th><th colspan="2">Sub Factors</th></tr>
<tr><td>BIM maturity</td><td colspan="2">Level 2</td></tr>
<tr><td>BIM definition</td><td colspan="2">Information
Collaboration
Technology
Process
Multi-dimensional</td></tr>
<tr><td>BIM benefits</td><td colspan="2">High level themes:
Quantification and Measurement
Productivity
Decision making
Quality
Low level themes:
Visualisation,
Collaboration,
Communication,
Efficiency,
Accuracy,
Change management,
Processes,
Diversification of services (includes whole life costing)
Competitive advantage (includes sustainable and global).</td></tr>
<tr><td>BIM barriers</td><td colspan="2">People
Cost
Demand
Knowledge</td></tr>
<tr><td>BIM adoption</td><td>Criteria for the adoption:
Market
External policy
Performance
Technology
Innovation
Processes
Diversification.</td><td>Stage of Adoption:
Stage 0 – client brief
Stage 1 – feasibility
Stage 2 - concept design
Stage 3 - detailed design
Stage 4 - technical design</td></tr>
<tr><td>Business planning</td><td colspan="2">Characteristics:
Maturity Level
Leadership
Workload</td></tr>
<tr><td>Organisational characteristics</td><td colspan="2">Decentralised decision making
Open communication,
Positive innovation,
Supportive learning environment,
Empowerment of employees
Flexible structure.</td></tr>
<tr><td>Organisational learning</td><td colspan="2">Organisation driven
Individually driven
Externally driven</td></tr>
<tr><td>Change management</td><td>Changes required by the organisation:
Technology
Training
Information management
Policies and protocols
Staffing
Performance management
Fees and contracts.</td><td>The resistors are founded on:
Benefits of BIM
Technology
Knowledge management
Decision making
Processes
Leadership.</td></tr>
</table>

The development of each of the factors, high level and low level themes will be discussed in the next section.

8.4. Framework development

The aim of this framework is to support the QS organisation in the creation of value, as a consequence of BIM implementation. The literature review (Chapters 2, 3 and 4) and the findings (Chapter 6 and 7) identified two overarching themes: BIM and organisational management. Included within the BIM theme were: BIM definitions, BIM benefits, BIM barriers, BIM adoption, and BIM maturity levels. Whilst organisational management included: organisational characteristics, business planning, change management and organisational learning. The research therefore identified 9 factors to be considered as influential in the development of this framework. The attributes of each of these factors and the justification for their inclusion in this framework, including a discussion on their interconnectivity, is the focus of this section.

8.4.1. BIM maturity

BIM maturity "identifies the measured and continual improvement in quality, repeatability and predictability within the available capabilities of the organisation" (Succar and Kassem,2015, p65). BIM levels and BIM Level 2 compliance have become the acknowledged designation of the criteria required to be deemed BIM-compliant. The current desire for BIM Level 2 is at the forefront of how clients articulate their expanding BIM aspirations, with the desired progression to Level 3 inevitable in the next ten years (National BIM report, 2016). As the implementation process moves from BIM level 0 to BIM level 3, BIM maturity levels can therefore be assumed to be the ultimate measure of performance in terms of successful implementation of BIM for a QS organisation. Furthermore, it has been assumed in the design of this framework that organisational survival is dependent on organisations aspiring to work at BIM Level 2 as a minimum.

The findings of this research in terms of the QS organisations current maturity can be compared against the most recent National Building Specification (NBS) BIM Survey 2016, which had 1000 respondents of which 3% were QS's. As a % of total respondents, this research identified in section 7.3.7, that more QS organisations were working at Level 0 than the NBS survey (1%, NBS, 9% this research), at Level 1 the results were similar (30%, NBS, 26% this research). However, at Level 2, there was a much bigger discrepancy, with the NBS survey finding over twice as many organisations working at Level 2 than those surveyed in this research (65%, NBS, 26% this research). Whilst this result is rather worrying and suggests that the QS organisation is behind other construction service providers, in terms of BIM readiness and capability, this survey also found that approximately 18% were between Level 1 and 2. Therefore there a considerable number of organisations that are working at or near Level 2 although still below the sector. At Level 3 the findings of this research suggests that the QS organisation is outperforming the sector (4%, NBS, 6% this research), with a further 7% claiming to be working between Level 2 and 3. It would appear therefore that in terms of maturity the QS organisation has outperformed the sector at the upper end but at the mandated Level 2, they are significantly lagging behind.

However, when ranking maturity this research found that BIM Level 2 was ranked 1. Hence this framework has been developed to support the QS organisation working at maturity level 2 in order to support the QS organisation in achieving the mandated standard.

8.4.2. BIM definition

Section 2.5.5 discussed the various definitions offered in relation to BIM. The proliferation of which is causing confusion amongst the industry with many calling for a consistent approach to its definition (Goucher and Thurrairajah, 2013). The findings from the initial interviews, section, 6.2.1.1, concluded that there was no clear consensus, but that it was a combination of process, collaboration, information, and technology, with process at the heart. In contrast, the survey confirmed the definition with "information" at its centre to be ranked first, but closely followed by the "collaboration" definition. For the purpose of this research, the definition adopted for BIM proposed by the RICS 2014 "BIM gets people and information working together effectively and efficiently through defined processes and technology" does appear to be validated by these results. However, the view held by Miettininen and Paavola (2014) that it was multi-dimensional and would evolve over time, was rejected by the survey, and ranked 5 out of 5.

The literature therefore suggested that it was important to understand what definition people placed on BIM as this influenced their expectations in terms of; Is it a technology? Is it a process? This in turn, could influence their perception in terms of the benefits it could offer to the organisation and to the QS. Interestingly, neither the interviews nor the survey emphasised technology as being a major influence in definition, yet it is the very technology aspect that first sparked fear amongst QS's, with Mathews, (2011), "Rise of the machines. Fall of the QS" article. It can be assumed therefore that the definition applied to BIM will be reflected in the perception of its threats and equally its benefits. Furthermore, if BIM definition is, as suggested, evolving over time, then it could perhaps be assumed that definition could also be associated with BIM maturity as this too develops with time.

Section 7.5.2 considered the relationship between BIM definition, BIM maturity, BIM benefits to the QS organisation and to the QS. Hypothesis 9.1, section 7.5.6 found, there is a significant negative relationship, between *BIM definition* and *BIM maturity level*. Therefore, it can be concluded that as the BIM maturity level of an organisation goes up the rankings the definition goes down and vice versa. The study found that BIM maturity Level 2 was ranked at 1, whilst the multi-dimensional evolving over time definition was ranked at 5. Hence, as maturity levels change the BIM definition changes, thereby supporting Miettinens' view and establishing that as an organisation's BIM maturity level increases, then the definition given to BIM will change.

There does, however, still appear to be a lack of consistency in defining BIM, with the research identifying a plethora of interpretations. CQS1 warned that this presented an issue, in that, if people do not understand what it is, then it follows that they do not understand what benefits it can offer and how they can be delivered. Hypothesis 9.2 confirmed that there is a significant positive relationship between *BIM definition* and *benefits to the QS*. Hence, the definition has a positive influence on the QS's perception of the benefits that will result from BIM. It could be concluded therefore, that having a good understanding of the definition of BIM will help realise the benefits of BIM to the QS, thus affirming the point made by CQS1. However, in contrast, hypotheses 9.3 concluded that there is a significant negative relationship between *BIM definition* and the *benefits to the organisation*. Therefore, as the benefits of BIM to the organisation become more positive, the definition of BIM will evolve and change, as the perceptions underlying the benefits of BIM change.

Section 2.5.5 questioned, whether or not it actually mattered what the definition of BIM is, but as there is a correlation between definition and what the perceived benefits of BIM are, it is clear that definition plays an important role in identifying benefits, to both, the QS as an individual and the organisation itself. In section 6.2.1.1, COQS1 warns that when defining BIM, it should not be seen as supplementary to the QS role, but as the norm. It is therefore essential that the QS understands the benefits that BIM will bring, not just to their role, but to that of the organisation itself, and that the organisation communicates this to the QS. McCarthy and Rich, (2015, p14) discuss the importance of engagement and "the need to provide an empowering vison and focus such that people can also identify with the challenge and become part of it." The definition an organisation places on BIM can therefore be said to be paramount in ensuring the congruence of benefits for both the QS and the organisation.

This framework is founded upon 5 definitions of BIM as discussed in sections 2.5.5, 6.2.1.1 and 7.3.4, and based around the following themes:

- Information - BIM is concerned with information about the entire asset and a complete set of design documents stored in an integrated database, where the information is parametric and thereby interconnected.
- Collaboration - BIM is a language of collaboration with people and communication at its centre.
- Technology - BIM is an Information Technology (IT) enabled approach that allows design integrity, virtual prototyping, simulations, distributed access, retrieval and maintenance of the building data.
- Process - BIM is the coming together of policy, process and technology.
- Multi-dimensional - BIM is a multi-dimensional, historically evolving, complex phenomenon.

8.4.3. The benefits of BIM to the organisation and the QS role

Section 8.4.2 concluded that BIM definition informs, the perceptions of the benefits of BIM, to both the QS and its organisation. Sections 7.5.2.1 and 7.5.2.2, found there was a significant negative relationship between the benefits of BIM to the organisation and the benefits of BIM to the QS, Hypothesis 1. inferring that as the benefits to the QS falls down the ranking the benefits of BIM goes up the rankings for the organisation.

Sections 2.6 and 2.8.3 discussed the benefits of BIM to the construction industry stakeholders, the QS and the organisation. The benefits of BIM to the QS were categorised into 4 themes: automation and efficiencies; improvements in: collaboration, communication, visualisation, accuracy and quality; earlier identification of risk and commercial advantage over competitors (Popov et al, 2008; Sabol, 2008; Sebastian, 2011; Goucher and Thuraurajah, 2012; Stanley and Thurnell; 2014, Harrison and Thurnell, 2015). This research affirms many of these benefits. Section 6.2.3.2, the initial interviews, identified the benefits to the QS into 5 main themes: increased accuracy, influence on decisions (least benefit), faster information flow, creation of efficiencies (biggest benefit) and better coordination. These were redefined in section 7.3.3 as the survey recognised the benefits of BIM to the QS in 3 themes: an increase involvement in processes/services (ranked 1,3,5,), the creation of efficiencies (ranked 2,4,6) and diversification of service provision (ranked 7,8,9).

In contrast, the initial interviews discussed in section 6.2.2.2, identified 6 themes in relation to the benefits to the organisation: better visualisation (least benefit), creates efficiencies (biggest benefit), improved collaboration, improved communication, improved decision making, and better data. Section 7.3.5, the survey, did not support these initial findings ranking visualisation as the most important benefit to the organisation, with the creation of efficiencies being ranked 4th out of 15. Furthermore, increased competitive advantage was ranked 15th out of 15, contradicting Smith's (2014) claim that cost management firms recognise the competitive advantage BIM offers. The highest ranking benefit of BIM to the organisation was improved visualisation, but this could fall down the rankings if the service offered by the QS did not require this improvement, e.g. whole life costing. Greater involvement in whole life costing was ranked 3, as a benefit of BIM to the QS, and is identified as a necessary service` by the UK government in its Construction 2025 strategy, supported by PAS1192.3 and Government Soft Landings.

These results suggest that the QS does not feel threatened by BIM in terms of extinction, in contradiction to the opinions of Saunders (2013) and Mathews (2011), with death of the QS, ranking 10th out of 10 in the benefits to the QS. However, it does demonstrate that there is a significant difference in the perceptions of benefits between the organisation and individual QS, the negative correlation suggesting that as the benefit increases with one group it has a negative impact on the other and their benefits decrease. In order to ensure the growth and survival of the organisation, it is necessary to ensure that the values are shared (McCarthy and Rich, 2015). However, Bennett and Bennett, p316 (2004) identify value as establishing a meaning and purport that "understanding the meaning of a situation allows us to understand its impacts on our own objectives and those of our organisation", thus adding further credence to the alignment of benefits of BIM to both the organisation and the QS.

In order to identify common benefits and to ensure alignment, with the perceptions of the individual and the organisation, the benefits at individual and organisational level were analysed for commonality. The benefits highlighted in blue are those found to be shared by both the organisation and the QS, as illustrated in Table 8.2.

T able 8-2 Identification of common benefits to both the QS and the organisation

Organisation benefit	**Ranking out of 15**	**QS benefit**	**Ranking out of 10**
Visualisation	1	Collaboration	1
Communication	2	Quantification and measurement	2
Quantification and measurement	3	Whole life costing	3
Communication	4	Decision making	4
Accuracy	5	Quality	5
Change management	6	Productivity	6
Processes	7	Diversification of services	7,8,9
Productivity	9		
Decision making	10		
Competitive advantage	11		
Sustainable competitive advantage	12		
Quality	14		
Global competitive advantage	15		

As a result of this alignment this framework is founded upon 4 high level common benefits of BIM to both the QS and the organisation:

- quantification and measurement,
- productivity,
- decision making
- quality

In addition to the high level benefits, consideration may also be given to some or all of the 9 low level benefits:

- visualisation,
- collaboration,
- communication,
- efficiency,
- accuracy,
- change management,
- processes,
- diversification of services (includes whole life costing)
- competitive advantage (includes sustainable and global).

8.4.4. Benefits of BIM and the criteria for BIM adoption

The results suggest thus far that perceptions based on definitions influence how the QS and the organisation see the benefits of BIM. Furthermore, these benefits can be aligned as common benefits. But can these benefits, as presented by the organisation, influence its decision to adopt BIM?

Section 7.5.2.2 considered if there was a relationship between the benefits of BIM to the organisation and the criteria used for adoption. Hypotheses 2.1 confirmed that there is a significant negative relationship between the *benefits of BIM to the organisation* and *criteria for BIM adoption*. The highest ranked criteria for adopting BIM was to keep pace with similar organisations who have adopted, with, to diversify the service, ranking 11th out of 11. If indeed a negative correlation exists between adoption criteria and organisational benefits, then it can be assumed, as there is an increase in diversifying the service, there will be a negative change in the benefits of BIM to the organisation. Hence, if the service changes, the benefits accruing to that service will also change. The results also confirm that the QS organisation is not seeking competitive advantage, but is merely attempting to keep pace with its competitors and maintain market position, ranked 2. Smith, (2014), section 2.2, argues it is the recognition of the competitive advantage of BIM realised by their competitors that is providing the catalyst for change more than anything else. Succar and Kaseem (2015), section 4.2.4, discuss this diffusion of BIM as being the spread of BIM amongst the population of adopters. Geroski (2000), identified two main types of diffusion, the epidemic model and the probit model. The QS organisation appears to follow the probit model with its three identifiable patterns of contagion, social threshold, and social learning (Young, 2006). These results suggest that the QS organisation is adopting as a consequence of social threshold, where the QS organisation decision to adopt is made when enough similar QS organisations have adopted. Therefore, the QS organisation is subject to institutional pressures and is being coerced, (DiMaggio and Powell,1983) by other QS organisations and the larger society it operates within, to adopt.

Whilst section 2.8.5 discussed, innovation as increasingly essential for creating competitive advantage and achieving superior performance (Velu, 2014), leadership and innovation is only ranked 7 out of 11. Section 3.1.3 argued, that there is a positive relationship between survival and the degree of innovation (Schwartz, 2013; Cockburn and Wagner 2007; Buddelmeyer, Jensen, and Webster, 2009). Thus, the QS organisation is not representative of an organisation seeking growth by diversification and domination (Chield and Kieser, 1991) but typically representative of one that is under threat from market competition (Frie and Mbachu, 2013), attempting to keep pace with its competitors, as opposed to demonstrating innovation and leadership.

This framework is founded upon 7 criteria of adoption with each of these criteria resulting from a need to respond, maintain or improve.

- market
- external policy
- performance
- technology
- innovation
- processes
- diversification.

Section 7.5.2.2 further considered the stage of BIM adoption and the relationship between this and the benefits of BIM to the organisation (H2.2). The results found that there is a significant positive relationship between the benefits of BIM and stage of adoption. The RIBA plan of work was used to ascertain the stage at which the QS is more likely to adopt BIM as, generally, the earlier BIM is adopted the greater the benefits to the project. At the inception stage, BIM benefits are realised as a conceptual tool (Azhar et al, 2008) with each of the other stages realising a significant benefit too (Doumbouya et al, 2016). Hunt (2016), argues ideally all delivery partners would be appointed at stage zero (client brief) and work collaboratively through the feasibility (stage one), concept design (stage two) and detailed design (stage three) phases to better equip them to work effectively together throughout the technical design (stage four) construction (stage five), handover (stage six) and monitoring (stage seven) phases. Section 7.3.2 identified that stage 3 developed design stage was identified as the most likely stage that the QS organisation would adopt BIM with stage 7 being the least likely. As a positive correlation has been identified between *organisational benefits* and *stage of adoption* it can be argued that the earlier that BIM is adopted the greater the benefits are seen by the organisation. Furthermore, if whole life costing is to continue to be a function of the QS then it would follow that the QS should be involved at client brief stage.

This framework is founded upon 5 stages of adoption: with the greatest benefits being achieved the earlier on in the project the QS adopts BIM.

- Stage 0 – client brief
- Stage 1 – feasibility
- Stage 2 - concept design
- Stage 3 - detailed design
- Stage 4 - technical design

In addition, it was found that there was a statistically significant difference between the CQS and COQS perception of the benefits to the QS role, albeit small. As there have only been 5 statistically significant differences between these groups overall variables, this research does not consider these differences to be of further importance to this study.

8.4.5. Barriers of BIM and BIM adoption

Section 8.4.4 has identified that a relationship exists between *the benefits of BIM to both the QS and the organisation* and *adoption*, but what of the barriers? Consideration must be given to the barriers to BIM in order to calculate the net gain of the benefits. Section 6.2.3.1, the initial interviews identified the barriers to the QS, into 5 main themes: software, people, model (biggest barrier), interoperability and confidence (2nd biggest barrier). In contrast, section 6.2.2.1 the initial interviews, produced 9 themes for the barriers to BIM for the organisation: capability, client, cost, interoperability (least barrier), lack of confidence (biggest barrier), liabilities, people, software, and standards. These exploratory interviews identified a major alignment between the barriers perceived by the QS and the organisation, whilst the survey only measured the barriers to the organisation. This was deemed appropriate as the QS would be represented as, “people”, within the organisational barriers and as such any barrier presented to them would be considered in relation to the management of culture by the organisation. The survey identified “lack of suitably skilled and experienced staff” as the major barrier to the organisation with “lack of confidence in the selection of appropriate software” being ranked 9th. Frei and Mbachu (2013), section 3.2, identified capability/capacity as one of 5 major threats to QS organisations when considering implementing BIM, with the “lack of suitably skilled and experienced practitioners” being critical. There are too few staff available to update BIM models and inadequate training to upskill the workforce (Yan and Damian,2008, Thwala et al, 2012 and Enegbuma et al, 2014). Skills and staff shortages are not confined to the QS but are systemic of the Construction industry as a whole. Section 2.3, the Farmer Review of the UK Construction Labour Model 2016 entitled “Modernise or die” confirms the lack of people and lack of skills as being a “real ticking time bomb that needs to be recognised” (p8). However, in terms of BIM implementation, the insufficient supply of adequately trained BIM professionals (Becerik-Gerber et al., 2011) represents a real barrier to further BIM implementation. In July 2016, it was reported that the QS shortage is still holding back construction with 57% of firms confirming a shortage of QS’s (Prior, 2016). Section 7.3.6 confirms this as being the biggest barrier to BIM, in terms of lack of suitably skilled and experienced staff. In contrast, section 7.3.6, did not recognise “fear of extinction” as being a barrier to BIM and ranked it 17th out of 17. In the short term this confidence in the QS role is supported by the national shortage of QS’s, but, in the long term, maybe the QS organisation should reflect on Farmer’s comment “Modernise or Die”!

Section 7.3.6, found that cost represented another significant barrier to adoption, with the cost of training (ranked 3), hardware (ranked 4), network (ranked 5) and software (ranked 8). Section 2.8.4 found cost to be a potential barrier to the adoption of BIM by the QS (NBS, 2012). in terms of both software, hardware and training (Mathews and Withers, 2011), particularly as it is claimed it could add a further £10 million to the industry (Zhou et al, 2012). In contrast, section 3.2, when identifying the threats to the QS firm, Frei and Mbachu (2013) did not identify cost as a threat.

Demand was a major consideration by Frei and Mbachu(2013), section 3.5, particularly as it represented itself in the form of market/competition. This survey identified demand as clients specific, undoubtedly linked to the UK Governments mandate for adoption on publically procured projects. Section 7.3.6, identified, it was the lack of client demand (ranked 5) and the lack of certainty in added value to the client (ranked 12) and by the QS (ranked 13) that this survey identified as being important, a view supported by Goucher and Thurairajah (2013) and Zhou et al (2010), section 2.8.4.

Section 6.2.4, the exploratory interviews, identified BIM learning as being essential with COQS2 urging “communication and feedback will help deliver an understanding of what BIM is”. Knowledge is seen as important in order to understand the barriers to BIM, as greater knowledge will allow reflection and encourage individuals/organisations to modify their behaviour (Garvin, 1993). It could be inferred, therefore, as more knowledge is gained in relation to BIM barriers, the organisations reaction to them could change. Section 7.4.6, identified lack of shared knowledge banks as being an important barrier (ranked 6) and identified others associated with lack of knowledge, which included lack of confidence in the selection of appropriate software (ranked 8), lack of training (ranked 10) and isolation of the QS from key decision makers (ranked 11).

The barriers as identified in section 7.4.6 in the survey, at organisational level, were analysed in relation to the threats identified by Frie and Mbachu (2013) in section 3.5. The aim of which being to identify high level themes that could form the basis of this framework in relation to barriers to the adoption of BIM to the QS organisation. The barriers/threats highlighted in various shades of blue, are those found to be shared, by both this research and that of Frei and Mbachu, (2013), as illustrated in Table 8.3. This resulted in the following 4 high level themes, to the barriers that impact the adoption of BIM by the organisation, being identified for this framework:

- People
- Cost
- Demand
- Knowledge

Table 8-3 Identification of common barriers to the adoption of BIM by the organisation

Organisation barrier from survey	**Ranking out of 19**	**Frei and Mbachu (2013) threats to the QS organisation**	**Themes developed for framework**
Lack of suitably skilled and experienced staff	1	X	People
The ageing workforce and the undersupply of new entrants.	2	X	
Cost of training	3		Cost
Cost of hardware	4		
Lack of private client demand	5		Demand
Cost of network	5		
Lack of shared knowledge banks available to the QS	7	x	Knowledge
Cost of Software	8		
Lack of confidence in the selection of appropriate software	8		
Inadequate professional body training provided by professional bodies	10	x	
The isolation of the QS from key decision makers and clients	11	x	
Lack of certainty of added value to the client	12		
Lack of certainty of added value to the QS role	13	x	
Contractual liability concerns	14		
Reduction in fees charged	15	x	
Increased competition	16	x	
Fear of extinction of the QS role	17		

Section 7.5.2.3 considered, if there was a relationship between the barriers of BIM to the organisation, and its criteria for adoption, hypothesis (H3). The results found that there was no significant relationship between the barriers of BIM to the organisation and criteria for BIM adoption. The result, indicating that the barriers do not influence the organisation when considering its criteria for adoption. This seems highly unlikely as much of the literature

discussed in section 2.8.4, considers barriers to be influential in the adoption of BIM. Justification for this stark contradiction to the literature, could in part be explained by the fact, that this survey looked specifically at internal not external barriers to adoption.

8.4.6. BIM maturity level and organisational planning

Section 4.4, established that maturity Level 2 is the mandated norm of the industry. How an organisation plans for maturity, therefore must be given consideration. Section 7.5.2.4 considered the relationship between BIM maturity level and organisational planning, where organisational planning included business audit, BIM planning, BIM leadership, the stage adopted, and the criteria for project adoption, hypothesis (H4). Section 4.2.4 identified 3 phases to implementing BIM: BIM readiness, planning required Pre BIM, BIM capability, implementation of new protocols, tools and workflows and BIM maturity, performance measures Post BIM (Succar and Kassem, 2015). This hypothesis considers the relationship between Pre BIM and Post BIM.

BIM maturity “identifies the measured and continual improvement in quality, repeatability and predictability within the available capabilities of the organisation” (Succar and Kassem,2015, p65). BIM Levels and BIM Level 2 compliance have become the acknowledged designation of the criteria required to be deemed BIM-compliant. The current desire for BIM Level 2 is at the forefront of how clients articulate their expanding BIM aspirations, with the desired progression to Level 3 inevitable in the next ten years (National BIM report, 2016). As the implementation process moves from BIM Level 0 to BIM Level 3, BIM maturity levels can therefore be assumed to be the ultimate measure of performance, in terms of successful implementation of BIM for a QS organisation.

In terms of BIM readiness, the NBS identified what businesses needed to do before 2016 in order to be Level 2 compliant (NBS, 2015). The NBS identified that it was essential to undertake a business audit and plan at the Pre BIM stage, in order to achieve Level 2. The relationship between BIM maturity and business audit (Hypothesis 4.1) was tested and the Spearman's correlation coefficient (rho) analysis concluded that there is a significant negative relationship between BIM maturity level and business audit. Surprisingly, the survey identified that approximately 30% (ranked 1) did not know if the organisation undertook a business survey with a further 6%(ranked 7) confirming that the organisation did not do a business audit. Therefore, it can be assumed that as the level of BIM maturity increases, the organisation starts to work on a business audit, considering its existing workload and capability in terms of people, IT, and processes, and more importantly, makes the QS's in the organisation aware of the fact. These results support the previous findings, which identified the biggest barrier to BIM as, "lack of suitably skilled and experienced staff" as the business audit would identify if a gap existed in terms of people that would in turn inform the organisations plan.

Hypothesis 4.2 considered if there was a correlation between BIM maturity and Pre BIM planning. Spearman's correlation coefficient (rho) analysis concluded that there is a significant positive relationship between BIM maturity level and BIM planning. Therefore, it can be determined that, as more items are considered at the strategic planning stage, then the BIM maturity level of the organisation is more likely to increase. At the strategic planning stage this research found that the training requirements (ranked 1) and budget requirements (ranked 2) were given greater precedence than the impact on workload (ranked 9), new ways of working (ranked 10) and impact on teams (ranked 12). A healthy organisation is one that undertakes regular checks on its strategic heath and carries out a business audit (the diagnosis) and prepares a plan (the prescription) in order to maintain the good health of the business (DeSmet,2007). Furthermore, section 7.5.2.4 found a significant positive relationship existed between BIM definition and BIM pre plan. Hence if individuals understand what BIM is, they are more likely to understand the need for strategic planning and the criteria to be considered and if BIM levels are used to assess performance then the level of BIM maturity should increase.

DeSmet (2007) identified leadership and direction as two of the nine core management components to a healthy organisation. Leadership is key to engaging individuals in the organisation and establishing common values, as an empowering vision and focus provides meaning for everyone (McCarthy and Rich, 2015) But how does leadership relate to BIM maturity and organisational success? Hypothesis 4.3 concluded that there is a significant negative relationship between BIM maturity level and BIM lead. Over 56% of those surveyed identified senior management or a designated BIM Champion as leading BIM implementation in their organisation with only approximately 6% being led by groups of interested individuals and 9% by individuals interested in BIM. The results suggest that as BIM maturity increases, there is move away from senior management leading BIM, towards engaging the individual and group interest in BIM. However, if top down direction is well communicated and combined with engaged and questioning staff, success and survival is guaranteed (McCarthy and Rich, 2015). BIM leaders need to communicate a defined vison of BIM to the organisation that will inspire and engage the QS, as of all the barriers to progress, it is the lack of people engagement that represents the greatest hurdle(Brown, 1996, Womack and Jones, 1996: Mann, 2010).

If it can be assumed that BIM has been implemented by the QS organisation after completion of the Pre BIM audit and plan, and that the QS and the organisation are working towards common benefits, then can BIM maturity level improve with the years adopted? Hypothesis 4.4 found that there is a significant positive relationship between BIM maturity level and years adopted, thereby affirming that an increase in performance occurs as organisations climb up the maturity levels, experience internal diffusion, and gradually improve their performance over time. (Succar and Kassem, 2015).

In the design of the framework, it was assumed that the organisational planning comprises the assessment of current capabilities, (business audit) and future capability requirements (business planning). Future capability identified in this research includes: training, budget, maturity level, deliverables, KPI’s, time, leadership, workload, team working and cash flow.

Current capabilities identified in this research are: create awareness, maturity level, technology, skills, demand, processes, security, workload, and policies.

Planning, audit, and leadership were analysed for commonality, in order to ascertain common themes in relation to business planning. The benefits highlighted in blue are those found to be shared by planning, audit and leadership as illustrated in Table 8.4. In addition, it shows leadership as one of the considerations to be made at the planning stage.

Table 8-4 Business planning characteristics

Planning	Audit	Leadership
Training	Unaware	BIM champion
Budget	Maturity Level	Senior managemen
Maturity Level	Technology	Project team
Deliverables	Skills	Individuals
KPI's	Demand	
Time	Processes	
Leadership	Data security	
Workload	Workload	
Teamworking	Policies	
Cashflow		

Table 8.4 identifies the following 3 high level themes, relating to business planning:

- Maturity level
- Leadership
- Workload.

8.4.7. BIM maturity level and knowledge management

If performance can be said to improve over time, what is it within the QS organisation that enables an increase in maturity? Section 3.3, identifies that knowledge is the key feature in the QS portfolio and, therefore, effective knowledge management skills can help to improve their expertise over time (Davis et al, 2007). The RICS, (1991), claim that knowledge base is at the core of professional practice and is essential to QS success. Knowledge is an asset and for the QS profession it is characterised by a wealth of experiential knowledge which is tacit and often lost as people leave the organisation, which can be prevented by an effective knowledge management system (Davis et al, 2007). Efficient knowledge management for the QS organisation depends on the capability of the individual to plan, manage, operate, monitor and control the information used for making decisions (Lobermans, 2002). If BIM is new to the organisation it is essential the knowledge and lessons learnt by adopting BIM in the organisation is captured, transferred and reviewed.

Section 8.4.7 found that 61% of QS's recognise the value of BIM knowledge, 63% are happy to share this knowledge, but only 36% are encouraged by the organisation to share this knowledge, suggesting it is the individual not the organisation that recognises the value of this new knowledge. However, the survey also found that just less than 90% of QS organisations recognised the importance of capturing BIM knowledge adopting an array of methods. Approximately 23% of those surveyed identified the BIM Champion as the person responsible for capturing BIM knowledge, with only 13% adopting a lessons learnt data base and significantly approximately 11% did not capture BIM knowledge at all. Reliance is placed upon the individual BIM champions as opposed to organisational systems to capture the knowledge. Section 7.5.3 considered hypotheses 5.1 which tested the relationship between maturity and BIM capture and concluded that there is no statistically significant relationship between BIM maturity level and knowledge capture. Therefore, it cannot be assumed that the more BIM knowledge an organisation captures the greater the level of BIM maturity.

In terms of the transfer of BIM knowledge, section 8.4.7 found, that the BIM champion (29%) was once again identified as taking on the responsibility for sharing good practice, with peer tutoring (15%), internal CPD events (13%) and regular team briefings (13%) all playing an important role. A cause for concern here is that 20% of those surveyed did not share BIM knowledge as an organisation, which could be due to the fact that organisations do not encourage individuals to share BIM good practice. Hypotheses 5.2 tested the relationship between BIM maturity and BIM concluding that there is a significant negative relationship between BIM maturity level and knowledge transfer. Therefore, it can be assumed that as more organisations transfer BIM knowledge and adopt more collective and inclusive methods of knowledge transfer, i.e. team briefings, peer tutoring, and CPD events, then BIM maturity will rise.

Finally, section 8.4.7 found, that what was reviewed and evaluated on BIM projects was: time spent on projects (ranked 1), mistakes and discrepancies (ranked 2) and final profit on work (ranked 3). Surprisingly the level of waste generated, was ranked 9, out of 9. These findings identify that the QS organisation is interested to record and review the efficiencies that BIM has created in relation to the service it provides, particularly as it impacts on time and profit and ultimately the competiveness of the organisation in offering a BIM service. Hypotheses 5.3 tested the relationship between BIM maturity and the review of BIM knowledge and concluded that there is a statistically significant negative relationship between BIM maturity level and knowledge review. It can therefore be assumed at the lower level of BIM maturity, the more likely an organisation is to consider efficiencies of service, and, as the BIM Maturity increases, it will start to review the benefits of BIM in terms of levels of waste and coordination with other stakeholders.

8.4.8. Organisational characteristics and the learning organisation

Section 3.3 and 8.4.7 have proven the importance of knowledge management to BIM maturity levels, but how does the organisation create an environment that is conducive to learning? A learning organisation is characterised by total employee involvement in a process of collaboratively accountable change directed towards shared values or principles (Watkins and Marsick 1992). It is essential therefore, that the QS individual must identify with the benefits of BIM and that these, as previously discussed in section 5.6, must be fully aligned with those of the organisation. That then begs the question, what does the QS organisation need to do in order to create a supportive learning environment capable of creating a shared BIM vison and values? Non bureaucratic with decentralised decision making structures, empowered employees and open lines of communication are characteristics typical of an effective learning organisation (Goh,2001). A flexible, flat, less hierarchical structure is less prone to leach knowledge (Davis,2007).

Section 7.4.1 confirmed, (60%) that the QS organisation is a supportive environment conducive to learning and that it typifies many of the characteristics of a positive learning environment, being more likely than not, to operate a decentralised decision making structure (40%), empower its employees (51%) and have open lines of communication (71%). In addition, the results found that the QS organisation demonstrates a positive attitude to innovation (69%), motivation of staff (60%) and team working (69%), thereby demonstrating the characteristics of an organisation capable of change. But how do these characteristics align with shared values? Section 7.5.3.1 discussed hypothesis 6.1 which tested the relationship between organisational characteristics and the benefits of BIM to the QS role. Concluding that there is a statistically positive significant relationship between organisational characteristics and benefits to the QS role. Therefore, it can be assumed that as the organisational characteristics change for the positive, it will have a positive impact on the perception of the benefits of BIM to the QS. It can be further assumed that QS organisations are typical learning organisations that support the capture, transfer, and review of knowledge.

This framework is based upon the 6 positive organisational characteristics as identified in this research:

- decentralised decision making
- open communication
- positive innovation
- supportive learning environment
- empowerment of employees

- flat structure.

But what about individual BIM learning? How can the organisation support this? Section 7.4.6 found, the QS BIM learning was individually driven as opposed to organisationally driven, with learning by doing (ranked 1) and personal reading (ranked 2), whilst attendance at internal BIM CPD events (ranked 9) and learning by following organisation best practice, (ranked 10). It can be assumed then that the organisation is not sharing its vision of BIM with the QS by offering collective learning opportunities within the organisation and would further explain why there is a negative correlation between benefits of BIM to the QS and to the organisation, as discussed previously in section 8.3. Is there a relationship between organisational characteristics and individual learning, in order that this vision might become united? Hypothesis 6.2, section 7.5.3.1, concluded that there is a statistically positive significant relationship between organisational characteristics and individual learning. Therefore, it can be assumed that as the organisation becomes less bureaucratic and demonstrates the characteristics typical of a learning organisation, then individual BIM learning will flourish, as the QS becomes empowered to learn and to share this learning with the organisation.

This framework is based upon the 3 drivers to BIM learning as identified by this research:

- Organisationally
- Individually
- Externally.

The organisation needs to lead the learning by the creation of knowledge management systems, which capture, review and transfer the BIM learning in order to create the vison of BIM that will appeal to both the QS and the organisation.

8.4.9. Organisational change and BIM impact

If an organisation does not demonstrate the characteristics essential to a supportive learning environment, then how can it change and how does that change impact on BIM? Section 7.4.4, found that the greatest change the QS organisation made as a consequence of BIM adoption was in relation to the technology aspect of BIM; software (ranked 1) and training (ranked 2). However, changes to information management and work processes were also ranked highly with both achieving joint 3 ranking. Least changes were made to structure ranked 12, professional indemnity ranked 13, and finally copyright ranked 14 out 14. As the majority of those surveyed previously identified their organisations as learning environments in section 8.4.8, then it would suggest that the structure supported this. However, the importance of organisational structure cannot be overlooked, section 3.4, as structure supports the flow of information in an organisation and hence influences the communication and interaction between organisation members, (Chen and Huang, 2007) and has been said to play an important role in determining learning processes (Fiol and Lyles, 1985; Dodgson,1993; Bapiji and Crosson,2004). Therefore, for those QS organisations that did not demonstrate a learning environment, structure must be one of the key characteristics to consider when implementing BIM.

How do these organisational changes support the QS? If BIM is being adopted to support them in their role, then what is the significance of organisational change on the impact to the QS? Section 7.5.4 ,concluded that there is a significant negative relationship between organisational change and QS impact, hypothesis H7.1. It can be assumed therefore, as changes are made to the organisational structure (ranked 12 out 14) then the impact that BIM will have on the QS role will increase and there can be even greater involvement in a collaborative project team environment (ranked 1 in QS impacts). This, in turn, can improve the performance of the QS organisation, a more collaborative organisation being a more profitable one (Lavoy, 2014).

Section 8.3 identified, the importance of the alignment of shared values between the QS and the organisation, but is there a relationship between organisational change and organisational impact? Hypothesis 7.2 concluded that there is a statistically significant positive relationship between organisational change and organisational impact. Therefore, it can be assumed as greater changes are made for example to the QS software, and training is provided to support that software, then it would follow that the roles in the organisation would become highly specialised. In contrast, changes to information management and work processes were identified as being significant in terms of organisational change (ranked joint 3). This hypothesis would also confirm that changes made to work processes would increase the formalisation and centralisation of the organisation, which according to Cameron et al, (1987) are characteristics of an organisation in decline. Once again there is a contradiction between the impact of BIM on the QS and the organisation, manifesting itself this time in relation to organisational change. This further supports the conclusions made in section 8.3 which suggests the necessity that both groups are convergent in their values in relation to BIM.

This would then impact on the criteria for adopting BIM which it would follow could impact on the changes made to the organisation. Hypothesis 7.3 concluded that there is a significant negative relationship between organisational change and criteria for BIM adoption. Therefore, it can be assumed as the organisation attempts to diversify its provision, the least ranked adoption criteria (11 out of 11), then the organisation would need to consider making further changes to its software and provide more training to its staff.

8.4.10. Resistance to change and BIM impact

Section 4.2 identified that BIM generates change (Watson,2010), but what if there is resistance to that change from within the organisation? Section 2.8.4 identified people as being one of the main inhibitors to change, identifying the conservatism of the people and the difficulties around changing the mind set (Smith, 2014). However, section 7.4.7 identified, that the underlying factor contributing to, the reluctance of staff to embrace new work flow practices, methodologies or technologies is that they are unaware. The QS is unaware of both the benefits to their role and of the software's available. Therefore, if the QS is conscious of the benefits and the available software, and once again this supports the idea that a better understanding of the value of BIM is fundamental to maturity and, hence, success, it would follow that they would be more receptive to organisational change.

Hypothesis 8.1 concluded that there is a statistically significant positive relationship between resistance to change, and impact on the QS role. Therefore, supporting the claim that the more aware QS staff are of the impact of BIM on their role, the less resistance they will have to the change required, to implement BIM within the organisation.

Does the same therefore apply to the organisation? Hypothesis 8.2 concluded that there is a statistically significant negative relationship between resistance to change and benefits to the organisation. Therefore, as there is an increase in resistance to change, there will be a decrease in benefits to the organisation, and there is less opportunity for the QS organisation to gain global competitive advantage as a consequence of BIM adoption.

If people play a significant role in resisting organisational change what influence do the barriers to the adoption of BIM have on resistance? Hypothesis 8.3, concluded that there is a statistically significant negative relationship between resistance to change and barriers to adoption. Section 7.3.6 identified, fear of the extinction of the QS role as being the least barrier to the organisation, in terms of BIM adoption. The results of this hypothesis confirm that an increase in positive leadership would have a posistive effect on the QS perception of growth and survival. The importance of leadership cannot be ignored as much of the literature identified effective leadership as fundamental to organisational survival (De Smet et al, 2007). This framework is based upon 2 factors of change management as identified in this research: Changes required by the organisation and resistors to change.

Changes required by the organisation consists of 8 factors:

- Technology
- Training
- Information management
- Policies and protocols
- Staffing
- Performance management
- Fees and contracts.

The resistors are founded on raising awareness, inadequacy and reluctance in relation to the following factors:

- Benefits of BIM
- Technology
- Knowledge management
- Decision making
- Processes
- Leadership.

8.5. Validation of framework

The validation of this framework contributes further, to objective 5 of this research. A focus group consisting of 4 participants, whose profile and experience are detailed in section 5.8.8.3, was used to validate the framework. All of the participants had been involved in either the exploratory interviews or completed the questionnaire and as such were familiar with the objectives of the research. The benefits of familiarity being seen to be more important to this study, than any bias that might occur, as a result of their involvement.

The developed framework illustrated in Section 5.15, including the component details, was emailed to the participants the day before the focus group met. This was to allow the participants to gain an insight into the information and allow them to prepare any questions they may have ahead of the skyped focus group meeting. Once all 4 participants joined the Skype meeting via the link provided, the framework was verbally presented. The presentation of the framework was deemed important in order to enhance the participants understanding, resulting in the framework being presented, from the top, with maturity first, and then from the bottom up, starting with definition and working through each component in turn. The presentation took approximately 15 minutes and provided the participants with an outline of each component, detailing the factors of each and their relationship with one another.

Following this, the participants were asked to consider the validity of each component and then the framework as a whole. The data was recorded, transcribed and thematically analysed in order to present the findings. The overall response was positive and all participants agreed that the developed framework with its components and factors was valid. The responses of the participants to each component is outlined below.

8.5.1. Validation of the components

Maturity: all participants agreed that BIM Level 2 was the level against which to measure performance and that it was a necessary minimum level to support organisational growth and add value. One participant commented “No choice in the matter, by default we are being dragged to Level 2” another agreed claiming “40-60% of our work is publically funded, so no choice”.

Definition: All participants agreed with the range of definitions, one participant commented “for our organisation it is early days and for us BIM is about the software and the technology” whilst another claimed “people were slow on the uptake of BIM because they didn’t know what it was”. 3 participants agreed that their understanding, which informed their definition of BIM, has changed over time. They identified that initially BIM meant changes to technology, but more recently it has been about process, therefore, influencing them in terms of definition. They found themselves aligning with the definition of BIM in terms of a complex phenomenon, evolving over time.

Barriers: All participants agreed with the barriers presented. One participants, however, argued that “we should not focus on the barriers, look at the changing attitudes. Barriers can be overcome by looking at the benefits” However, another argued that “the benefits are known; it is the barriers that prevent adoption,” a view supported by another participant “people acknowledge the benefits, but at the initial stage when you are introducing new software, it is the staff on the ground, the time, that is an issue”

Benefits: All participants agreed with the benefits presented. One participant claimed “if you understand the benefits it will drive BIM through the organisation”, whilst one participant argued “we can be blinded by the barriers and don’t want to see the benefits as individuals. Organisations consider the bigger picture.” Another participant claimed “scepticism prevent careful consideration of the benefits”, the participants identifying more with the barriers than the benefits, yet finally agreeing that benefits need to be within the framework or else “why else would you adopt?”

BIM adoption: The stage of adoption, all participants agreed, should be at Stage 3 when there “is sufficient information to warrant the investment” or claimed another, “Stage 1 for optioneering”. One participant argued it was more do with “whenever there is a credible model from the client brief”. All disagreed with the adoption beyond stage 4 claiming it was not viable, despite the claims that it would benefit facilities management.

Business planning: all of the participants agreed that the organisation should undertake a business audit and prepare a business plan, but expressed concern as to the level of detail provided for this component, citing the shortage of people and skills as critical to the plan. They believed that this component was particularly important as traditionally “BIM is about finding our feet. We don’t know what we need until we are asked for something. Initially we were software focussed, but now it’s about process and information and knowing what we need in order to do this” Another claimed “we are reactive, we have no plan”, whilst another participant claimed “maybe the organisation has a plan and I just don’t know it”.

Organisational characteristics: The participants agreed with the characteristics as being appropriate for BIM delivery, although one participant warned “it is not just the characteristics, it is more to do with the organisational values of the business.” Recognising the importance of values and culture on the organisation.

Organisational learning: all of the participants agreed with the drivers for organisational learning. They agreed that the organisation should do more in this respect and that it was currently left to individual “BM champions” or “me a senior partner playing with technology, whilst still doing my day job. I need to pass on my lessons learnt, but I’m not sure anyone wants to listen.” Recognising the importance of lifelong learning culture within organisations. All participants agreed with the idea of knowledge management being key to BIM learning, and questioned why it had not been included in the list.

Change management: The participants in general agreed with the factors that may require change by the organisation although one participant claimed “I can’t see fees changing and contracts well it won’t be until Level 3 that we see contracts change”. Two of the four participants confirmed that some parts of their business had changed as a consequence of BIM, particularly in relation to process and technology. The resistors to change were also well received, although all 4 participants believed people should be included as resistors, as fundamentally, it is people who resist change not organisations.

External Factors: This was not a component included in this research as it was outside of the scope of this investigation, the participants were confused by its inclusion and asked for the word “factor” be amended to “influences”

Arrows and lines: on conclusion of the presentation one participant identified that, as explained in the presentation, the relationship between definition and maturity moves in both directions although the arrow only moved in one.

8.5.2. Feedback on practical implementation of the framework

The participants were asked to consider what their views were in relation to the practical implementation of the framework. All participants agreed that it was suitable for practice, but that its application was more to do with creating awareness and discussion as to the potential impact of BIM on the QS organisation. All participants agreed with the CSF’s although one participant would like external influences (factors) to be considered in further detail. Two participants identified the framework as highlighting the key factors to value creation and claimed it would help you “get your house in order”. All participants identified the framework as an enabler for organisations to construct a plan to support them in their BIM journey to Level 2 and beyond. The participants commented that the framework had raised their awareness of the importance of definition and its influence and implication for successful BIM adoption and implementation. Furthermore, the implication of organisational learning as being critical to BIM maturity was identified as potentially influencing QS organisations to put systems in place to capture, store, and transfer BIM knowledge. It was concluded that the framework provides a stimulus for the QS organisation to begin to make changes and therefore, has practical implications.

The modified validated framework is presented in the next section.

8.5.3. Revised and validated framework

The original framework has been revised as per the suggestions of the focus group. As illustrated in figure 8.2, “External Factors” have been amended to “External Influences” for clarity and the arrows between BIM maturity and BIM definition are now two way representing the two-way relationship between the components.

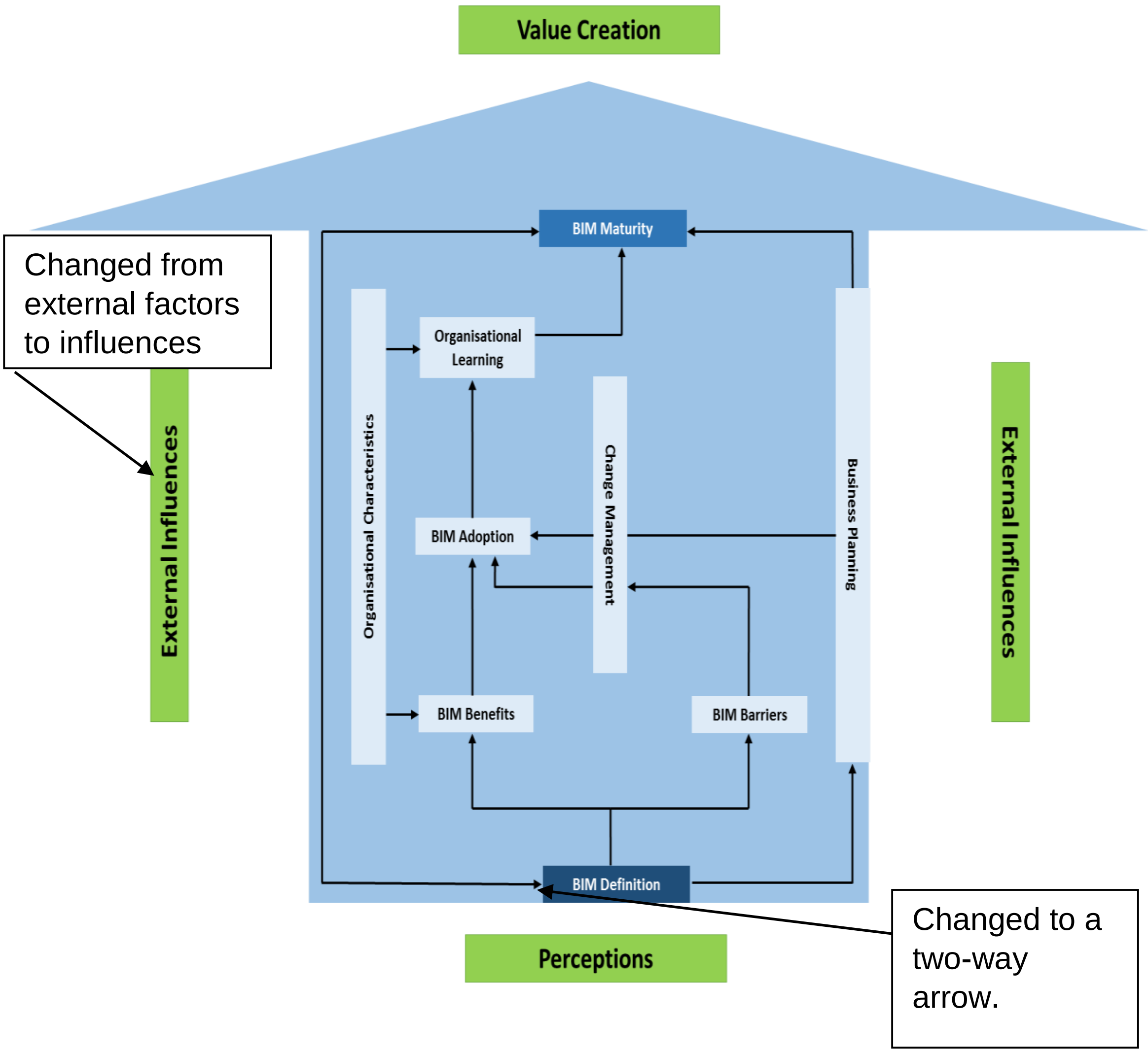


Figure 8-2 The revised and validated structure of the framework for the survival of the QS organisation in a BIM enabled era

BIM benefits: The participants argued that adoption was influenced more by the barriers than the benefits, inferring that they should not be included in the framework. However, as benefits are linked to definition, as identified by the research, and also have a relationship with BIM adoption and change management, this research has not removed benefits from the framework.

Business Planning: The participants identified a need for clarification and detail with respect to this component. The composition of this component has been identified as business audit, leadership and planning in order to avoid confusion. In addition, the participants expressed concern that people and skills were not identified alongside workload.

Organisational learning: The participants identified the importance of knowledge management and asked for its inclusion. This was accepted as being critical to the understanding of this and was included as a header to the drivers as it had been previously identified in the analysis as being key to organisational learning.

Change management: The participants identified people as being critical to resistance. This research has identified people as being one of the major contributors to the successful or otherwise, implementation of BIM and hence a decision was taken to include people in change management.

The original CSF's of the framework have been revised as per the suggestions of the focus group, and as agreed by the researcher, and is illustrated in Table 8.5. The changes made are shown in bold.

Table 8-5 The revised and validated CSF's of the framework

Component	Factors	
BIM maturity	Level 2	
BIM definition	Information Collaboration Technology Process Multi-dimensional	
BIM benefits	High level themes: Quantification and Measurement Productivity Decision making Quality Low level themes: Visualisation, Collaboration, Communication, Efficiency, Accuracy, Change management, Processes, Diversification of services (includes whole life costing) Competitive advantage (includes sustainable and global).	
BIM barriers	People Cost Demand Knowledge	
BIM adoption	Criteria for the adoption: Market External policy Performance Technology Innovation Processes Diversification.	Stage of Adoption: Stage 0 – client brief Stage 1 – feasibility Stage 2 - concept design Stage 3 - detailed design Stage 4 - technical design
Business planning	**Comprises business audit, leadership and planning: (This was added as a sub heading)** **People and skills(This was added as a factor)** Maturity Level Leadership Workload	
Organisational characteristics	Decentralised decision making Open communication, Positive innovation, Supportive learning environment, Empowerment of employees Flexible structure.	
Organisational learning	**Knowledge management: (This was added as a sub heading)** Organisation driven Individually driven Externally driven	
Change management	Changes required by the organisation: Technology Training Information management Policies and protocols Staffing Performance management Fees and contracts.	**The resistor is people and their influence on**: Benefits of BIM Technology Knowledge management Decision making Processes Leadership.

8.6. Guidance notes to framework

The following guidance comments must be carefully considered by the QS organisation when it embarks on its BIM journey:

- BIM definition – ensure that the individual QS' and the organisation's perceptions around definition align.
- BIM benefits – understand the benefits specific to the QS and to the organisation and where possible, align the two.
- BIM barriers – work with the barriers and understand them but also recognise the importance of the benefits of BIM as it is the lack of understanding of the benefits that could ultimately constitute a barrier.
- Business planning - undertake a business audit of the current organisation position, undertake a strategic plan of where the organisation wants to be with BIM and identify the resources required to achieve this. The organisation needs to identify the current capacity and capability of the organisation in terms of BIM, and manage the resources of the organisation, in order to achieve the aligned BIM vision of both the QS and the organisation.
- Organisational characteristics – create organisations that are flexible in structure and decentralised, with clear open lines of communication and that positively promote innovation.
- Change management – identify the changes required to implement BIM, make the staff aware of these changes and provide them with the knowledge they need to make effective changes to their way of working. The organisation needs to adopt a change management programme and the associated aspects of vison, communication, leadership, style etc. Consideration must also be given to people. People are key to resisting change and their influence of cannot be underestimated in relation to the benefits of BIM, technology, knowledge management, decision making, processes and leadership.
- BIM adoption – identify the criteria for adopting BIM and align with the perceived benefits, the stage that BIM is to be adopted by the organisation, and the projects that are suitable for BIM adoption.

- Organisational learning – create strong organisational BIM leadership, create a supportive BIM learning environment, manage BIM knowledge and put systems in place to capture, record and manage BIM knowledge.
- BIM maturity – Level 2 BIM maturity should be set as the initial objective of the QS organisation and recognition given to the critical success factors essential to allow a positive response by the QS organisation to the challenges set by BIM – enabled construction.

8.7. Chapter Summary

This chapter has presented the discussion of the findings of the research in order to develop a framework for value creation of the QS processes and services, in response to the challenges set by BIM - enabled construction. The findings of the exploratory interviews and the survey as presented and analysed in Chapters 5 and 6, have been combined with the associated literature in Chapters 2 ,3 and 4, in order to develop this framework. The research identified the foundation of the framework to be BIM Definition whilst the measure of survival was identified as BIM Maturity. This chapter discussed the development of a total of 9 components which are contained within the framework.

The proposed framework has been validated via a focus group and has been identified as being of practical significance, albeit with some limitations. The presented validated framework enables QS organisations to “get their house in order” and supports them towards Level 2 maturity and beyond. Finally, this chapter has recorded the achievement of objective 5 of this research.

9. Conclusions and recommendations

9.1. Introduction

This chapter presents the overall conclusions of this research which include: a reiteration of how the aims and objectives were achieved by highlighting the significant findings, the contribution to knowledge and research limitations and recommendations for further work.

9.2. Achievement of research aim and objectives

The overall research aim of this study is to develop a framework for the QS organisation that will support value creation when adopting and implementing BIM. Research objectives were outlined in section 1.4 of chapter one in order to achieve the research aim. There were 5 objectives that were achieved and the methods used to achieve them are identified in Table 9.1. This section provides an outline of the processes that were followed to establish the achievement of the research aim and objectives.

Table 9-1 Methods for achieving research objectives

Research aim: is to develop a framework for the survival of the Quantity Surveying organisation to respond to the challenges set by Building Information Modelling (BIM) - Enabled Construction.			
Research objectives	Method of achievement	Related chapters in thesis	Summary
1.To assimilate the existing literature and theories on BIM implementation and organisational development to provide a comprehensive academic basis for the framework of value creation through BIM.	Review of literature.	Chapters 2, 3 and 4	Chapter two and three presented a comprehensive review of the literature identifying the current knowledge base focussing on the QS, BIM and organisational theories including change management It identified the gap in the knowledge that inspires this investigation to consider the opportunities offered by BIM that can create value to the QS organisation.
2.To establish the critical success factors of BIM to the QS that will identify the opportunities and challenges to the quantity surveying organisation when adopting and implementing BIM.	Review of literature, exploratory interviews by expert sampling with 8 construction practitioners and analysis of the findings of the questionnaire.	Chapters 3, 4, 6 and 7	The analysis of the findings of the data collected identified 9 CSF's: BIM maturity BIM definition BIM benefits BIM barriers BIM adoption Business planning Organisational characteristics Organisational learning Change management
3. To determine the implication of organisation BIM learning in creating and adding value to the quantity surveying organisation.	Exploratory interviews by expert sampling with 8 construction practitioners and analysis of the findings of the questionnaire.	Chapters 3,6 and 7	The analysis of the findings of the data collected identified that organisational learning was dependent upon 6 supportive organisational characteristics: decentralised decision making open communication, positive innovation, supportive learning environment empowerment of employees Flat structure. In addition, the research identified 3 drivers for learning as related to knowledge management: Organisationally Individually Externally
4. To determine the organisational changes needed to accommodate BIM in a quantity surveying organisation to support the value proposition of BIM.	Review of literature and analysis of the findings of the questionnaire.	Chapters 3,6 and 7	The research identified that organisational change needed to be considered alongside resistors to change. Identifying changes required to implement BIM in the areas of: Technology Training Information management Policies and protocols Staffing Performance management Fees and contracts. In addition, it identified the resistors to change as being people centric in terms of: Benefits of BIM Technology Knowledge management Decision making Processes Leadership.
5. To develop and validate a framework of value creation for a quantity surveying organisation when adopting and implementing BIM.	Back-and-forth iteration between literature comparison analysis and empirical observations of the exploratory studies.	Chapters 4,6, 7 and 8.	Detailed analysis of the findings and their relationships facilitated the development of the framework. 9 CSF's factors were adopted to construct the framework. Definition being the foundation and starting point of the framework, culminating in Maturity as the ultimate objective.

Objective one: To assimilate the existing literature and theories on BIM implementation and organisational development to provide a comprehensive academic basis for the framework of value creation through BIM.

The first objective was achieved by reviewing the relevant literature which provided a detailed understanding of BIM and organisational development. It identified the challenge that the abundance of definitions of BIM presented to the implementation of BIM, which was confirmed by the main empirical study in Chapter 6 and 7, in that no consensus of definition could be concluded. BIM implementation was further considered, in relation to BIM frameworks which recognised the practical implications of BIM and identified stages of organisational adoption and implementation, illuminating maturity levels in terms of organisation development and BIM. The significance of an increase in BIM implementation maturity was found to require a greater change to the organisation’s business processes and workflow practices, which highlighted the importance of strategic planning in terms of current and future capabilities of the organisation.

The parallel innovation and evolutionary changes required of individuals, groups and organisations to achieve the optimum benefits of BIM was further reviewed in terms of organisational theories that considered the implications of structure and organisational learning. Furthermore, the literature identified the QS’s fear of extinction as a consequence of BIM implementation and considered theories that would support the growth and survival of organisations under threat by new innovations. The threat to the QS however was further not confirmed in this research as the findings in Chapters 6 and 7 offered consistent justification for the survival of the QS role. Chapter 7 concluded that a relationship was statistically found to exist between BIM definition, BIM benefits and BIM maturity. Finally, the achievement of the first objective provides evidence that the QS will survive and provides the theoretical foundation to achieve the research aim of developing the framework for value creation.

Objective two: To establish the critical success factors of BIM to the QS that will identify the opportunities and challenges to the quantity surveying organisation when adopting and implementing BIM.

The second objective was achieved by conducting a three stage pragmatic research study as identified in section 5.7. The first stage reviewed the literature, the second stage of the strategy consisted of an exploratory study of 8 selected BIM experts in order to gain an initial understanding of their expectations of the consequences of BIM to the role of the QS. This was followed by the third-stage, which consisted of a questionnaire, focusing on the impact of BIM on the QS and the QS organisation. The findings of the exploratory studies augment the findings of the third stage and, together with the review of the literature, provided a detailed understanding of the critical success factors of BIM implementation to the QS organisation. Furthermore, the construction industry, the need for change, the evolving role of the QS and the historical problems of the construction industry were outlined and the subsequent parallel transformation to the quantity surveying profession, and the functions it performed, were acknowledged. Government reports and strategies were reviewed and BIM was identified as a UK strategy to help improve performance and increase productivity in the construction industry.

The benefits and barriers of BIM to the construction industry stakeholders were considered and the ramifications for the value creation to the QS organisation recognised. The empirical studies in chapter 6 and 7 sought to clarify and extend the critical success factors of BIM to the quantity surveying organisation and revealed the divergence between the perceptions of the QS and the organisation, and augmented triangulation for this objective of the research. Through rigorous analysis, 7 other factors in addition to benefits and barriers were identified as contributing to critical success, and their relationships tested to demonstrate the inter relationship between each. Chapter 7 concluded that a relationship was statistically found to exist between BIM benefits and BIM adoption. Finally, the necessity to align the two set of values was presented and justified in terms of the implication for BIM definition, BIM adoption and BIM maturity.

Objective three: To determine the implication of organisation BIM learning in creating and adding value to the quantity surveying organisation.

This objective was also achieved by conducting a three stage pragmatic research study. The first stage reviewed the literature, the second stage of the strategy consisted of exploratory interviews followed by the third stage, which consisted of a questionnaire focusing on the capture of information by the organisation in terms of “BIM lessons learnt”, individual BIM learning and the organisations role in developing that learning. The literature identified that the rate of learning can be linked to growth, organisation survival and value creation. It also confirmed the importance of the organisation to demonstrate the characteristics of those of a learning organisation. Chapters 6 and 7 explored the experiences of the participants in relation to knowledge management and organisation learning. Stage 2 and 3 confirmed the importance of organisational learning to value creation and identified the relationship between organisational learning and BIM maturity. Chapter 7 concluded that a relationship was statistically found to exist between BIM maturity and knowledge management. The queries developed during the literature review, and the emerging themes from the findings in Chapter 6 and Chapter 7, were decisive in augmenting triangulation in this research.

Objective four: To determine the organisational changes needed to accommodate BIM in a quantity surveying organisation to support the value proposition of BIM.

The fourth objective was achieved by reviewing the relevant literature as it pertained to organisational growth and survival, organisational change and resistance to change, which was confirmed by the main empirical study in Chapter 6 and 7. The emerging requisites for organisational growth were discussed in Chapter 3 and were tested in Chapters 6 and 7, culminating in the identification of survival/growth characteristics appertaining to the QS organisation when implementing BIM. The organisational change required to develop these characteristics were considered along with the resistors to change. Furthermore, the results of the findings provide a general overview of the issues associated with organisational change associated with BIM implementation. Chapter 7 concluded that a relationship was statistically found to exist between organisational characteristics and the learning organisation, and between organisational change and BIM impact on the QS role.

Objective five: 5. To develop and validate a framework of value creation for a quantity surveying organisation when adopting and implementing BIM.

This objective was achieved through the development of a framework that was developed to support the creation of value for a QS organisation in a BIM enabled era. The development of the framework is predominantly presented in Chapter 8 but the contribution towards its development can also be found in Chapters 4,6 and 7. The proposed framework emerged as a consequence of the abductive approach following reiteration moving back and forth between the theory and empirical study. Chapters 2 and 3 provided the theory to inform the interviews whilst the exploratory findings in Chapter 6, together with the theory from Chapters 2 and 3, informed the questionnaires. These findings together with the theory, justified the theory behind the framework.

Accordingly, the study developed a framework that had 9 Factors each with its own characteristics and attributes which included:

- BIM definition,
- BIM benefits,
- BIM barriers,
- Business planning,
- Organisational characteristics,

- Change management,
- BIM adoption,
- Organisational learning,
- BIM maturity.

Finally, the framework was validated by a focus group who identified the practicality in providing the QS organisation with a holistic overview of the factors to be considered when working in a BIM enabled environment. This holistic overview could facilitate their planning towards improving their BIM maturity.

9.3. The research question

Can the QS role survive, and, if so can the organisation respond to the challenges set by BIM- enabled construction and create value to its processes and services offered?

By adopting a mixed methods approach of interviews and surveys, the rigorous analysis and testing of data and the adoption of a focus group to validate the research, the answer to this question was found to be as follows:

The QS organisation will survive. Despite the predictions of the literature review both the exploratory interviews and the survey confirmed that the QS role will transform and evolve and hence the organisation that provides QS services will survive. The QS is resilient to change and with the opportunities that BIM presents the QS will develop and add value in new areas that will support the Construction 2025 strategy in the achievement of its targets to create efficiencies.

9.4. Conclusion of research

The following conclusions can be drawn from this study.

- The QS role will survive, as both the findings from the interviews and survey confirmed. The QS role will evolve and transform, as it has done historically, to reflect the opportunities that BIM presents.

- Presently the BIM maturity of the QS organisation is below the Government mandate, with the findings indicating, that approximately only a third of QS organisations are working at BIM Level 2.

- From the research findings it emerged that BIM definition is the starting point for value creation, and that the end point is, BIM maturity. BIM definition will change as BIM maturity changes.

- The importance of the perceptions of both the individual QS and that of the organisation, on the definition of BIM, cannot be underestimated. The research identified that the definition of BIM, had a great influence on people's perceptions, particularly in terms of the perceived benefits and barriers of BIM. Furthermore, perceptions that impacted on the definition, and consequently the perceived benefits and barriers of BIM implementation, was also found to impact on BIM maturity.

- The findings further indicated that the perceived benefits of BIM to the QS and the benefits of BIM to the organisation are incongruent, and, need to be aligned, if BIM implementation is to create value.

- Knowledge management was found to be an enabler of BIM innovation. The findings indicated that the sharing of experiences and best practice, being facilitated, by effective organisational learning.

- The research identified that organisational change needed to be considered alongside resistors to change, in order to create value with

BIM. In addition, it identified the resistors to change as being people centric.

- Finally, from the research findings 9 CSF’s emerged, that enabled the development of a framework that supported value creation from BIM implementation. These included: BIM maturity, BIM definition, BIM benefits, BIM barriers, BIM adoption, business planning, organisational characteristics, organisational learning and change management.

9.5. Contribution to knowledge

The contribution to knowledge is in two parts comprising theoretical and practical. This section presents each of these parts.

9.5.1. Theoretical contributions and propositions

The thesis has argued from a rational reductionist view point and applied reductionist tools and methods to the QS organisation when implementing BIM. The QS organisation was identified as a complex system, a reductionist approach to identifying the problem and the application of a system approach to assessment was decided as the best approach. The theoretical contributions of the research are presented below:

1. The findings of the thesis exposed the importance of BIM definition as the foundation upon which the organisation should seek to implement BIM. It was found to be of far more significance than most theorist purport, as the adoption process requires systemic transformation at all levels within the organisation, based on a unified vison. This stems from individual and organisational perceptions of BIM, which in turn go back to definition. A lesson from this theoretical perspective is that a rigid BIM definition will not support BIM maturity levels and that a fluid dynamic definition, flexible in purpose, is required to support the juxtaposed visons of the individual and the organisation. The

proposition derived from the research, which can inform further research in this is as follows:

As BIM definition evolves BIM maturity increases.

2. A contribution is also made through the analysis of the key findings and its implications to the existing theoretical underpinnings. It identified that the BIM barriers reported by the theorists are not the dominant barrier to implementation, but it is more to do with the lack of understanding of the benefits of BIM to the individual. The findings reveal that the implementation process of BIM is socially-constructed and dynamically-determined and, hence, how the QS organisation responds to BIM is greatly influenced by an understanding of the benefits of BIM. It is the lack of understanding that prohibits or restricts adoption, not the perceived barriers. The proposition derived from the research, which can inform further research in this is as follows:

   It is the lack of understanding and clarity of the benefits of BIM to the individual QS, that is the barrier to successful BIM implementation.

3. Finally, the findings of this thesis have demonstrated new evidence and insights and contributed to the current knowledge in the academic field of BIM implementation, with the development of the framework. This framework for value creation, has identified several new factors along with establishing their relationship, that organisations can consider when adopting and implementing BIM.

9.5.2. Practical contributions

This thesis has contributed to the understanding of BIM implementation within QS organisations and the critical success factors to be considered when working in a BIM - enabled environment. Despite the rapidly evolving research in BIM frameworks and the prediction of many construction industry observers of the extinction of the QS, there is limited analysis that considers the QS organisation, BIM implementation and value creation mechanisms. The practical contributions of the research are highlighted below.

1 The thesis has provided a framework that enables organisations to recognise the key critical success factors necessary to support BIM level maturity. The developed framework can be used as an essential tool to evaluate the impact of BIM on the organisation, and enables organisations to pursue change, that will focus on the realignment of holistic visions and values between the QS and the organisation itself.

2 It provides a clear understanding of BIM as a change process and provides support to QS organisations wishing to implement BIM. It does so by recognising the importance of definition in creating shared visons and values that will positively encourage engagement from individual QS's.

3 The thesis has identified the practical importance of the creation of a learning environment to support BIM maturity. It reinforces the importance to the QS organisation of establishing knowledge management systems, that are capable of delivering the unified vison of BIM to the organisation.

4 It is identified that it is the lack of understanding and clarity of the benefits of BIM to the individual QS that is the barrier to successful BIM implementation. Affirming to the QS organisation, that focus on the benefits of BIM will support value creation.

5 Other BIM stakeholders can utilise this contribution to knowledge, particularly as it pertains to people and perceptions, BIM definition, benefits and BIM maturity, knowledge management and organisational learning, change management and resistors to change. This research has identified that people and perceptions are centric to value creation and as such the presented framework can be used

generically across industry stakeholders when creating value through BIM.

6 Finally, the study provides a better understanding of the current prominence of BIM implementation in QS organisations based on their BIM maturity level, thus informing the government in terms of the status of its Level 2 mandate.

9.6. Research Limitations

The research started with an ambitious aim *to develop a framework for the QS organisation that will support value creation when adopting and implementing BIM,* despite the limited theoretical discussion in this field.

1 The study is focussed on the QS organisation, which includes the Consultant QS and the Contractors QS and therefore a generalised framework has been produced. The lack of differentiation between these two QS roles could be seen as an inherent weakness in this study and is perhaps best viewed as a platform for future research.

2 The developed framework was not validated and applied in a real case scenario, which would enable greater rationalisation of its components.

3 Another limitation is the embryonic nature of BIM itself. This study presents the current challenges to implementation confronting the QS, but, as BIM in part is technology, the rapid pace of change in this field could impact on the components and sub components of the framework, particularly at foundation level, definition.

4 In order to fully understand the critical success factors impacting value creation then consideration should be given to the external factors that impact on organisations when implementing BIM. Consideration of internal factors only could be seen as an inherent weakness in this

study and is perhaps best viewed as a platform for future research.

5 Finally, this research is UK focus and no direct comparisons have been made with the global environment, thus restricting the conclusions that can be taken from this study.

9.7. Future research direction

The construction industry is being encouraged to adopt BIM in order to improve performance and create efficiencies and, as such, knowledge about the impact of BIM, in terms of business growth, cannot be underestimated. More recently, the Farmers Report 2016, “Modernise or Die” warns about the threats to the construction industry if it fails to respond to modern methods of working. Hence this research considered value creation and BIM implementation by the QS organisation. The premise being that the QS organisation comprised both Consultants QS’s and Contractors QS’s, not withstanding, that each QS group were employed in different organisations. Future research could consider each group separately, and undertake a comparative case study to examine the different attitudes, if any, to the critical success factors within the framework. A comparative case study approach could be used to assess the difference in perceptions between the two groups, particularly as they relate to definition and benefits. It would also highlight the potential differences in terms of adoption and value creation between the two organisations.

The research suggested correlations existed amongst some of the identified components within the framework. These relationships need further investigation to identify their impact on value creation with the potential, of identify new relationships, that will support a further increase in value. There is potential to apply the framework beyond the QS organisation. Therefore, further investigation needs to consider how the proposed framework can be extended and applied to construction industry stakeholders when implementing BIM. Furthermore, the external influences on the framework were not given due consideration, as identified by the focus group, particularly as it relates to the environment, potential markets, finance, government policies and direction. Further research could consider the influence of external factors on the QS organisation when implementing BIM, and assess how influential they are, when compared to the internal factors.

Finally, this research has focussed on the UK market and a comparative analysis with a QS organisation from outside of the UK would enable the global implications of this research to be established.

9.8. Chapter Summary

This chapter has summarised the thesis and provided an overview of the achievement of its objectives, contributions to research knowledge, limitations and future research direction. This research has addressed the aim of the study, identified 9 critical success factors and proposed a framework for QS organisations to respond to the opportunities when working in a BIM enabled environment. Furthermore, it provided a contribution to knowledge that will support the QS organisation by creating an awareness for the need to understand the value of BIM and to align that value at macro and micro level within the QS organisation.

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APPENDIX 1

Ethics form
Examples of the participant information sheet and consent forms

Date received	Initials	LJMU REC Ref

Ethical Approval of Undergraduate, Postgraduate or Staff Research involving Human Participants or the Use of Personal Data

Where research involving human participants or databases of personal information is being conducted by a member of staff or student LJMU Research Ethics Committee (REC) considers and advises researchers on the ethical implications of their study.

No research must be started without full, unconditional ethical approval. There are a number of routes for obtaining ethical approval depending on the potential participants and type of study involved – please complete the checklists below to determine which is the most appropriate route for your research study.

A. Pedagogic Research

To find out if your study can be conducted under the University's Code of Practice for Pedagogic Research please answer the questions below.			
1.	Is the proposed study being undertaken by a member of LJMU staff?	Yes	
2.	Is the purpose of the study to evaluate the effectiveness of LJMU teaching and learning practices by identifying areas for improvement, piloting changes and improvements to current practices or helping students identify and work on areas for improvement in their own study practices?		No
3.	Will the study be explained to staff and students and their informed consent obtained?		No
4.	Will participants have the right to refuse to participate and to withdraw from the study?	Yes	
5.	Will the findings from the study be used **solely** for internal purposes? *e.g. there is no intention to publish or disseminate the findings in journal articles or external presentations*		No
If you have answered **Yes to all Qs1-4** your study may be eligible for consideration under the University's Code of Practice for Pedagogic Research. You should **not** complete this application form but seek further guidance at			

http://ljmu.ac.uk/RGSO/114123.htm or by contacting Sue Spiers s.spiers@ljmu.ac.uk.
If you have answered **No to any of Qs1-4** you should complete the checklists below to determine which route you should use to apply for ethical approval of your study.

B. National Research Ethics Service (NRES)

To find out if your study requires ethical approval through NRES answer the questions below.			
1.	Involve access to NHS patients or their data?		No
2.	Include adults who lack capacity to consent as research participants?		No
3.	Involve the collection and/or use of human tissue as defined by the Human Tissue Act 2004? **		No
If you have answered **Yes to any of Qs1-3** you should **not** complete this application form. You must seek approval for your study through the NHS National Research Ethics Service (NRES). For further information and details of how to apply to NRES can be found at http://www.nres.nhs.uk/ *Please note that once ethical approval has been received from NRES University staff or students* ***must*** *submit a completed LJMU Research Governance Proforma and provide LJMU REC with written evidence of full, unconditional ethical approval from NRES prior to commencing their research. On receiving confirmation of NRES ethical approval formal notification of LJMU REC approval will be issued via Chair's action.*			
If you have answered **No to all Qs1-3** you should complete the checklist below to determine whether your application is eligible for proportionate review or if a full review by the University's REC is required.			
** *Studies involving the use of human tissue from healthy volunteers which are taking place within the University's Research Institute for Sports and Exercise Sciences (RISES) can apply for approval through the University REC (for further information contact Sue Spiers – s.spiers@ljmu.ac.uk)*			

Research Mode

	Undergraduate – specify course
	Postgraduate
	MRes,
	MPhil,
x	PhD
	Prof Doc
	Other – please specify

	Postdoctoral
x	Staff project
	Other – please specify

Has this application previously been submitted to the University REC for review? – **/ No**

If yes please state the original REC Ref Number and

the date of the REC meeting at which it was last reviewed

Section A – The Applicant

A1a. Title of the Research

The impact of Building Information Modelling(BIM) – enabled construction on the Quantity Surveyor.

A2. Principal Investigator (PI) *(Note that the in the case of postgraduate or undergraduate research the student is designated the PI. For research undertaken by staff inclusive of postdoctoral researchers and research assistants the staff member conducting the research is designated the PI.)*

Title	*Mrs*	Forename	*Dianne*	Surname	*Marsh*

Post: Principal Lecturer

Department / School / Faculty: School of the Built Environment/Faculty of Technology and Environment

Email: d.marsh@ljmu.ac.uk Telephone: 01512312849

Relevant experience / Qualifications

ool Polytechnic	BSc (Hons) Quantity Surveying	2:2	1982
	Post Grad Certificate education		1995
N	Post Grad Diploma in Management	Distinction	1998

Principal Lecturer LJMU BSc/MSc Quantity Surveying Programme Leader 200 date

Senior Lecturer UCLAN BSc Quantity Surveying Programme Leader 2003 –2(

Development Manager Built Environment – St Helens College 1992- 2003

Sole proprietor QS Practice 1989- 2005

Managing Quantity Surveyor St Helens MBC 1987- 1989

Quantity Surveyor West Lancs Council 1984 – 1987

Quantity Surveyor Davis Langdon 1982- 1984

A3. Co-applicants *(including student supervisors)*

Co-applicant 1

Title	*Prof*	Forename	*David*	Surname	*Bryde*

Post	Professor in Project Management
Department / School / Faculty	School of the Built Environment/Faculty of Technology and Environment

Email	d.j.brydeh@ljmu.ac.uk	Telephone	01512312892

Relevant experience / Qualifications

Professor in the School of the Built Environment – working as a member of the quantity surveying programme team whose research includes BIM in relation to project management.

Co-applicant 2

Title		Forename		Surname	

Post	
Department / School / Faculty	

Email		Telephone	

Relevant experience / Qualifications

Where there are more than 2 co-applicants please append an additional page to your application containing the relevant details

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SECTION B – PROJECT DETAILS

B1. Proposed Date for Commencement of Participant Recruitment *(Please enter the date when you propose to start recruiting participants – note that no recruitment can take place without full, unconditional ethical approval)*

Start Date	**01.07.2013**

B2. Scientific Justification. State the background and why this is an important area for research *(Note this must be completed in language comprehensible to a lay person. Do not simply refer to the protocol. Maximum length – 1 side of A4)*

In an attempt to address many of the issues challenging the Construction Industry the UK Government have recently introduced the Government Construction Strategy (2011) that identifies BIM as a tool to help improve the performance of the construction industry, reduce waste and improve collaboration. BIM is a 3D model designed to encapsulate data to simulate the entire construction and lifecycle of the building. As well as showing the building form and construction, the model has the potential to display scheduling, quantities and costs, lifecycle maintenance, energy consumption alongside health and safety information. The introduction of BIM is set to challenge the way the quantity surveyor will work in the future. It is crucial that quantity surveyors integrate BIM within cost management, or risk marginalising themselves within construction projects. The quantity surveyor must extend and refine their knowledge and understanding to ensure that they possess the necessary skills to apply BIM in their roles.

The changes that BIM will undoubtedly bring to the industry and current work practices will be the subject of this research to establish the impact it will have on the role of the quantity surveyor and, the curriculum that underpins the education of the profession. Particular emphasis will be given to assessing the impact on the current duties of the quantity surveyor both pre and post-contract including: procurement advice, cost estimates, cost planning, value engineering, tender estimates, bills of quantities, whole life costing, budgetary control, valuations, financial reports, cash flow control and final account calculation.

B3. Give a summary of the purpose, design and methodology of the planned research

(Note this must be completed in language comprehensible to a lay person. Do not simply refer to the protocol. Maximum length – 1 side of A4)

This research will firstly examine BIM- enabled construction and evaluate the changes it is likely to bring to the construction industry. Consideration will then be given to the current role of the Quantity Surveyor and the implications that BIM will have on this role. This will then inform a re- evaluation of the RICS Quantity Surveying competencies that will then be used to propose a new educational framework for the curriculum of Quantity Surveying degrees in the UK. Finally this will be presented to a focus group to validate the findings.

The research methodology adopted is a pragmatist research philosophy to facilitate the linking of practice and theory using a mixed methods approach.

The first stage is to gather qualitative data by undertaking semi structured interviews with expert quantity surveyors in the industry that reflect both the contractors and the clients view point in relation to the role of the quantity surveyor.

The second stage is to gather quantitative data and produce a questionnaire that will be distributed over a large sample group representing once again both the contractors and the client's quantity surveyor. This will be used to validate and consolidate the data gathered in the first stage.

The third stage is to present the findings to a focus group of representatives from the School of the Built Environment which will include both the quantity surveying and construction management industrial liaison panels.

B4. State the principal research question

The aim of the research is to develop an educational framework which will provide Quantity Surveying graduates with the necessary knowledge and skills required to meet the requirements of BIM-enabled Construction.

To achieve this aim a number of supporting objectives have been developed, which are as follows:

- To examine BIM to assess the changes it will bring to the construction industry in the UK.
- To establish the barriers and enablers of BIM in the construction industry.
- To analyse the impact that BIM has on the current and future role of the quantity surveyor.
- To re-evaluate the RICS quantity surveying competencies and evaluate the impact of BIM on their status quo.
- To develop and validate a new educational framework for the curriculum of quantity surveying degrees in the UK.

B5a. Give details of the intervention(s) or procedure(s) which involve human participants *(including psychological or physical interventions, interviews, observations or questionnaires)*

Procedure	Number of participants	Numbers per individual participant	Avg. Time / Intervention / participant	Is this a novel procedure?
Eg Interview	*25*	*1*	*1 hour*	*No*
Interview	*15*	*1*	*1 hour*	*No*
Questionnaire	*150*	*1*	*10-15 mins*	*no*

To include additional interventions place your mouse cursor in the last cell of the final column and press the tab button on your keyboard. A new row will be created for the above table.

B5b. Where questionnaires are to be used have these previously been validated?

☐ **Yes** ☒ **No** ☐ **Not Applicable**

*If yes, state by whom and when. If no, you **must** append copies of the questionnaire to this application.*

B5c. Where interviews or focus groups (structured or semi-structured) are proposed you must append an outline of the questions you are going to ask your participants.

B6. Will individual or group interviews/questionnaires discuss any topics or issues that might be sensitive, embarrassing or upsetting or is it possible that criminal or other disclosures requiring action could take place during the study? (e.g during interviews or focus groups)

☐ **Yes** ☒ **No** ☐ **Not Applicable**

If yes give details of procedures in place to deal with these issues. Information given to participants should make it clear under what circumstances action may be taken

B7. Where will the intervention (s) take place?

☒ **LJMU premises** ☐ **NHS or other external organisations** ☒ **Public places**

B8. How will the findings of the research be disseminated? *(eg thesis, dissertation, peer-reviewed articles, conference presentations, reports)*

The findings will be distributed by thesis in addition to being presented at conferences and publications in journals.

The participants will also be provided with a copy of the findings after completion upon request.

SECTION C – THE PARTICIPANTS

C1a. Identify the participants for the study *(LJMU staff, LJMU students, members of the public, other please specify)*

Groups of Participants *(eg students, staff, managers, children, parents, members of public)*	**Number of participants from each group**
Interviews *Experts and professional in the construction industry*	*15*
Questionnaire *Experts and professional in the construction industry* *Particularly in the field of BIM and quantity surveying.*	*150*
Focus Group *The School of the Built Environment industrial liaison panels.*	*2*

C1b. How will the participants been selected, approached and recruited? If participants are to be approached by letter/email please append a copy of the letter/email. Please include details on how much time participants will have to decide if they want to take part.

The participants are known contacts of the researcher from current employers of students to past contacts made during their industrial experience.   *The participants for the questionnaire will be contacted by e – mail and for the interviews either via e mail, telephone or personally. The participants will be allowed one week to consider if they wish to participate.*

C2a. How was the number of participants decided? *(eg was a sample size calculation performed)*

The participants were determined by considering the known contacts of the researcher and subsequent networks available from these contacts. It was essential that both quantity surveyors representing both the contractor and the client were included alongside experts in the field of BIM.

It was calculated that around 500 questionnaires would be distributed amongst these contacts and it was assumed that a 30% return would be achieved. Resulting in the completion of 150 questionnaires.

For the interviews key experts in the field of BIM were considered to be essential to support the findings these were then added to key quantity surveying representatives from small to large sized quantity surveying practices representing the client's quantity surveyor to representatives of small to large contracting organisations representing the contractor's quantity surveyor. It is hoped to interview 5 from each of the groups.

C3a. Will any of the participants come from any of the following groups? (Please tick all that apply)

Please note that the Mental Capacity Act 2005 requires that all research involving participation of any adult who lacks the capacity to consent through learning difficulties, brain injury or mental health problems be reviewed by an ethics committee operating under the National Research Ethics Service (NRES). For further information please see

http://www.ljmu.ac.uk/RGSO/101579.htm

- [ ] Children under 16
- [ ] Adults with learning disabilities
- [ ] Adults with mental illness (if yes please specify type of illness below)

- [ ] Drug / Substance users
- [ ] Young offenders

☐	Those with a dependant relationship with the investigator
☐	Other vulnerable groups please specify

Justify their inclusion

C3b. If you are proposing to undertake a research study involving interaction with children do you have current, valid clearance from the Criminal Records Bureau (CRB)

☐ **Yes** ☒ **No** ☐ **Not Applicable**

C4a. What are the inclusion criteria? *(Please include information on how you will ensure that your participants will be informed of your inclusion criteria and how you will ensure that any specific inclusion criteria are met)*

Questionnaire- the participants must be experts in BIM and/or in the area of quantity surveying either in the client or contacting side.

The participants will be informed of the inclusion criteria at the beginning of the questionnaire. In the general information section they will be asked to provide information about their professional background to ensure that the inclusion criteria are met.

Interviews - The participants will be informed of the inclusion criteria at the beginning of the interview. As many of the interviews will be with ex industrial contacts, current construction employers and known BIM experts met via attendance at conferences and networking events there will be opportunity to check in advance by to check that the criteria are met.

C4b. What are the exclusion criteria? *(Please include information on how you will ensure that your participants will be informed of* *your exclusion criteria and how you will ensure that any specific exclusion criteria are met)*

Participants must meet the inclusion criteria. There are no exclusion criteria.

C5. Will any payments/rewards or out of pocket expenses be made to participants?

	Yes	**x**	**No**

If yes what or how much?

SECTION D – CONSENT

D1. Will informed consent be obtained from (please tick all that apply)

x	**The research participants?**
	The research participants' carers or guardians?
	Gatekeepers to the research participants?

(ie school authorities, treatment service providers)

D2. Will a signed record of consent be obtained? *Please note that were the study involves the administration of a questionnaire or survey a signed record of consent is not required for completion of the questionnaire as long as it is made clear in the information sheet that completion of the questionnaire is voluntary. Under these circumstances return of the completed questionnaire is taken as implied consent.*

In such cases the REC would expect a statement to be included at the start of the questionnaire where the respondent confirms that they have read the participant information sheet and are happy to complete the questionnaire.

Participation in any other interventions within the same study eg interviews, focus groups must be supported by obtaining appropriate written consent.

x	**Yes**		**No**	**x**	**Implied consent for questionnaire**

A Participant consent from for the interviews can be found in the appendices.

A statement concerning this matter is included in the sample list of questions for the questionnaires which can be found in the appendices.

D3. Will participants, and where applicable, carers, guardians or gatekeepers be provided with an information sheet regarding the nature, purpose, risks and benefits of the study?

x	**Yes**		**No**

A participant information sheet can be found in the appendices.

D4. Will participants be able to withhold consent or withdraw consent to the procedure?

x	**Yes**		**No**

If no please explain why not

SECTION E - RISKS AND BENEFITS (Where risks are identified an LJMU risk assessment form must be completed)

E1. Describe in detail any potential adverse effects, risks or hazards, including any discomfort, distress or inconvenience, of

involvement in the study for research participants. *Explain any risk management procedures which will be put in place.*

NONE

E2. Explain any potential benefits of the proposed intervention for individual participants.

NONE

E3. Describe in detail any potential adverse effects, risks or hazards (mild, moderate, high or severe) of involvement in the research for the researchers. *Explain any risk management procedures which will be put in place.*

NONE

SECTION F – DATA ACCESS AND STORAGE

F1.Personal Data Management

Will the study involve the collection and storage of personal, identifiable or sensitive information from participants? Please note that signed consent forms constitute personal data. *(eg names, addresses, telephone numbers, date of birth, full postcode, medical records, academic records)*

[x] **Yes** [ ] **No**

If yes please provide details of what personal information will be collected and stored

The names of the interviewees will be collected and stored on consent rms forms as detailed below.

Applicants should note that personal identifiable information or sensitive information relating to participants ***must not*** *be transferred in or out of the EEA without the explicit consent of participants. Such information must be handled with great care and only used in the way described in the written information you give your participants.*

You ***must*** *store any hard copies of personal date (eg printed data sheets, signed consent forms) in locked cupboards or filing cabinets and any electronic data containing personal information* ***must*** *be stored securely on LJMU password protected computers.*

Personal data ***must not*** *be stored on USB drives or other portable media or stored on home or personal computers.*

Where the use of verbatim quotes is proposed in future publications or presentations or it is intended that information is gathered using audio/visual recording devices explicit consent for this must be sought from participants.

F2. Will you share personal, identifiable data with other organisations outside of LJMU or with people outside of your research team? *(eg supervisor, co-applicants)*

	Yes	**x**	**No**		**Not Applicable**

yes please provide further details

F3. For how long will any personal, identifiable data collected during the study be stored?

Data will be stored for 5 years after completion of the PHD in accordance with the requirements.

Once you have completed the above application form please submit it electronically to either EthicsPR@ljmu.ac.uk for proportionate review or to researchethics@ljmu.ac.uk for full review by the University REC. *If possible please submit your application form and any additional supporting documentation as a single pdf file.*

Both you and you supervisor or school director must sign the signature page below, complete the checklist of documents sent electronically and send a paper copy of the following 2 pages only to the Research Ethics Administrator, Research Support Office, 4th Floor Kingsway House, Hatton Garden, Liverpool L3 2AJ.

Please ensure that you complete the summary project details below to ensure that your signature page can be associated with your electronic submission for approval.

Title of the Research Study

The impact of Building Information Modelling(BIM) – enabled construction on the Quantity Surveyor.

Principal Investigator (PI)

Title		Forename		Surname	
Title	*Mrs*	Forename	*Dianne*	Surname	*Marsh*

For RSO use only

Date received	Initials	LJMU REC Ref

DECLARATION OF THE PRINCIPAL INVESTIGATOR / SUPERVISOR / STUDENT

The information in this form is accurate to the best of my knowledge and belief and I take full responsibility for it.

I undertake to abide by the ethical principles underlying the Declaration of Helsinki and LJMU's REC regulations and guidelines together with the codes of practice laid down by any relevant professional or learned society.

If the research is approved I undertake to adhere to the approved study procedures and any conditions set out by the REC in giving its favourable opinion.

I undertake to seek an ethical opinion from LJMU REC before implementing substantial amendments to the approved study plan.

If, in the course of the administering any approved intervention, there are any serious adverse events, I understand that I am responsible for immediately stopping the intervention and alerting LJMU REC.

I am aware of my responsibility to comply with the requirements of the law and relevant guidelines relating to security and confidentiality of personal data.

I understand that any records/data may be subject to inspection for audit purposes if required in the future.

I understand that personal data about me as a researcher will be held by the University and this will be managed according to the principals of the Data Protection Act.

I understand that the information contained in this application, any supporting documentation and all correspondence with LJMU REC relating to the application will be subject to the provisions of the Freedom of Information Act. The information may be disclosed in response to requests made under the Act except where statutory exemptions apply.

I understand that all conditions apply to my co-applicants and other researchers involved in the study and that it is my responsibility that they abide by them.

Signature of Principal Investigator

Date

April 17 2013

Print Name

Dianne Marsh

Signature of Supervisor / School Director or nominee

Date

April 17 2013

Print Name

Professor David Bryde

CHECKLIST OF DOCUMENTS SUBMITTED ELECTRONICALLY (Please tick relevant boxes)

x	Ethics Application Form (MANDATORY)
x	Protocol (MANDATORY) see note below
	Copies of any recruitment/advertisement material e.g. letters, emails, posters etc.
x	Participant Information Sheet
	Carer Information Sheet
	Gatekeeper Information Sheet
x	Participant Consent Form
	Carer Consent Form
	Gatekeeper Consent Form
x	Non-validated questionnaires
x	List of interview questions
	Risk Assessment Form

☐	Other please specify

Research protocol

RESEARCH PROTOCOL (taken from RD9R)

Date	Activity
2011	**Phase 1: Preliminary work**
Sept	Enrolment
Nov – Dec	Formulation of main aims, establish specific objectives
2012	
Jan – Dec	Review of BIM and complementary literature
2013	
Jan - May	Compilation and submission of RD9R including research proposal
May	**Research Committee consideration of RD9R – request registration period to be backdated to September 2011**
May	**Submit for ethical approval**
	Phase 2: MPhil
June	Design interview questions
July – September	Undertake interviews with 6 BIM/QS experts
Oct - Nov	Analysis of data
Dec - Feb 2014	Write up transfer report, format, binding, review with supervisor
2014	
February	**Submission of transfer report**
	Phase 3: PhD work
April	Review and revision as necessary of main aims and specific objectives
May - Oct	Review of additional literature
Nov	Develop and pilot questionnaire
Dec	Online surveys go live to 500 BIM/QS professionals
2015	

Jan -Mar	Analyse data from questionnaires
April - August	Design interview questions and undertake supplementary interviews with a further 9 BIM/QS Experts
Sept - Nov	Analyse data from interviews
Oct - Dec	Develop framework
2016	**Phase 4: Thesis write up**
Jan - Feb	Validate with focus groups
Mar - Aug	Write up, format, binding, review with supervisor
Sept	Thesis submission & viva

Participation Information sheet

LIVERPOOL JOHN MOORES UNIVERSITY

PARTICIPATION INFORMATION SHEET

INTERVIEWS

Title of Project

The impact of Building Information Modelling(BIM) – enabled construction on the Quantity Surveyor.

Name of researcher and School/Faculty

Dianne Marsh

School of the Built Environment

Faculty of Technology and Environment

You are being invited to take part in a research study. Before you decide it is important that you understand why the research is being done and what it involves. Please take time to read the following information. Please ask if there is anything that is not clear or if you would like more information. Take time to decide if you want to take part or not.

1. What is the purpose of the study?

In an attempt to address many of the issues challenging the Construction Industry the UK Government have introduced the Government Construction Strategy (2011) in which BIM is identified as a tool to help improve the performance of the construction industry, reduce waste and improve collaboration. BIM is a 3D model designed to encapsulate data to simulate the entire construction and lifecycle of the building. The introduction of BIM is set to challenge the way the quantity surveyor will work in the future. The quantity surveyor must extend and refine their knowledge and understanding to ensure that they possess the necessary skills to apply BIM in the area of quantity surveying.

The changes that BIM will undoubtedly bring to the industry and current work practices will be the subject of this research to establish the impact it will have on the role of the quantity surveyor and, the curriculum that underpins the education of the profession. The aim of the research is to develop an educational framework which will provide Quantity Surveying graduates with the necessary knowledge and skills required to meet the requirements of BIM-enabled Construction.

2. Do I have to take part?

No. It is up to you to decide whether or not to take part. If you do you will be given this information sheet and asked to sign a consent form. You are still free to withdraw at any time and without giving a reason.

3. What will happen to me if I take part?

If you agree to take part in the interview you will be asked to sign a consent form. Afterwards you will be interviewed by the researcher for no longer than an hour. The interview will be audio recorded and afterwards typed written.

The findings of the interviews will be essential for the discussion and answer of the above mentioned research in the framework of a PHD dissertation.

All of the data will be treated with anonymity and confidentiality.

4. Are there any risks / benefits involved?

There are no risks for the participants of the survey.

The participants will have the benefit to obtain the results of the research after completion.

5. Will my taking part in the study be kept confidential?

You will be asked to sign a consent form. Transcripts from the interviews will be coded and made anonymous. The publication of direct quotes from the interviews will not be attributed to named individuals and their identities will be protected.

Therefore your participation will be kept strictly confidential and it will not be possible to identify any individual in future reports or publications.

Contact Details of Researcher

Dianne Marsh

School of the Built Environment

Faculty of Technology and Environment

Byrom Street Campus

Cherie Booth Building Room 204

Liverpool

L3 3AF

Telephone:0151 231 2849

E mail: d.marsh@ljmu.ac.uk

Please retain a copy of the participant information sheet with a copy of the signed consent form.

Interview consent form

LIVERPOOL JOHN MOORES UNIVERSITY

CONSENT FORM

The impact of Building Information Modelling(BIM) – enabled construction on the Quantity Surveyor.

Dianne Marsh

School of the Built Environment

Faculty of Technology and Environment

1. I confirm that I have read and understand the information provided for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily

2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving a reason and that this will not affect my legal rights.

3. I understand that any personal information collected during the study will be anonymised and remain confidential

4. I agree to take part in the above study

5. I understand that the interview/focus group will be audio / video recorded and I am happy to proceed

6. I understand that parts of our conversation may be used verbatim in future publications or presentations but that such quotes will be anonymised.

Name of Participant Date Signature

Name of Researcher Date
Signature

APPENDIX 2

Examples of the individual interview questions, sample transcript and questionnaire

Background:
Introduction to BIM

BIM is set to challenge the QS.

BIM definitions and implications for the QS and the organisation

BIM maturity Levels
My Research is proposing to develop a framework to support the QS organisation to respond positively to the challenges set by considering the critical success factors required when adopting BIM.

Questions

1. What is your job title, what are your main duties / areas of responsibility and how long have you been in this role?

2. What kind of projects are you usually involved in? Private or public? What sectors and typical contract values?

3. What would you describe as the main function of quantity surveyors within your organisation?

4. Has your organisation got a BIM strategy?

5. How would you describe or define BIM? Do you consider it as a model or process?

6. Is BIM used within your organisation for any purposes, if so what for?

7. Do quantity surveyors in your organisation use BIM to assist them in their role? If so how?

8. Have you experienced any advantages from using BIM on a project? If so please describe.

9. Do you think that the automated quantity and cost calculation would assist the quantity surveyor?

10. Do you think this could free up time for the quantity surveyor to concentrate on other services, such as value engineering?

11. Do you think that using the BIM model will enable faster, accurate life cycle cost calculations?

12. Do you think utilizing RFID barcode scanners remotely connected to the BIM model could feasibly facilitate post contractual valuations?

13. Can you think of any other benefits that BIM brings to the role of the quantity surveyor?

14. Have you experienced any barriers to using BIM on a project? If so please describe.

15. Do you expect young graduates to be BIM aware? If so, to what level?

16. Do you think the QS will survive the BIM revolution and why?

Sample interview transcript

TITLE

	Interviewee Voice 06
Interviewer	Dianne Marsh
Date	venue

DM: Hi it's me Adrian, sorry about that

A: oh that's ok, no problem at all

DM: oh brilliant. Right if I just give you a little bit of background about the research. Did you get the email that I sent this morning?

A: I did and I've bounced back the consent form to say that it was pretty much late in the day but it should be with you when you get back to your desk

DM: yeah no, there's no problem. Basically I'm head of Quantity Surveying and Liverpool John Moores

A: uh huh

DM: and what we're trying to do is to look at how the course is going to evolve as a result of BIM. You know whether or not we do need to change anything whether it be whole scale change of modules, whether we move away from giving students the knowledge and perhaps more a skill based qualification and that's basically the basic research we are hoping to undertake. We are speaking to initial eight QS practices to see what they think. Obviously you seem to be in the lead so you know we'll be listening to what you have to say with great interest and we're also speaking to eight contractors as well

A: right

DM: so that's

A: so you'll get quite a lot of interesting information from that as well

DM: yeah well hopefully because you know there's a variety of sources

A: Umm

DM: and you know you've seem to be ahead of the game whereas other people you know are still writing the BIM strategy and things so

A: that's good to hear because we put a huge amount of work in to it so its nice to get that confirmation back that we are doing something right as well

DM: oh yeah I mean everywhere you go its a, people are talking about the direction based upon Gould are going in so its, its positive for you but less positive for the rest of the industry if you know what I mean

A: right

DM: we need to get them up to your standard

A: well we've still got a long way to go ourselves I'm sure of that so

DM: yeah. Yeah well hopefully, what I'd like to do is ask you, there's roughly 17 questions here and in the past it has taken just on an hour but following up from the interview what I would like to do and I know you're extremely busy is to perhaps come and see you to see exactly what it is that you are doing with BIM. We're going to talk about it generally today

A: uh huh

DM: but if we can see some examples of what it is you're doing so that we can actually use those within the research as well. If that's ok

A: uh huh we'll try and set that up. Yeah out of my diary, and I always apologise for my diary, my diary is awful between now and roundabout November, December time would you believe

DM: yeah

A: so but certainly I will try my best to set something up

DM: yeah. Oh no that's great, that's no problem. Are there any questions you want to ask me before we make a start

A: I don't think so other than it would be useful, would it be possible to see some summary of the research once you've concluded it

DM: yeah

A: to help develop our, I'm always keen to get some external sort of benchmark and feedback in terms of areas that we might need to focus on to kind of continue to develop so it would be useful just to see what's come out of your research in general

DM: yeah no problem. What we are hoping to do is the aim is to have all the interviews completed by January to write it up by March/April time

A: great

DM: cos obviously you know you're waiting for people and people are busy so we've had to set our self this target of January. But yeah so soon as its complete we're publishing a paper and we'll give you all feedback. Ok

A: fantastic, thank you

DM: no probs ok. I've divided the questions in to five themes. Initially looking at the company and basically what you role is. Then looking at your understanding of what BIM is generally. Then looking at the benefits and barriers to BIM. Then I'll looking specifically at the role of the Quantity Surveyor or Commercial Manager if you are working for a contractor

A: Uh huh

DM: and then looking at the knowledge and skills that are required at graduate Quantity Surveyors. So that's the, that's the structure of the questions

A: ok

DM: so first of all if you don't mind can you just confirm your job title and what your main duties are, areas of responsibility and how long you've actually been in this role

A: well this particular role with this new title is very recent, so my title now is Head of BIM and Knowledge Management and that's been my title since the 1st July, so quite a short amount of time. But I've actually been responsible for BIM for roundabout probably 16 to 18 months. My title before that was Head of Knowledge Management but I kind of picked up bits of BIM within that and we just recognised that so much of my role now is BIM that we extended the title to include that and actually prior to the 1st July I was also HR Business Partner. So I was as I said about 3 years leading the business through quite a large process of transformation around our HR delivery

DM: yeah

A: so I'm not an HR practitioner by trade but I do a lot of change leadership activity and that was something that I picked up and lead for three years so I've handed that over now to a real HR person and I've now got 100% of my time to focus on BIM and Knowledge Management. So my responsibilities in terms of BIM are predominantly focused on the UK, most of my time is spent working with the UK business and its about really three strands of activity. One is building our internal capability. So making sure that all of our Quantity Surveyors, Project Managers, Building Surveyors understand what BIM is, have got access to the right training and support so that when a BIM opportunity comes along they are able to deliver that effectively. But also encouraging curiosity amongst them and encourage them to talk openly to partners on project teams and to clients because I am very conscious that we're we're in an early stage in BIM where we're very often just having that conversation can open up an opportunity to develop some ricer??? skills. So first of all its about developing an internal capability, secondly about raising our profile around BIM, partly from a Business Development point of view but also cos we recognise that by having profile people will come and talk to us and that creates a virtual circle where we increase our BIM capability through having those conversations. And then finally to look to the future. So we are doing quite a lot of research and activity in to thinking about what BIM means for our service delivery model, what BIM means for the markets we face and the projects we deliver and how we organise and deliver those projects. So within that we sponsor a four year engineering doctorate programme with the University of Reading for instance and we're about eight months in to that now, really exploring in depth, looking at the UK government strategy so looking at construction 2025 and what that means for our business and for our clients but also looking at the projects we are delivering and taking the learning out of that and trying to feed that back in to the business. And think about how, how we develop our service delivery and the way we kind of manage ourselves to make best use and hopefully realise the potential of BIM that's out there, that's I've been in the industry long enough to know that there can be great opportunities for change and transformation and they can slip through our fingers all too often so we're trying to make sure that we don't allow that to happen on this particular occasion. That's sort of kind of my BIM side in the UK and then what I do is I then work extensively across both the Faithful & Gould global business so in to China, Singapore, North America, the Middle East etc etc. And I've got a network that's quite rich already but increasingly I'm building in those areas to try and join up our BIM delivery and best practice and knowledge around our business and that is part of the Atkins group. I sit on the Atkins BIM global team and represent Faithful & Gould globally. And at that point we then look at group level, how we are setting up the group as a whole to deliver BIM effectively and consistently. You know facing lots of different national standards and national working practices and industry models in the different territories we operate around the globe. So that's the BIM stuff and in addition to that I've got Knowledge Management responsibilities which is looking at innovation and how we share best practice and knowledge and structure and all kind of things to make best use of knowledge both technical and kind of practice knowledge in general

DM: right if, you've talked a lot about BIM, did you start off your career as a Quantity Surveyor

A: no I'm not a Quantity Surveyor

DM: right

A: my, well my degree was in Geography

DM: right

A: and I then joined the industry probably about 17, 18 years ago and did a whole bunch of things. I worked as a health and safety assistant initially on a rail track project so I kind of worked in the rail environment and then moved through an IT role so I managed to start when we were just starting to put dusty old computers on construction sites so sort of vacuuming the circuit boards to keep them working. And then I moved from there in to Facilities Management. At one point I was managing a Helpdesk team and management information and looking after all the KPIs and issuing works to technicians, keeping one of the, it was one of the mobile phone operators we virtually maintained their networks around 9 or 10 thousand sites up and down the country. And provided hard FM to them and then I moved in to a role of Knowledge Manager and then Head of Knowledge Management at Taylor Woodrow and then about six years ago I left Taylor Woodrow to join Faithful & Gould as Head of Commercial Research. So bringing that kind of knowledge management background in

DM: yeah

A: but looking at looking at it that was the kind of connection in to the QS world

DM: right

A: because I was then looking at the cost data that we were developing you know cost database doesn't need anymore broadly in the business and looking how we can package that up and use it internally and externally to help deliver our services

DM: right I see. That makes sense now because some of the things you were saying I was thinking well where you came from, what was your background. But I can recognise now its more and IT background that you're using and developing your IT within the QS practice. Cos that's something that we'll obviously be looking at. Whether or not we, at the end of this research whether or not we need to introduce more IT in to the programmes on the QS degrees

A: I think it's partly IT but the reason why knowledgemanagement was always attractive to me was because it combined really 50/50 IT but also people and coaching

DM: yeah

A: and you know the three years I spent at HR business partners was very much around people and culture and organisational change, I guess that's why there's a natural extension in to BIM because BIM is very much about technology yes but even more so I'd suggest around people and project team culture and collaboration and the process of the project delivery

DM: yeah. I mean and that's true I mean we're trialling some collaborative projects with our first years in seven weeks time on a BIM model because for me its more about collaboration and process than it is about IT

A: yeah

DM: but that almost seems to be the summary of my research so I need to confirm that really by speaking to people. Obviously they need to be aware of the packages that are out there and to be able to demonstrate some skills initially

A: Yeah

DM: but that's what we're trialling and obviously that will be part of the research to see whether or not its actually worked

A: well certainly my introduction to BIM I worked on a European research project for three years, a project called MANIBUILD, it was a framework 6 project

DM: right

A: it was a big project, there was 23 partners across nine countries and we had partners from places like Finland at the time when the Finns were really getting onboard with them

DM: yeah

A: but my introduction to BIM, I probably worked with BIM as an information structure process for 12 to 18 months before I picked up a piece of software

DM: right

A: it was very much more around BIM as a set of protocols and BIM as a collaborative process rather than BIM as a 3D design tool

DM: yeah brilliant ok thanks for that. What kind of projects are you usually involved in in relation to BIM. You know typically is it public and private because we know there's the public drive obviously with the government but do you work on any private projects in relation to BIM and what sectors and typical value of projects are there

A: oh typical value there's probably. The frustration is that while we got quite a healthy number of BIM projects its still by no means the majority of the projects that we work on

DM: yeah

A: so if you're talking about typical values then it's very lumpy,we've got projects ranging from probably the two to three million pound mark up to perhaps one hundred and eighty, two hundred million in project value plus a couple of frameworks that we're working on as well where the overall size of the framework is quite considerable but the individual projects related our smaller

DM: yeah

A: when we're working with BIM. But we've got public sector work, you know the obvious example is Cookham Wood which I mentioned cos its one of the early trial projects

DM: yeah

A: and we were the PM there. So we were the employers agent. Also the education sector. So City College Plymouth for example we've been doing some work with them, Birmingham City University and in to the retail sector so they're slightly more difficult to talk about

DM: yeah

A: but we are working with a couple of the kind of the firms in the retail sector. So we've got projects across the public sector and the private sector, Education, Health, Retail, Industry and so quite a broad spread really

DM: do you find that the private sector are keen to take BIM onboard

A: there's a real mixture. There's a small number, well its a growing number but initially it was a small number but certainly a growing number of clients from the private sector who are now asking about our BIM capabilities as part of PTQs and so on

DM: yeah

A: so its slowly coming on. Part of the difficulty when we are talking about BIM is its a huge range of what people mean by BIM

DM: yeah

A: so sometimes we'll have a client come to us and say ok we want, tell us about your BIM capability and its all about has it been designed in REVIT. And there's other clients who are coming to us and saying well actually what we are interested in is something much broader than that.

So you know it is kind of, there isn't a bit, at the moment there isn't a consistent level of questioning from clients in fact what we find sometimes is the clients come to us with all kind of issue tender questions which almost demonstrate, well do demonstrate through the questions that are being asked that the person asking the question doesn't actually understand fully what BIM is or how it should be delivered. So they're sometimes asking for things that aren't appropriate or aren't the best measure of BIM capability which obviously when you know when we are involved in the tender process we can advise on but when we're the respondents to the tender its a little bit more difficult

DM: yeah yeah thanks for that. If we move on to BIM, how would you describe or define BIM, you know do you consider it more a model or a process

A: we kind of talk about it as being being technologies, so its a model, its a set of protocols and its also a process and its the kind of the culture and the dynamics of the project itself so we talk about it hopefully in its broader sense in terms of kind of an ethos for a project and a process and a set of information management protocols for the delivery of that project and having the technology that underpins that delivery

DM: ok alright, great thanks. Has your organisation got a BIM strategy

A: yes we've got, well it's at two levels. At a group level we've got a whole standards and protocols around delivering the project in BIM and then at a business level we've got a BIM strategy. In fact our BIM strategy is one of our strategic priorities for the business so its something that's reported back in to the board every month and also by myself on behalf of the board

DM: is it possible for me to have a copy of your BIM strategy please to compare it to others

A: yeah I can get something, obviously we would keep it confidential

DM: yeah

A: but I can get that to you

DM: no that's no problem it's just so I can do a comparison of BIM strategies in the organisations

A: yeah I can send something through on that

DM: oh fantastic thank you. How long have you had the BIM strategy, the project one specifically cos that's something that's new to me, a lot of people have business BIM strategies but not specific project strategies

A: so we've had, well our business BIM strategy in terms of making BIM a priority for the business

DM: yeah

A: is something that we put in place about, if I remember correctly about 18 months ago

DM: yeah

A: in terms of project BIM strategy, I don't know it depends on how you describe them

DM: yeah

A: we've got to set of project protocols and we've got a set of project guidance and so on and that's been in place for, well for our project managers it's been in place longer for our Quantity Surveyors for instance so

DM: right

A: let's say its our approach

DM: yeah

A: of working through our delivery disciplines and getting the house in order so anywhere from roundabout eight months ago through to roundabout now

DM: yeah

A: I terms of work in progress

DM: ok brilliant alright thanks for that. This question, you've almost answered. I want to know how extensively do you use BIM within our organisation and for what purposes. Obviously its Atkins now so its not just used by Quantity Surveyors presumably

A: that's right, at an Atkins level, at a group level BIM is used for all design. But again we are back in to the territory of you know REVIT being used for all design

DM: yeah

A: or in certain cases other software tools as well like Bentley but REVIT's the predominant tool

DM: yeah

A: and sometimes that's in conjunction with the collaborative process and sometimes its purely as a design tool. Again depending on the project and the client requirements. So you know we've got examples where we're just designing in 3D with object models through to some projects specifically where Faithful & Gould and the Atkins design teams are working together where we're approaching, I wouldn't say we are all the way to Level 3 with BIM yet but we're kind of go beyond Level 2 in terms of the richness of the sharing, you know single view of the model and so on. So it varies enormously. In terms of our UK Project Management and Quantity Surveying business we use we use BIM and we've got experience of working with BIM in an QS capacity, in a Project

Management, Building Surveying, to a certain extent in terms of Health and Safety and sort of CDM co-ordination and so on as well and some some experience working in terms of dateability consultancy in addition to that and also around well general kind of consultancy services. So we've got, I'd say pockets of

DM: yeah

A: experience in those areas, the predominant experience is in quantity surveying and project management and some in building surveying

DM: ok they're the key ones

A: yeah

DM: brilliant. What, well I think you've answered that one. What level of BIM is your organisation working at. You've said its not quite at Level 3 but beyond Level 2

A: oh I wouldn't say that on every project

DM: yeah

A: that Level 2 and a bit is very exceptional and really frustrated ???? across there there's already working at Level 3

DM: yes

A: or up or whatever you you know we're not. We work at the level of maturity that we can with the team and with the project and with the client. The majority is probably still not even Level 2

DM: right

A: because unless unless the design is in the right format, unless the rest of the project team is willing and able then we're very much working at you know in traditional construction so the model is presented to us as a 2D or we ask whether there's a BIM model available but if there's not then by default we're almost boxed straight back in to working pre BIM and that happens still very frequently. I terms of working at Level 2 we we can certainly do that, we've got the capability and we've got projects where we're delivering at that, the only times we've gone anywhere beyond that is where we are working with our colleagues as part of the group because that takes away the complexity of you know firewalls around information struct, you know kind of providing access to the model and it takes away any complexity around around the kind of the legal and the IT type considerations. And there's still a lot of work to do to solve those. So we know, we kind of I guess we'd rate ourselves somewhere on a scale of Level 1 for some stuff, Level 2 for other things and slightly about Level 2 very infrequently where the opportunity presents itself

DM: ok great thanks. If I move on to Benefits and Barriers now. What would you describe as the generic benefits of using BIM on projects

A: the biggest benefit that teams report back is, and I don't know whether this will continue to be the case as BIM becomes more widely adopted but certainly on the early BIM projects the project team as a whole and by that I mean the architect and the structural designer and the QS and everybody else who is involved talk to each other a lot more about how they're going to deliver the project

DM: yeah

A: and in terms of establishing that project culture and that team dynamic and understanding of how they are going to deliver the project that's a huge benefit that we see so its nothing to do with the technology and its probably nothing to do with BIM itself its just that because its something new and different perhaps than because its BIM we find that people talk to each other and set out the project better from the beginning and that tends to lead to better project outcomes. So there's that kind of softer benefit. From a QS prospective certainly the quantity take off is massively speeded up and you know and the accuracy provided the model is set up in the right way

DM: yeah

A: is is a huge benefit and the ability to rapidly generate revision and to work through optioneering and scenarios and so on is all there. So certainly in terms of just efficiency of process information there's a benefit. I think there's a benefit in terms of again from a QS prospective in particular of having an earlier involvement. Cos at that time as a QS we'd have an early involvement with a project but having an early involvement in terms of the ability to influence or talk about and also get access to the design and to have influence over that is a big benefit and I would say better co-ordination within the project, and there's a big caveat around that because what we find is that where the project has been set up well and where there's agreed structures and protocols around how the model would be developed then its considerably more efficient. Where something goes wrong with that then there are times when working with BIM can be less efficient because the model has to be reworked to get the information of the right format to be able to then you know take off quantities and work with the data so BIM doesn't guarantee greater efficiency, that only comes about either by good luck or by good planning and hopefully its what we put in the effort to make sure there's good planning in most cases

DM: yeah I mean we've seen that as being a key. We've just devised a house REVIT model, one of our architects are trying to set it up properly so that the QS can use it has been time consuming to say the least over summer. So I appreciate that

A: you know its around can our software handle it in terms of taking off information for the model, its not just a case of is it in the right format. You know we get DWFX files

DM: yeah

A: and yes we can read them but then we've had a huge number of situations where either elements of the model have been duplicated on the same co-ordinates so if you take off a quantity at double

DM: yeah

A: we've had situations where we've perhaps wanted to take the model and sent it for 3D printing and unless the model's been set up correctly with all the geometries properly aligned to do that then you need to do some work to the model to allow the printer to print it for instance. You know in terms of kind of taking that through to an FM situation then again the information's got to be structured properly in the model and available at the right sort of depth of information and level of detail to allow that to be done. And part of the challenge is that because its still quite new in terms of industry awareness and the standards are only just starting to come through that you've got to catch it very early and you've got to have a lot of clarity very early to make sure that everybody who's worked on the project is putting the right stuff in in the right format and the right structure at the right time to allow those outcomes to be achieved. And I think our industry isn't quite used to working it that way necessarily so its that's probably the steepest learning and you know if they've got a good question around barriers

DM: yeah

A: then that's a huge barrier be wherever there's either a gap in in in ability and understanding around working with those kind of structures, I mean we've got that within our own business as well. You know we're not a thousand strong people you know experts in the UK you know we've got different levels of understanding and capability and still despite a huge amount of effort that we put in to educating people you know we've still got people in the business who haven't yet worked on their first BIM project for example through to people who are working day in and day out on BIM projects and we are working hard to address that but we are still got gaps our capabilities so we are not critical of anybody else who finds themselves in that situation. But where you've got a lack of ability or a lack of willingness to kind of think ahead, plan ahead and work in that co-ordinated way then that's a huge barrier to achievement and you know another barrier is still the maturity of the software so still we you know we would like to be in the position where the software's driving innovation for us and at the moment rather than kind of helping us innovate at the moment its probably acting as a slight buffer and a drag in that we need to keep going off and working with our software vendors to ask them to develop new capability or fix bugs to allow us to deliver things that we want to be able to offer to our designs

DM: do you see people as being a barrier. You've talked about lack of willingness and you've talked earlier on about change management. Do you think this is going to be an issue

A: I think it will, at the moment we've kind of worked on that sort of gradually expanding you know kind of evolutionary approach in terms of seeking out opportunities to work with BIM and develop those opportunities as we try to deliver BIM and deliver it effectively but we are not yet at the point where for example in the public sector we're at a situation still where if a client wants to use BIM they can but if they don't want to they don't have to yet. When we get to 2016 we will suddenly find a lot of clients I think who potentially don't see the benefits, don't want to use BIM but are being mandated to by the governments BIM strategy

DM: yeah

A: and at that point I think that's kind of when people issues will come through and you know we're trying to do our bit for that, we're going out and running breakfast seminars and sort of half day conferences and publishing articles and talking to our clients in public and private sectors to try and help that process of selling the benefits of BIM and encouraging them to think what BIM might deliver for them but I'm quite sure when we reach 2016 in the public sector they'll still be some clients who don't see the value and therefore don't give it the lead that it needs and you know what we see and its the same old story with any kind of change and any kind of initiative in our industry where the client's behind it and passionately behind it, its a dream. Often quite a challenging dream but its a dream from the point of view you've got that backing but wherever you've got a client who isn't bought in to that particular way of working that's when the real challenge is going to come

DM: yeah ok thank you. If we can look now specifically at the role of the QS what would you describe as the main function of the QS's within your organisation

A: oh crikey that's an impossible to answer

DM: its a difficult one

A: you know the kind of the classic production of cost estimates or building quantity but build these days. But really I think particularly as we are moving through to a BIM environment that whole kind of measurement and take off becomes much less, I don't think for quite some time we're going to see a situation where we would just

A: and then that environment is then, its about bringing the, I guess the thought process and the understanding of the construction process and the understanding of the clients requirements and then be able to think about how the designs going to be able to achieve those outcomes and working with the project team to help deliver it on behalf of the clients that it becomes the mainstay of the QS I think will be delivering. And its less then about understanding the legal and contractual environment, its about understanding that having priority over the project roles. There's a bit of an information management role there in terms of understanding the model and how it needs to be structured whether that's owning the model or whether its just working as a you know stakeholder with a lot of influence around it that really makes them sure that the project that the client outcomes are achieved through the delivery of the BIM process. I think becomes much much more part of the QS's role. So I think its going to be quite an interesting evolution that, I don't quite know how its all going to fit together in terms of individual responsibilities at the moment because I think there's a lot of fluidity around that at the moment that certainly there's always going to be that strong role around quantification and around ownership of the accuracy of the model data from a cost prospective and there's always going to be a strong element in terms of the advice around procurement routes and advice around forms of contract in order to achieve the clients outcomes. I think there will be a much greater degree of this involvement in terms of thinking about the model or the model process as well and the jury's still out in terms of whether that role extends in to carbon quantification which I think it might

DM: yeah

A: and even in to the quantification of water you know so we talk about embodied carbon and operational carbon we're increasingly we'll I would say increasingly we're starting to see small examples of people talking about embodied water and operational water. It will be interesting to see how that one, its a much slower burn so I can see over the next three to five years carbon becoming much more part of the you know something that the QS quantifies that perhaps in the next five to fifteen years which is pretty broader now in terms you're looking at water now as well

DM: yeah well that's interesting cos a colleague of mine is meeting with somebody from Faithful & Gould in London to look at carbon quantification

A: oh who's that

DM: its Steve Finnegan he's meeting. I don't know your colleague's name, its Faithful & Gould London anyway, somebody who's interested in doing some research with him

A: Ok we've got, well Shaun Lockehead does that team and Shaun is just fantastic, he's got so much knowledge

DM: yeah

A: and a brilliant reputation in that area ?????a couple of lads for example they work on Shaun's team who's passionate about that so its a really fantastic team down there

DM: yeah. I know he's keen because we, that's an area that we're doing some research in to and Ste is looking at bringing that in to obviously the curriculum of our degree and that's something that after interview people I've been seeing that a lot of QS's see carbon quantification as being something that we're going to be heavily involved with in the future

A: yeah and I think certainly in terms of operational carbon its almost a proxy for energy costs

DM: yeah

A: so whether a clients bought in to it from a sustainability credentials point of view, and some are, or whether they have just bought in to it because they need to manage their energy costs

DM: yeah

A: in either case operational carbon becomes important point and everybody carbon I guess has got the strong sustainability angle to it but I think you know over time then that's going to become increasingly important as various protocols and you know standards come in to play that affect what their taking a BREAM credit so or whatever the structure becomes in the future

DM: I see. When you just talked about the QS's role, do Faithful & Gould have a basic job descriptions for different levels that QS's say, Assistant QS's, Senior QS etc

A: we do

DM: would I be able to have a copy of that please

A: yes again obviously you need to keep them confidential

DM: yeah

A: yeah we've got a set of role profiles so obviously each person has got their individual job description which relates to their kind of project role and we got a sort of development framework for the whole organisation which goes all the way from trainee through graduate and assistant up to Quantity Surveyor and Managing Quantity Surveying, Senior QS on it to Associate Director, Regional Director and Director so we've got a, and we get to map that experience on it and the qualifications and so on that we'd expect there and the contribution that we'd be looking for at all those different levels as well

DM: oh well that would be great. Everything that you give me is totally confidential you know obviously when its published it will have a list of full QS practices and give you the size of the practice etc but it won't name names who's doing what so you needn't worry about that

A: ok. Thing with that is there are real profile documents themselves

DM: yes please so if we look at those later on when we are actually looking at the curriculum it will help us to determine, I mean that's a second stage of the research to determine how we should move the curriculum to ensure its currency with what industry actually require of its QS's

A: another thing I need to say about those role profiles is and I've been heavily working on them over the last three years with my HR hat on

DM: yeah

A: and we published them about four years ago initially and that was part of the programme of sort to of employee engagement programme that we had at the time and then I've probably spent the last two years working with colleagues to refresh them and look at a line of competencies across all of our service delivery disciplines so making sure that the level for example in terms of management of staff is kind of consistent in terms of expectations between a Managing Building Surveyor, a Managing QS and qualification levels and so on

DM: yeah

A: the next step which is probably in the next eighteen months is to probably scrap them and start again

DM: yeah

A: in terms of understanding what BIM's going to mean for those roles

DM: yeah

A: cos they've been written before BIM was, well they were created before a BIM strategy was really in place and the last review was big enough in itself without introducing BIM in to that whole equation as well so they did all talk about BIM yes but I think the next refresh when we put some missing energy to do it

DM: yeah

A: will be quite a big rewrite from a BIM prospective

DM: yeah well that's interesting cos it actually ties in with what we're trying, we're thinking that you know the degree may need a total rewrite as a result of changes in industry

A: yeah

DM: so whilst I recognise the profiles, there all profiles maybe historic that a starting point cos there's one of the questions that I am going to be asking you in a minutes is you now where are we moving forward you've also in relation to QS you've talked about carbon but what, how do QSs feel that BIM is going to assist them in their role for instance, you know how's it going to change the way in which they work. Have you any ideas on this

A: I think there's the obvious answer which is that they'll be interfacing with a model rather than with a set of cad drawings

DM: yeah

A: which means that they're interfacing with much richer information at an earlier stage in a project or any kind of development in the design. And then its very much what that then leads to which is the interesting bit and I don't think anybody's really got the answers you know we do lots of different things with BIM within our QS roles on different projects and there isn't a consistent sort of standard response to that question yet

DM: umm

A: because some projects where its very much about you know particularly in framework type environments its about making sure that there's a library of common objects which are quantified and which are consistently sort of managed as information working with the client to our standardised design on you know kind of on multiple assets and advise on that whole process. There's other sort of pockets of activity in our business where we are working very much in terms of advising folk the whole line both the lifecycle and also so kind of you know how to deliver soft landings or FM

DM: yeah

A: and then there's other places where its more of a kind of traditional QS role but what BIM means is we can generate revisions to the cost plan far more efficiently so we can look at different design options so you know where as in the past our design team would present three or four different design options and you would kind of very roughly quantify them

DM: yeah

A: and the team would draw on their experience to work out which was the most likely to be more expensive or kind of within budget and that would be developed further what we're finding is we can increasingly do their estimating process in far more levels of detail from multiple designs with both the same level of effort and but again that's what the caveat want, that's only where the model is set up in the right way and where the team are working in a way that they allow that to happen. So there isn't an answer to that yet. I think its too early cos I don't think the industry has quite worked it out yet

DM: yeah

A: I guess part of the reason why we are doing the research activity that we're doing for example with the engineering doctorate and with another number of initiatives we've got on is to partly understand that and also hopefully influence it as well

DM: yeah yeah. When you talk about producing quantities and cost plans and things do you envisage that a BIM model will be used to produce a full, you know traditional bills of quantities that we've been used to in the past or do you think procurement routes are such now that they'll, they'll no longer be a need for that

A: we're still sometimes, there's far fewer examples of full bill of quantity being prepared these days and that's been a trend in the industry over the last probably five years they've been very much in the decline. But then we get, we still get high end stats from it when the client asked for it then we deliver it

DM: right

A: and it tends to be around the clients preferred procurement route

DM: yeah

A: and you get its kind of very much client led and sector led to a certain extent but it tends the head of procurement in a particular client organisation likes to see bills of quants and likes to see a particular procurement route we've been using that's what gets supplied. We still get some examples of that. I think certainly in terms of working with BIM then production of that type of detail is in theory easier, not always in practice

DM: no

A: but in theory is easier in terms of it should be when all software and standards are worked out. I guess the question is do you reach a point where you actually need to do that

DM: umm

A: and that gets us in to discussion about whether not just quantities but bills of costs should be within the model you know certainly when you are working at level three which I know the government has said that they're kind of waiting til 2025 for that

DM: yeah

A: which is quite a long way ahead. But you're working in, whatever you are working in a Level 3 type environment and I kind of say that because Level 3 is a bit of a woolly definition at the moment. Then I think inevitably you've got to need some costs in the model, I think the challenge is that not all the, model doesn't consider everything that's a project cost

DM: yeah

A: if that makes sense

DM: yeah it does

A: still I honestly don’t know the answer at the moment

DM: yeah

A: we’ve got quite a pragmatic view on putting that level of detail in to a model which is we don’t see any issues with doing it, you know I think some people kind of worry that we’ll give away all of our IT and there won’t be a need for a QS anymore

DM: umm

A: and I think a QS brings substantially more to a project than a database of costs but actually we haven’t seen a situation yet where a client or project team is set up in such a way to work with that level of detail around cost in a sufficiently robust way for that to add any value to the project and so at the moment its kind of just ways down the model with additional information which very quickly falls out of currency and becomes out of date. So don’t know is probably the short answer

DM: yeah

A: to that question. And I’m kind of, its one of the ones I’m watching, I’m kind of interested to see how it develops

DM: I don’t think anybody knows do they at the minute so

A: no

DM: so from a QS prospective then do you feel that BIM will bring benefits to their role

A: I think its got the potential to. To a certain extent its going to depend on how positively the profession embraces BIM. I think that if QS’s embrace BIM in a constructive way then they’ve got a lot to offer the project team in doing that and the role of the QS will be strengthened. I think if QS’s are negative or resistant or conservative about BIM then there’s a potential that other members of the project team, and by that I mean usually the architects and the designers and structural engineers and so on where run ahead and have to find different ways to deliver their projects. And in that sense the QS’s role could be diminished or you know not risk obsolesce I don’t think but certainly could lose the potential influence they could bring. I think you know QS’s have got an opportunity to have a significant degree of influence and support for the project team if they can demonstrate the value that they can add. Not just in terms of being able to provide analysis of the information because that’s something that can be broadly achieved by anybody in a project environment with BIM but by bringing that whole mind set and way of thinking and understanding or the project which I think the QS is quite unique to the QS profession

DM: yeah, do you think the QS will survive the BIM revolution then

A: I hope so. Whether they'll still be called Quantity Surveyors at the end of it I don't know but the kind of the underlying. I'll tell you the way I think about it. There's a little bit of story just a quick one but as I said at the start I studied geography and I remember as part of my under graduate degree I was sat in a lecture with a postmodern geographer, he was one of the lecturers there and he'd written a whole paper on the movie Bladerunner

DM: yeah

A: and he was talking about Bladerunner from the prospect of post modern geography and we all sat there for about an hour and a half for this two hour lecture wondering what on earth was going on and then somebody in the audience plucked up the courage to put up their hand and said "Sir what's any of this got to do with Geography" and I still remember his answer which came back to me which I thought was brilliant he said geography is what geographers do and its the way that you know when you do geography if you are trained to look at the world in a particular way you tend to think in a particular way and then you bring that mindset and you bring that skill base and that experience to solve problems. And I think its a similar thing with Quantity Surveyors

DM: yeah

A: in particular way of thinking about the construction process, a particular way of thinking about the world and the way it is constructed in terms of the built environment which Quantity Surveyors learn through and this is kind of where you come in with your courses. You train people to think about a project in a particular way and there's a mix of technical skill but there's also a mix of understanding the process and things to be concerned about and things to focus on and things to care about. And the kind of character that comes with a QS, that's not kind of you know turn in get a blank stereotype but there's something about a QS which is different to an Architect which is different to a Structural Engineer and I think when you get that mix right and you bring a team together with those different views of the construction process then you get the right mix and you deliver a successful, successful project so from that point of view you know kind of bringing that that kind of role of a QS and that kind of personality of a QS in to a multi-disciplinary team working with BIM I think is where there is a huge opportunity and I can't ever see a project being delivered without somebody with that kind of character to them and that kind of skill base to them

DM: yeah

A: what they're called I don't know. For now but I think there's still a role for that kind of thought process

DM: its funny I mean we change our side. When I set up my own business you know I called myself Cost Consultants and then you change it back to Quantity Surveyor when people want you to be called a Quantity

Surveyor now its Commercial Managers and I don't think we'll ever know what to call ourselves

A: no

DM: in that respect

A: no I've been through a whole bunch of job titles and I don't care what you call me as long as I can get on and do what

DM: yeah

A: I need to do

DM: that's right. As long as you are doing the job, that's the important. Do you think that BIM will make the QS, well enable the QS to make faster more effective decisions. You know for instance value engineering, lifecycle costing etc

A: yes absolutely as long as the model's set up correctly I think is that kind of message all the way through

DM: right

A: so again where you know where the team have got together and either agreed to use a set of off the shelf standards properly or where they've sat down in workshops and agreed how they are going to structure, how they are going to co-ordinate then we see lots of examples of being able to do that. As I say its just where somebody runs off and does it in their own way without thinking about the implications of on the you know on the other members of the project team that that becomes more difficult

DM: ok well moving on to now to the final bit which should be probably the shortest one where I am just looking at knowledge and skills in relation to QS's and universities. First of all the, just purely in relation to QS's, what do you think of the ability of new graduates within your organisation

A: I think in general. Well I think first of all the positives. The new graduates coming in to our business are brilliant people, we've got so many people coming in with real kind of passionate energy and I know that sounds like a glib statement

DM: yeah

A: but it kind of is and I guess we are in the fortunate position where we can choose the best

DM: yeah

A: you know if that doesn't sound too arrogant and we put a huge amount of effort in to our graduate assessment process and graduate recruitment process so we do get amongst the best graduates coming out of the universities. And then we put a huge amount of effort in to our APC programme in terms of then helping to develop them all. So I think we're lucky in that we've got some really good people and quite a lot of them get in touch with me about BIM so there's certainly a lot of interest in BIM. I guess the gap that I see is that we don't see many. That the graduates that come in to our business, who've got some kind of BIM knowledge tend to have written a dissertation about it or have gone off and learnt something almost extra curriculum paid activity to learn about BIM. What we're still not seeing from any of the universities in particular is graduates kind of coming in fully trained and competent and fully versed in BIM

DM: right

A: and I think that's a challenge. I kind of do quite a lot of sort of public presentations and kind of speak at different institute events and talk around BIM and I still I remember one not so long ago where there was a graduate in the room and it turned out the graduate was the only person who knew anything about BIM the rest of the audience knew nothing at all

DM: yeah

A: which was quite shocking. And what was even more shocking was the graduate was misinformed about BIM

DM: oh god

A: so he was saying you know kind of I've been told on my course that BIM can only be used on big projects and there was other sort of beliefs that we're being kind of drilled in to him or he's kind of picked it up from his university course that were actually quite misleading

DM: yeah

A: there's a huge gap at the moment, big potential, lots of opportunity but there's a very big need for not so much the technical skills around working with the software

DM: yeah

A: less about some of that but we can train that and we can develop that quite easily but its that kind of richer understanding of what BIM is and how it can be used and what it can achieve which I think is currently one of the big gaps that I see

DM: ok brilliant. What skills would you expect new graduates to have when leaving with a QS degree. I mean not just in relation to BIM I mean is it communication skills, presentation skills, is it supply chain management you know, do we need to do away with measurement. Do students need to do a measurement module at years one, two and three anymore if the BIM model's going to do the quantification. So

A: I think certainly in terms of kind of the broader categories you know our graduate programme I guess that's where its quite nice in terms of our selection process. And in that we look at the right kind of technical knowledge. So knowledge of procurement routes and contracts for example is important. Knowledge of the construction project and the built environment so you know the kind of elements that make up a building or an asset and how they are constructed and so on. That kind of basic knowledge of

DM: yeah

A: the decision process is important and always will be. Then its the interpersonal skills and we put I think equal weight to those as well. So its about those communication skills, its about being able to inter-relate to others and its about problem solving and thinking skills, but they're all important to. And then the big question is the one that you asked at the end of that which is should QS's be trained in quantification and its one that I'm probably going to disappoint you cos I don't quite know at the moment and I guess the reason I don't know if it kind of goes back around that sort of comment I made earlier which is there's a particular mindset, a particular kind of process set that comes with a Quantity Surveyor which is important to the construction delivery as a whole. And sometimes you have to go back and learn the basics manually to understand how things fit together

DM: yeah

A: so if learning quantification and learning measurement is part of the process of developing kind of the cognitive skills around that being able to work effectively pull quantities out of a BIM model then I think its still important as part of the curriculum. But from the point of view of, I mean two things. One is that in the immediate future people are still going to need to do manual take off because not every project is BIM

DM: yeah

A: so for the next three to five years that's skill going to be relevant and then even beyond that I think we'll reach a point where let's say every project was BIM then its important that QS's coming out of university understand how the costs fit together if they are presented with here is all the quantities from the building as a just an export out of the BIM model, the thing that a QS really brings to a project is that understanding about how they fit together and how they are derived and be able to spot what might be missing amongst that or kind of what needs to be included from a none construction element prospective. So I think there is still a role to kind of go through a manual process of unpicking the way a building is constructed from an elemental point of view of being able to work with that almost from pen and paper to then have the knowledge to work with the BIM model if that makes sense

DM: yeah no it does. I mean that's something that we're looking at the minute. We think that in first year at level four that students need a basic understanding of the drawing and understand the where the quantities come from and then move on to the BIM model and first of all looking at CAD and CAS measure and then the BIM model in final year

A: yeah

DM: so we see a developmental approach to that

A: I think its a, you know the way I look at that is that is if a model just exported the quantities and at some point in the future put a predicted cost against them as well then unless the QS has got that knowledge of having worked through it as almost kind of like a manual process then they are no different to an architect exporting a model through QTO and know which works

DM: yes that's right. Well that concludes the questions Adrian

A: ok

DM: that was absolutely fantastic. What I'll do is I'll follow this up with an email and just confirming that obviously that it is anonymous and I'll just put a statement in requesting the BIM strategies and the job profiles if that's ok. And then you've got my email address again to return them to. And if I can just make a request to the email for perhaps an appointment in person you know December, January whenever you are free

BIM implementation and the Quantity Surveying profession

Page 1: Welcome

This is a national survey looking at BIM implementation on the Quantity Surveying profession in the UK. Responses are based on your own experiences therefore please answer all questions as honestly as possible. All responses will be treated in the strictest confidence and you are not asked for your name or organisation. The questionnaire should only take about 10-15 minutes to complete.

Page 2

The survey is in five sections and it is not possible to return to a section once it has been completed. Therefore, please think carefully before responding so that your views are accurately represented. When you arrive at the final **Thank you** page, you will know that your responses have been recorded on our database.

Once you click **Continue** you will be directed to the first section of the survey.

If you would like a summary of the survey results, please contact Dianne Marsh at the email address below.

Thank you in advance for your participation in the survey,

Dianne Marsh

Liverpool John Moores University

Built Environment Department

email: d.marsh@ljmu.ac.uk

Page 3: Your organisation

How many employees are in your organisation?

- 1-24
- 25-249
- 249-500
- 501+

What type of organisation do you work for?

- Consultant
- Contractor
- Client
- Other

If you selected Other, please specify:

Where is your organisation predominantly located?

- UK
- International

Approximately how many offices does your organisation hold?

- 1-5
- 5-10
- 10-20
- 20-50
- 50+

What is the approximate turnover of your organisation?

- 100k
- 100-500k
- 500-1 milion
- 1-5 milion
- 5-10 milion

Approximately how many years has your organisation been in existence?

- 1-5 years
- 5-10 years
- 10-20 years
- 20-50 years
- 50+ years

Which of the following sectors do you work in?

- [ ] Building
- [ ] Civil Engineering
- [ ] Engineering
- [ ] Other

If you selected Other, please specify:

Page 4

Quantity surveying services

Which of the fo lowing services are offered by your organisation?

	Please state if the service is offered	
	Yes	No
Investment appraisal.	○	○
Advice on cost limits and budgets.	○	○
Whole life costing.	○	○
Value management.	○	○
Risk analysis.	○	○
Insolvency services.	○	○
Cost engineering services.	○	○
Subcontract administration.	○	○
Environmental services and measurement and costing.	○	○
Technical auditing.	○	○
Planning and supervision.	○	○
Valuation for insurance purposes.	○	○
Project management.	○	○
Facilities management.	○	○
Administering maintenance programmes.	○	○
Advice on contractual disputes.	○	○
Planning supervisor.	○	○
Employers agent.	○	○
Programme management.	○	○
Cost modeling.	○	○
Sustainability advisor.	○	○
Design economics and cost planning.	○	○
Whole life costing.	○	○

Procurement and tendering.	○	○
Contract administration.	○	○
Commercial management.	○	○

Which of the following services adopt BIM technology, processes and/or policies?

	Please state if BIM Technologies, processes or policys are used.	
	Yes	No
Investment appraisal.	○	○
Advice on cost limits and budgets.	○	○
Whole life costing.	○	○
Value management.	○	○
Risk analysis.	○	○
Insolvency services.	○	○
Cost engineering services.	○	○
Subcontract administration.	○	○
Environmental services and measurement and costing.	○	○
Technical auditing.	○	○
Planning and supervision.	○	○
Valuation for insurance purposes.	○	○
Project management.	○	○
Facilities management.	○	○
Administering maintenance programmes.	○	○
Advice on contractual disputes.	○	○
Planning supervisor.	○	○
Employers agent.	○	○
Programme management.	○	○
Cost modeling.	○	○
Sustainability advisor.	○	○

Design economics and cost planning.	○	○
Whole life costing.	○	○
Procurement and tendering.	○	○
Contract administration.	○	○
Commercial management.	○	○

At which stage in the project life cycle does your organisation utilise BIM technologies the most? Please rank in order of greatest utilisation, with 8 being greatest and 1 being least.

Please don't select more than 1 answer(s) per row.

	1	2	3	4	5	6	7	8
0. Strategic Definition	☐	☐	☐	☐	☐	☐	☐	☐
1. Preparation and Brief	☐	☐	☐	☐	☐	☐	☐	☐
2. Concept Design	☐	☐	☐	☐	☐	☐	☐	☐
3. Developed Design	☐	☐	☐	☐	☐	☐	☐	☐
4. Technical Design	☐	☐	☐	☐	☐	☐	☐	☐
5. Construction	☐	☐	☐	☐	☐	☐	☐	☐
6. Handover and Close Out	☐	☐	☐	☐	☐	☐	☐	☐
7. In Use	☐	☐	☐	☐	☐	☐	☐	☐

Please indicate your level of agreement in relation to the statements below which best describe the impact of BIM on the QS role.

	5=Strongly Agree, 4=Agree, 3=Neutral, 2=Disagree, 1=Strongly Disagree				
	5	4	3	2	1
To improve the accuracy.	○	○	○	○	○
To improve quality of service.	○	○	○	○	○
To diversify role.	○	○	○	○	○
To move into the measurement of carbon.	○	○	○	○	○
To move into post occupancy evaluation.	○	○	○	○	○
It wil require new skils.	○	○	○	○	○
Wil it survive?	○	○	○	○	○

Page 5: BIM (Building Information Modelling)

Please indicate your level of agreement in relation to the statements below which are commonly used to define BIM.

	5=Strongly Agree, 4=Agree, 3=Neutral, 2=Disagree, 1=Strongly Disagree				
	5	4	3	2	1
BIM is an Information Technology (IT) enabled approach that a lows design integrity, virtual prototyping, simulations, distributed access, retrieval and maintenance of the building data.	○	○	○	○	○
BIM is concerned with information about the entire building and a complete set of design documents stored in an integrated database, where the information is parametric and thereby interconnected.	○	○	○	○	○
BIM is a multi-dimensional, historica ly evolving, complex phenomenon.	○	○	○	○	○
BIM is the coming together of policy, process and technology.	○	○	○	○	○
BIM is a language of co laboration with people and communication at its centre.	○	○	○	○	○

Please indicate your level of agreement in relation to the perceived benefits of BIM from the statements below.

	Please indicate if BIM a lows for major benefits, minor benefits or no benefits.		
	Major benefit of BIM	Minor benefit of BIM	No benefit
Improved visualisation.	◌	◌	◌
Improved communication across the project team.	◌	◌	◌
Improved processes.	◌	◌	◌
Faster quantification and measurement.	◌	◌	◌
Faster updating of changes.	◌	◌	◌
Faster decision making.	◌	◌	◌
More accurate quantification and measurement.	◌	◌	◌
More accurate updating of changes.	◌	◌	◌
More accurate decision making.	◌	◌	◌
Improved efficiency.	◌	◌	◌
Improved productivity.	◌	◌	◌
Improve the quality of delivery.	◌	◌	◌
Increased confidence in decisions.	◌	◌	◌
Increased competitive advantage.	◌	◌	◌
Increased global competitive advantage.	◌	◌	◌
Increased sustainable competitive advantage.	◌	◌	◌

Please indicate your level of agreement in relation to the perceived barriers to the adoption of BIM from the statements below.

	Please indicate if BIM adoption is subject to major barriers, minor barriers or no barriers.		
	Major barriers	Minor barriers	No barriers
Reduction in fees charged.	○	○	○
Increased competition.	○	○	○
Contractual liability concerns.	○	○	○
Cost of hardware.	○	○	○
Cost of software.	○	○	○
Cost of network.	○	○	○
Cost of training.	○	○	○
Lack of confidence in the selection of appropriate software.	○	○	○
Lack of suitably skiled and experienced staff.	○	○	○
The ageing workforce and the undersupply of new entrants.	○	○	○
Inadequate professional body training provided by professional bodies.	○	○	○
Lack of shared knowledge banks accessible to the QS.	○	○	○
The isolation of the QS from key decision makers and clients.	○	○	○
The lack of private client demand for BIM.	○	○	○
Lack of certainty of added value to the QS role.	○	○	○
Lack of certainty of the added value to the client.	○	○	○
Fear of extinction of the QS role.	○	○	○

With reference to the diagram below what is your current BIM maturity? how do i insert?

- ☐ Level 0
- ☐ Level 1
- ☐ Level 2
- ☐ Level 3

Which of the following documents are you currently adopting?

☐ PAS1192-2	☐ PAS1192-3	☐ PAS1192-4
☐ PAS1192-5	☐ BIM Protocol	☐ Government Soft Landings(GSL)
☐ Digital plan of Work	☐ Standard classification e.g. UNICLASS 2	

Page 6: Organisational development and BIM

Please indicate your level of agreement in relation to the statements below regarding your organisation.

	5=Strongly Agree, 4=Agree, 3=Neutral, 2=Disagree, 1=Strongly Disagree				
	5	4	3	2	1
It has a flat organisational structure	○	○	○	○	○
It operates a decentralised decision making structure	○	○	○	○	○
The organisation empowers its employees.	○	○	○	○	○
It has open lines of communication.	○	○	○	○	○
It positively motivates its staff.	○	○	○	○	○
It positively promotes innovation.	○	○	○	○	○
Team based decision making is encouraged.	○	○	○	○	○
Individuals are given time to reflect.	○	○	○	○	○
It supports change.	○	○	○	○	○
It is a supportive environment conducive to learning.	○	○	○	○	○
It adopts a philosophy of trust and openness.	○	○	○	○	○

Which of the following statements best describes why your business adopted BIM?

	5=Strongly Agree, 4=Agree, 3=Neutral, 2=Disagree, 1=Strongly Disagree				
	5	4	3	2	1
To support the existing business.	○	○	○	○	○
To diversify service provision.	○	○	○	○	○
To improve the use of technology.	○	○	○	○	○
To improve the management processes within the business.	○	○	○	○	○
To improve performance.	○	○	○	○	○
Perceived generic benefits of BIM , learned by word of mouth.	○	○	○	○	○
An industry stakeholder with whom you were working with adopted BIM.	○	○	○	○	○
Another QS organisation had adopted BIM.	○	○	○	○	○
The business case of BIM adoption by QS business's was proven.	○	○	○	○	○
Someone from within the organisation recognised the potential of BIM and championed its adoption.	○	○	○	○	○
You have not adopted.	○	○	○	○	○

Please indicate your level of agreement in relation to the statements below which best describe the impact on your organisation as a result of adopting BIM.

	5=Strongly Agree, 4=Agree, 3=Neutral, 2=Disagree, 1=Strongly Disagree				
	5	4	3	2	1
Roles have become highly specialised.					
Roles have reduced autonomy.					
Roles have less variety.					
Roles have less task identity.					
Greater conflict.					
Greater secrecy.					
Greater centralisation.					
More formalised.					
Decrease in innovation.					
Decrease in employee participation in decision making.					
Decrease in risk taking.					
Decrease in long term planning.					
Decrease in leader influence.					
Increase in revenue.					

Page 7: Organisational strategic planning and BIM

Did you undertake a business audit prior to BIM implementation? If so which of the following did you consider?

- ☐ Establish your existing BIM "maturity" level.
- ☐ Existing client base.
- ☐ Existing workload.
- ☐ Future work sector plans and ambitions.
- ☐ Existing skils.
- ☐ Existing Hardware capability
- ☐ Existing software capability.
- ☐ Existing network infrastructure capability.
- ☐ Existing data security policies and procedures.
- ☐ Existing working practices.
- ☐ Existing Quality Assurance policies

Please indicate your level of agreement in relation to the statements below which best describe the consideration given in the strategic planning stage for BIM implementation.

	5=Strongly Agree, 4=Agree, 3=Neutral, 2=Disagree, 1=Strongly Disagree				
	5	4	3	2	1
An assessment of the current BIM maturity level the business is working at.	○	○	○	○	○
Budget required to implement.	○	○	○	○	○
Cashflow forecasts	○	○	○	○	○
Time constraints for implementation.	○	○	○	○	○
Training requirements.	○	○	○	○	○
Impact on workload.	○	○	○	○	○
Identification of BIM champions.	○	○	○	○	○
New ways of working.	○	○	○	○	○
Impact on project teams.	○	○	○	○	○
Key Performance indicators.	○	○	○	○	○
Definition of BIM deliverables.	○	○	○	○	○
Phasing of BIM implementation.	○	○	○	○	○

Please indicate your level of agreement in relation to the statements below which best describe the changes made to your existing business in order to adopt BIM.

	5=Strongly Agree, 4=Agree, 3=Neutral, 2=Disagree, 1=Strongly Disagree				
	5	4	3	2	1
Structure.	○	○	○	○	○
Software.	○	○	○	○	○
Hardware.	○	○	○	○	○
Staffing.	○	○	○	○	○
Training.	○	○	○	○	○
Information management.	○	○	○	○	○
Performance management.	○	○	○	○	○
Policies.	○	○	○	○	○
Work processes and procedures.	○	○	○	○	○
Protocols.	○	○	○	○	○
Fees.	○	○	○	○	○
Contract Documents.	○	○	○	○	○
Professional indemnity insurance.	○	○	○	○	○
Copyright.	○	○	○	○	○

Page 8: BIM LEARNING

Who has led the development of BIM within the organsiation?

- Individual interested in BIM.
- A specific client who asked for BIM.
- A specific project team.
- Groups of interested individuals.
- Senior management.
- BIM has not been developed.
- A BIM appointed champion.

Has your individual learning on BIM been as a consequence of?

- Learning by doing
- Learning by fol lowing organisation best practice.
- Debriefing.
- Problem solving techniques.
- Attendance at CPD events organised by the RICS
- Attendance at CPD events organised internal ly within the organisation.
- Attendance at University led events.
- Personal reading in professional body journals.
- Personal reading on the Government BIMGroup Task Forum site.
- Personal reading on the NBS web site.
- Personal reading of academic journal articles.

Which of the following do you review and evaluate on completed BIM projects

- ☐ Time spent on project
- ☐ Fees received
- ☐ Final profit.
- ☐ Any abortive work.
- ☐ Mistakes and discrepancies
- ☐ Coordination with other stakeholders.
- ☐ Quantity of requests for information and variations.
- ☐ Level of waste generated.
- ☐ Actual operating costs compared with predicted.

As a consequence of adopting BIM do you think the organsiation has?

- ☐ increased its levels of expertise in BIM
- ☐ Increased its experience of working on BIM projects
- ☐ Become more efficient
- ☐ concentrated on a specific market niche and BIM

Please indicate your level of agreement in relation to your own personal experience as a consequence of your organisation adopting BIM.

	5=Strongly Agree, 4=Agree, 3=Neutral, 2=Disagree, 1=Strongly Disagree				
	5	4	3	2	1
I was made aware of the benefits of BIM to my role prior to adoption.	○	○	○	○	○
I was made aware of the likely changes to my role prior to adoption.	○	○	○	○	○
I was made aware of the likely changes in the relationships between my role and other project stakeholders prior to adoption.	○	○	○	○	○
I was provided with appropriate training to use BIM technology.	○	○	○	○	○
I was provided with appropriate knowledge in relation to BIM process and policy.	○	○	○	○	○
The technology I adopted did what I expected it to.	○	○	○	○	○
The technology made my role easier.	○	○	○	○	○

The technology I adopted facilitated better collaboration with other stakeholders.	○	○	○	○	○
I was told which technology to use.	○	○	○	○	○
I experimented with technology to find one that best suited my needs.	○	○	○	○	○
I found it difficult to "unlearn" the technology.	○	○	○	○	○
I found the technology complex.	○	○	○	○	○
I found the technology simple to use.	○	○	○	○	○
I recognise the value of BIM knowledge.	○	○	○	○	○
I was encouraged to share my BIM knowledge.	○	○	○	○	○
I am happy to share my BIM knowledge.	○	○	○	○	○
I am competent with BIM technologies.	○	○	○	○	○
I am competent with BIM policies and processes.	○	○	○	○	○

How do you capture BIM knowledge within the organisation?

- ☐ BIM champion.
- ☐ Ad hoc on an individual basis.
- ☐ Lessons learnt data base.
- ☐ Recorded Evaluation/feedback on individual project at the end of the project.
- ☐ Case studies.
- ☐ On specific types/values of project.
- ☐ Recorded Evaluation/feedback on individual project throughout the end of the project.
- ☐ On a l projects

How do you transfer BIM knowledge within the organisation?

- ☐ BIM champion shares good practice.
- ☐ Regular team briefings and meetings.
- ☐ Peer tutoring.
- ☐ Supervision/monitoring system

- [ ] Internal CPD event.
- [ ] You do not share BIM knowledge as an organisation.

Please indicate your level of agreement in relation to the statements below which best describe the resistance to change by your organisation when implementing BIM.

	5=Strongly Agree, 4=Agree, 3=Neutral, 2=Disagree, 1=Strongly Disagree				
	5	4	3	2	1
Poor leadership from senior management.	○	○	○	○	○
Inadequate top management support for implementation.	○	○	○	○	○
Reluctance of staff to adopt new work flow practices.	○	○	○	○	○
Reluctance of staff to adopt new methodologies.	○	○	○	○	○
Reluctance of staff to adopt new IT technologies.	○	○	○	○	○
Lack of knowledge of the software's available.	○	○	○	○	○
Inadequate reference material within the organisation.	○	○	○	○	○
Inadequate component data base.	○	○	○	○	○
Lack of staff involvement in the decision making to implement BIM.	○	○	○	○	○
Staff unaware of the benefits of BIM to their role.	○	○	○	○	○

Page 9: Personal details

Which of the following statements best describes your role?

- Apprentice quantity surveyor.
- Trainee quantity surveyor.
- Assistant quantity surveyor.
- Quantity surveyor
- Senior quantity surveyor
- Partner
- Project quantity surveyor
- Commercial manager
- Trainee commercial manager
- Assistant commercial manager
- Senior commercial manager

Which of the following age range relates best to you?

- 16-21 years
- 22-40 years
- 41-54 years
- 55-67 years
- 67+years

Thank you for completing the survey

Dianne Marsh

APPENDIX 3

Sample statistical tests

Table 1 KMO and Bartlett' test QS activities

KMO and Bartlett's Test QS Activities		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.883
Bartlett's Test of Sphericity	Approx. Chi-Square	2239.134
	df	300
	Sig.	0.000

Table 2 KMO and Bartlett' test RIBA stages

KMO and Bartlett's Test RIBA stages		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.762
Bartlett's Test of Sphericity	Approx. Chi-Square	894.559
	df	28
	Sig.	0.000

Table 3 KMO and Bartlett' test impact on the QS

KMO and Bartlett's Test impact on the QS		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.778
Bartlett's Test of Sphericity	Approx. Chi-Square	805.458
	df	55
	Sig.	0.000

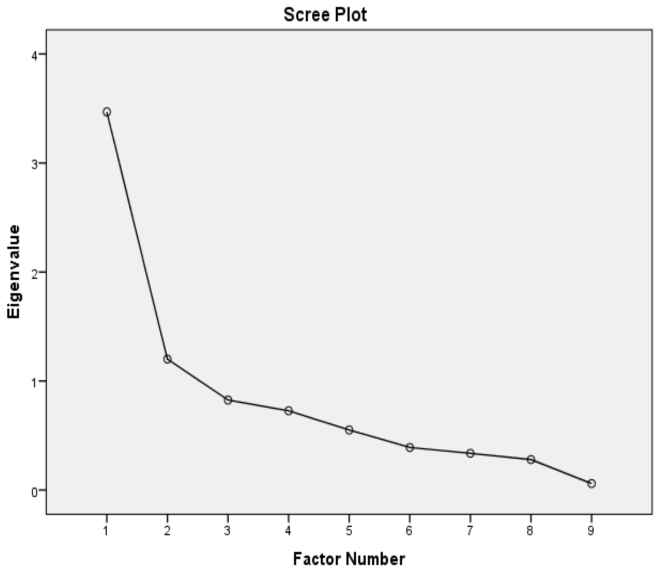

Figure 9-1 Benefits of BIM to the QS

Table 4 Summary of exploratory factor analysis for the benefits of BIM to the QS

Rotated Component Matrix[a]		
	Component	
	1	2
Collaborative working	0.772	0.079
Quality Assurance	0.748	0.129
Quantification	0.691	0.082
Faster decisions	0.669	0.181
Whole Life Costing	0.626	0.371
Post Occupancy evaluation	0.551	0.479
Carbon measurement	0.329	0.875
Water measurement	0.345	0.840
Identifying gaps in information	0.358	-0.490
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.		
a. Rotation converged in 3 iterations.		

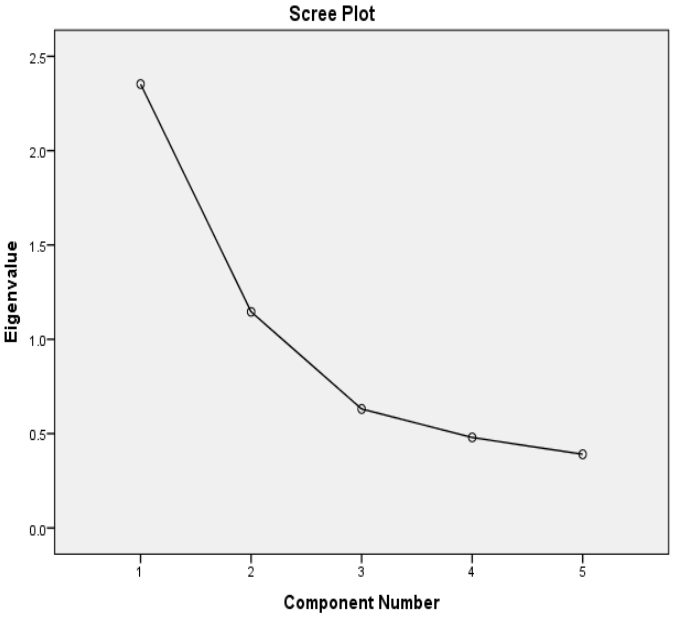

Figure 9-2 BIM definitions

Table 5 Summary of exploratory factor analysis for the benefits of BIM to the QS

Rotated Component Matrix[a]

BIM Definitions	Component 1	Component 2
BIM Definition 1 BIM is an Information Technology (IT) enabled approach that allows design integrity, virtual prototyping, simulations, distributed access, retrieval and maintenance of the building data.	0.857	0.005
BIM Definition 2 BIM is concerned with information about the entire building and a complete set of design documents stored in an integrated database, where the information is parametric and thereby interconnected.	0.854	0.024
BIM Definition 3 BIM is a multi-dimensional, historically evolving, complex phenomenon.	0.722	0.326
BIM Definition 4 BIM is the coming together of policy, process and technology.	-0.094	0.901
BIM Definition 5 BIM is a language of collaboration with people and communication at its centre.	0.410	0.646

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

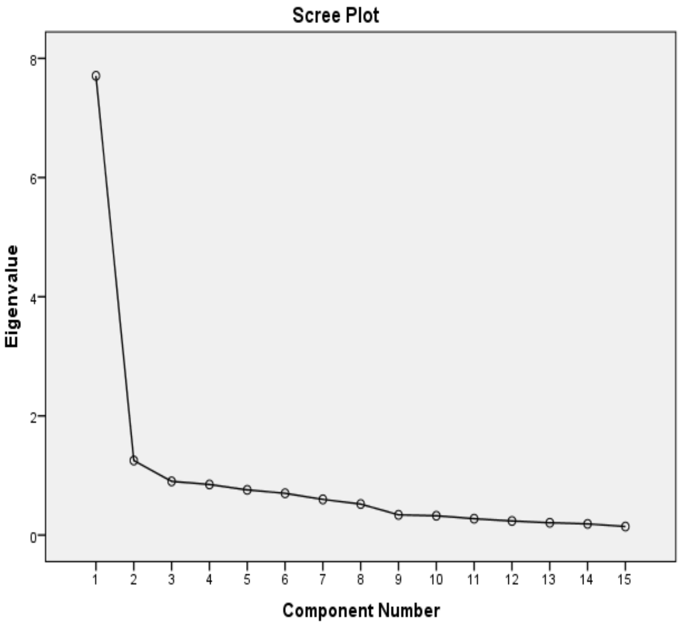

Figure 9-3 Benefits of BIM to the organisation

Table 6 Summary of exploratory factor analysis for the benefits of BIM to the organisation

Rotated Component Matrix[a]

	Component	
	1	2
Accurate change	0.745	0.339
Faster Quantities	0.732	0.338
Faster Decisions	0.726	0.229
Faster Change	0.694	0.243
Improved Process	0.674	0.234
More accurate Decisions	0.662	0.367
More accurate quantities	0.656	0.446
Improved communication	0.643	0.215
Improved visualisation	0.485	0.148
Global Advantage	0.170	0.870
Sustainable Advantage	0.282	0.825
Competitive Advantage	0.299	0.812
Improved Productivity	0.503	0.629
Improved Quality	0.335	0.628
Improved Efficiency	0.505	0.622

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

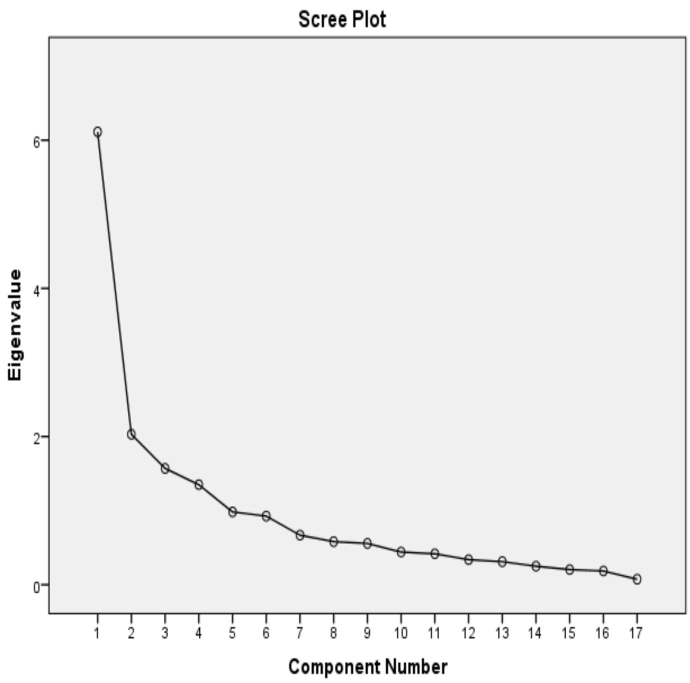

Figure 9-4 Barriers of BIM adoption to the organisation

Table 7 Summary of exploratory factor analysis for the barriers to adoption of BIM to the organisation

Rotated Component Matrix[a]

	Component			
	1	2	3	4
Software Cost	.931	.182	.156	.074
Network Cost	.905	.138	.073	.108
Hardware Cost	.886	.167	.150	.161
Training Cost	.768	.160	.317	.104
Added Value to QS	.060	.781	.200	.155
Added Value to Client	.087	.759	.210	.205
Private Client	.110	.682	.148	.119
Clients Isolation	.252	.612	.355	-.098
Extinct QS	.195	.587	-.010	.094
Staff Skills	.044	-.078	.801	.018
Confidence in Software	.169	.186	.727	.202
Ageing Staff	.113	.369	.717	-.042
Professional Training	.201	.252	.646	.141
Shared Knowledge banks	.245	.296	.580	.214
Reduced Fees	.151	.183	.062	.792
Increased Competition	-.015	.250	.070	.742
Contractual Liability	.191	-.028	.159	.691

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. a. Rotation converged in 5 iterations.

Figure 9-5 Organisational characteristics

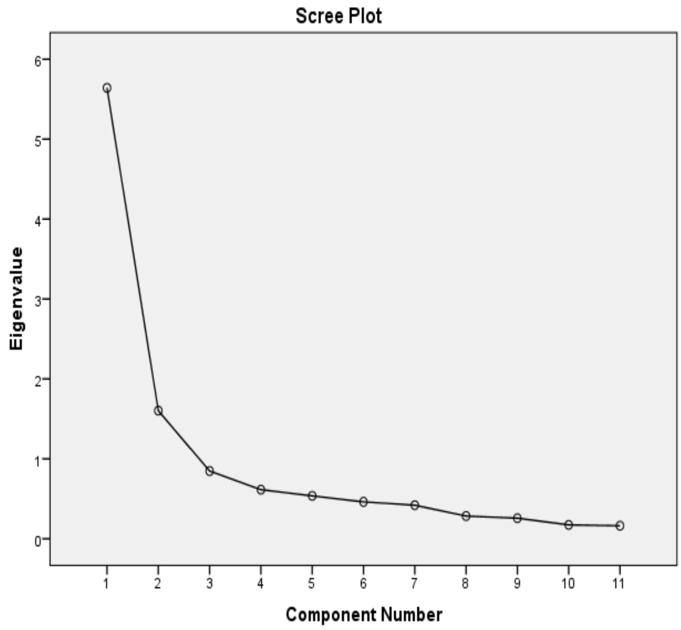

Table 8 Summary of exploratory factor analysis for organisational characteristics.

Rotated Component Matrix[a]

	Component	
	1	2
Trust	.875	-.071
Supportive learning environment	.860	-.161
Promotes Innovation	.850	.025
Motivate Positively	.824	.147
Open Communication	.779	.128
Reflection	.761	.038
Team decision making	.754	.190
Supports change	.738	-.277
Organisation empowers people	.630	.262
Decentralised Decision making	.144	.846
Flat organisational structure	-.067	.805

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

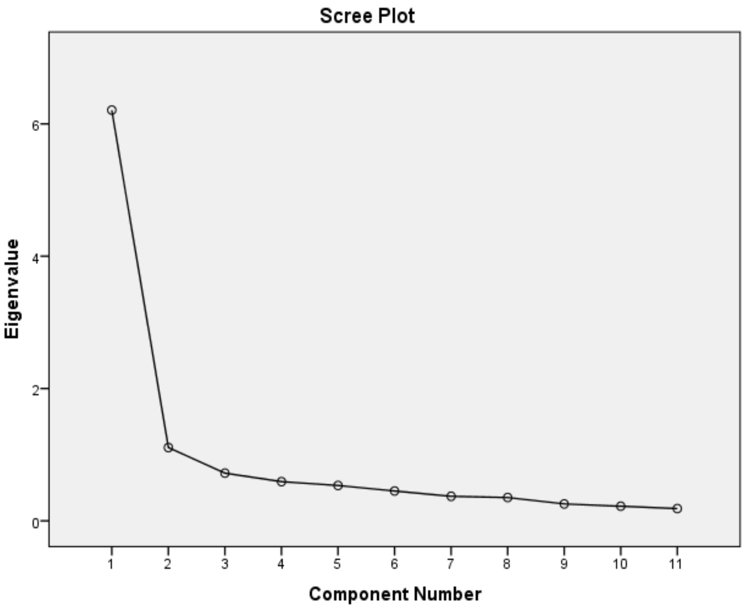

Figure 9-6 Criteria used by organisation when adopting BIM

Table 9 Summary of exploratory factor analysis for Criteria used by organisation when adopting BIM

Rotated Component Matrix[a]

	Component	
	1	2
Improve IT	.890	.125
Improve Performance	.784	.348
Diversify service	.752	.236
Improve Process	.750	.305
Leadership in innovation	.690	.413
Support the business	.539	.532
Respond to Client needs	.205	.833
Maintain Stakeholder relationships	.310	.803
Respond to Government push	.185	.748
Keep pace with competitors	.550	.565
Maintain market share	.516	.564

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

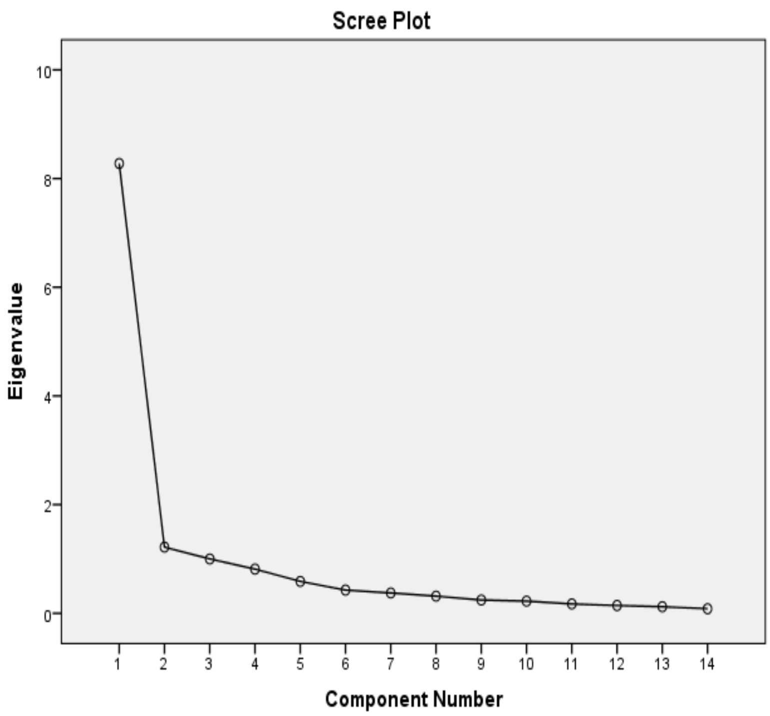

Figure 9-7 Impact on organisations as a consequence of adopting BIM

Table 10 Summary of exploratory factor analysis for the impact on organisations as a consequence of adopting BIM

	Mean	Std. Deviation	N
Specialise Roles	3.11	1.197	163
Reduced Autonomy	2.79	1.097	163
Roles less varied	2.72	1.057	163
Roles less tasks	2.57	1.006	163
Organisation more Complex	2.40	.985	163
Increased Organisation Secrecy	2.45	1.107	163
Increased Organisation Centralisation	2.88	1.033	163
Increased Organisation Formalisation	2.96	1.024	163
Organisation decrease in innovation	2.52	1.068	163
Decrease in in employer decision making	2.55	1.038	163
Decrease in Risk	2.57	1.006	163
Decrease in Planning	2.42	1.116	163
Decrease in leader influence	2.31	1.102	163
Increase in Revenue	2.76	1.127	163

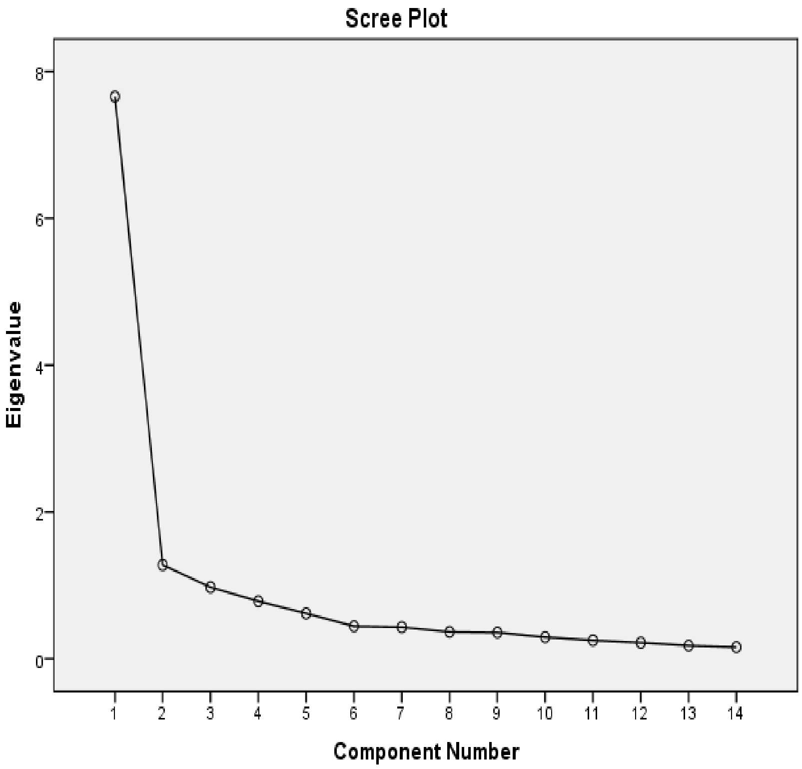

Figure 9-8 Changes made by the organisation as a consequence of BIM adoption.

Table 11 Summary of exploratory factor analysis for the changes made by the organisation as a consequence of BIM adoption

Rotated Component Matrix[a]

	Component	
	1	2
Training	.819	.106
Information management	.817	.294
Processes	.750	.391
Protocols	.696	.349
Policies	.694	.418
Software	.672	.178
Performance management	.667	.432
Hardware	.661	.409
Staffing	.548	.397
Copyright	.209	.856
Professional indemnity	.244	.853
Contract Documents	.323	.813
Fees	.345	.674
Structure	.412	.521

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

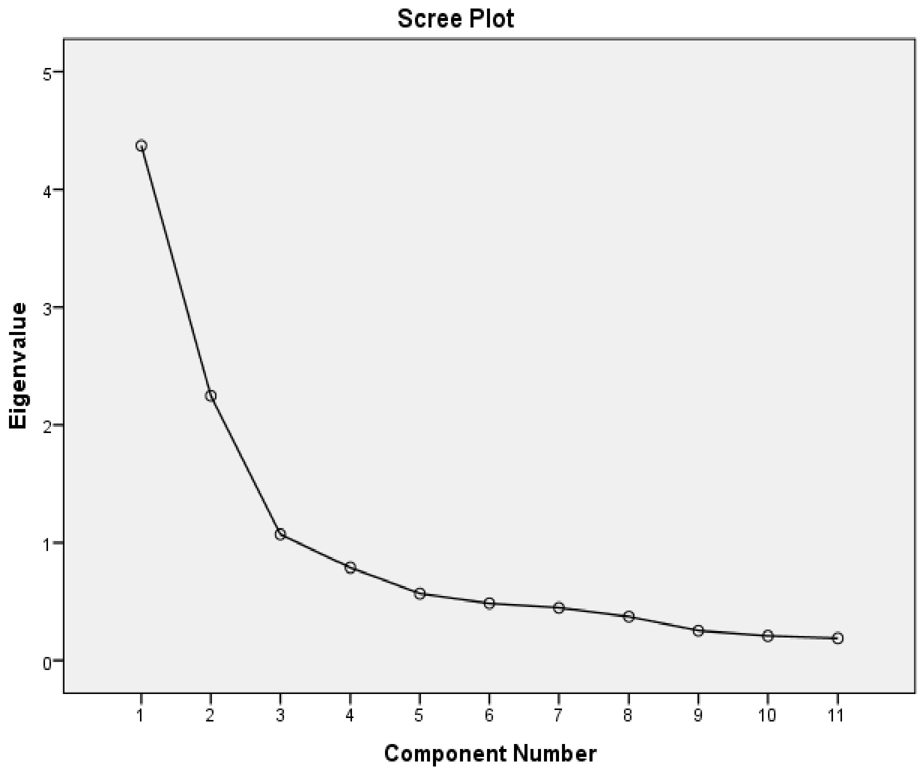

Figure 9-9 The BIM learning mode adopted by the organisation

Table 12 Summary of exploratory factor analysis for the BIM learning mode adopted by the organisation

Rotated Component Matrix[a]

	Component		
	1	2	3
BIM Task Group	.881	.170	-.029
Academic Journal	.839	.125	.088
Professional Journal	.807	.256	.021
NBS	.774	.302	-.074
University CPD	.691	-.303	.332
Internal CPD	.194	.825	-.007
Debrief	.058	.803	.294
RICS CPD	.365	.663	.079
Best Practice	.059	.651	.424
By doing	.037	.130	.856
Problem solving	.052	.503	.649

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 6 iterations.

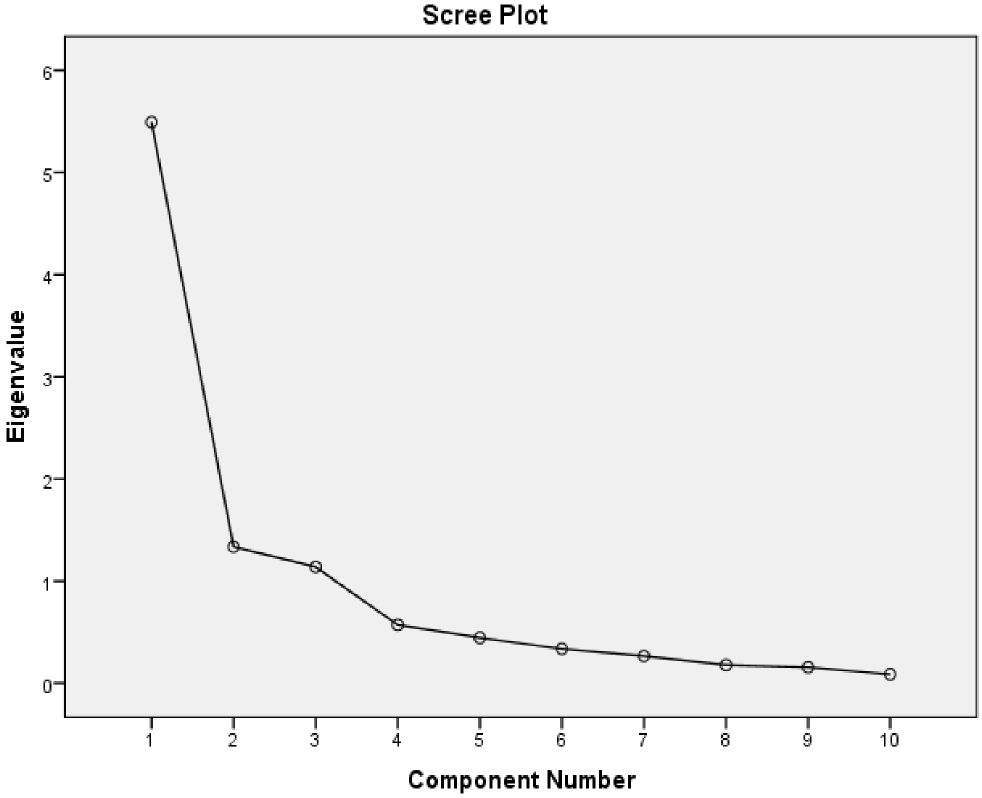

Figure 9-10 The factors influencing resistance to change by organisations when implementing BIM

Table 13 Summary of exploratory factor analysis for the factors influencing resistance to change by organisations when implementing BIM

Rotated Component Matrix[a]

	Component		
	1	2	3
Poor Organisational information	.868	.145	.174
Poor Component Database	.792	.268	.186
Staff not involved in decision making	.771	.069	.406
Staff unaware of the benefits	.628	.398	.139
Poor Software Knowledge	.584	.555	.009
Staff reluctant to adopt new methods	.208	.906	.233
Staff reluctant to use IT	.284	.875	.116
Staff Reluctant to change work flows.	.147	.833	.386
Inadequate Management support	.264	.183	.895
Poor Leadership	.214	.292	.875

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 6 iterations.

Table 2 Tests for normality of the data

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Benefits of BIM to the organisation	0.132	175	0.000	0.894	175	0.000
Barriers of BIM to the organisation	0.127	183	0.000	0.882	183	0.000
QS services	0.093	162	0.002	0.941	162	0.000
Criteria used for BIM adoption	0.114	148	0.000	0.904	148	0.000
Organisational characteristics	0.107	175	0.000	0.976	175	0.004
Individual BIM learning	0.103	162	0.000	0.973	162	0.003
Individual QS experience of BIM	0.137	155	0.000	0.958	155	0.000

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction