UNIVERSITY OF THE WITWATERSRAND

THE DISPOSITION TOWARDS BIM ADOPTION AMONGST CLIENTS FOR THE MINIMISATION OF VARIANCE ORDERS RELEVANT TO THE SOUTH AFRICAN BUILDING INDUSTRY

BY

Christian Weitz 0718318A

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SUPERVISOR: PROF. DAVID ROOT

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DECLARATION

I declare that this dissertation is my own unaided work. It is being submitted to the Degree of Master of Science in Building (Project Management in Construction) to the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination to any other University.

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Christian Weitz

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ABSTRACT

The adoption rate of BIM (Building information Modelling) in South Africa is substantially lower than many other countries both developed and developing, which is surprising given BIM's significant advantages particularly in automating clash detection within design information, which has been a significant challenge for designers and project managers. Such clashes between *inter alia* different building services and systems are frequently a major cause of cost overruns and delays on South African construction projects. The benefits of such BIM functionality may well be the necessary driving force behind BIM adoption. However, in adopting change, the industry is often slow and often requires clients and end users to drive change in a fragmented industry as they are often the parties that stands to benefit the most, and this is arguably true of BIM.

This study focuses on private sector clients of the South African construction industry, and whether they have identified the potential of using BIM to minimise clashes between building services on their projects. The study reviewed literature on the current state of BIM adoption internationally and in South Africa along with the benefits of using BIM on projects in South Africa and abroad. The benefits of BIM adoption were summarised and were distributed to several pre-selected interviewees to read. Interviews were conducted based on a questionnaire that was set up drawn from client organisations in the private sector. The data was represented graphically and the outcomes of the interviews analysed. The interviewees were generally of the mind that they should not be the driving force behind BIM adoption. They all agreed that their consultants should implement any cost or time saving technology as a value added service to them.

Keywords: BIM, Building Information Modelling, Clashes, Clash Detection, Property developers, Designers, Developers, Variations,

DEDICATION

I would like to thank first and foremost my parents, Marie and Chris Weitz, for all of their support and for bringing me to this point in my life. Thank you for instilling in me a drive to better myself and to seek out new challenges.

I would also like to thank Professor David Root for all his patience and for mentoring me throughout the process of writing and compiling this document.

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1 Introduction

1.1 Context of the Study

BIM, or Building Information Modelling, is generally considered to be the digital representation of knowledge pertaining to a construction project in which different designing entities (Structural/Mechanical/Civil Engineers and architects etc.) collaborate and merge their digital designs. BIM can be viewed as a process, or a piece of software (Ahmed, Damien and Price, 2012).

BIM has the potential to revolutionize the South African construction industry as it is already doing so in the United States and other countries around the world. In the United States a 2012 study by McGraw Hill concluded that BIM technology increased profits and reduced project costs (McGraw Hill Construction, 2012). However uptake in SA is slow as indicated by www.implementbim.com which states that there are currently only four registered BIM consultants in South Africa As of December 2015.

One of BIM's key functionalities is the ability to detect clashes between services, such as an air-conditioning duct that intersects a sprinkler pipe. Traditionally these clashes may have only been detected on site despite attempts to coordinate designs beforehand. Such clashes may require remedial or additional work in addition to redesign. If they are only discovered on site, these non-value adding costs will typically result in variance orders, as they are not part of the initial scope of works and they do not form part of the basic budget on a project. A variation order is any modification to the contractual guidance provided to the contractor by the client or the client's representative (Arain and Pheng, 2005) This paper focusses specifically on variation orders that are caused by such design clashes.

Variance orders can be categorized as being due to two different events; an instruction to vary the design and, an instruction to resolve discrepancies between contract documents (Ndihokubwayo, 2008). Discrepancies between contract documents including drawings, specifications, and schedules lead to variances including clashes between services.

Generally the problem of design coordination of building services has always existed on building projects. To minimise the problem, many hours are spent manually integrating drawings by using techniques such as redlining drawings. However whilst this reduces the

risk of clashes, it does not eliminates the risk of clashes occurring on site. In contrast, the use of BIM provides the opportunity to make these manual integrations redundant, by automating the process.

Direct and indirect non value-adding costs, which can include waste, are associated with variation orders. Non value-adding costs contribute to higher construction delivery costs due to wasted materials and the inefficient use of resources (Ndihokubwayo, 2008). As a result of non-value adding costs caused by clashes, the overall cost of a project is increased. This may, in turn, impact on the feasibility of approving the project for construction in the first place particularly by developers who, along with their financiers, require a minimum return to be achieved before projects are allowed or proceed. Globally, the construction industry has been reluctant to adopt new technologies (Davis, 2008). Clash detection in buildings, facilitated by BIM technology, could reduce the costs related to variance orders by detecting the clashes early and bypassing the need for rework on site, thus making the technology an attractive value adding service that will need to be offered to clients by consulting firms in order to stay competitive. The scale of the problem is illustrated by a study done by Sunday (2010) which indicates that the additional costs on a project that were associated to variance orders was equal to an average of 28.68% of the original budget of the project for projects managed by consultants.

Such additional costs on a building project is a universal problem in the back of every Quantity Surveyors mind, however using BIM software during the process could significantly decrease the likelihood of such overruns occurring (Fazli, Fathi and Enferadi, 2014). This study focused on overruns incurred by the client by way of clashes between different building services that may be designed by different design consultants. Where clashes occur, such services need to be re-routed; this leads to unproductive work, delays, cost overruns, as well as redesign.

BIM technology detects clashes early, making construction projects less risky for stakeholders by reducing the opportunity for claims by contractors, improving workflow, and allowing more accurate planning and program control, and thus, possibly, a more attractive investment case. However, before this can happen, the resistance to adopting BIM must be overcome and evidence shows that the technology will likely have to be demanded by clients

or be mandated by government. It is therefore possible that South African clients will need to demand that their consultants make use of BIM technology as a cost saving tool.

Clashes are generally considered a major problem in the private construction sector of South Africa, and currently BIM technology may not be being required by clients. Thus, the opportunity to minimise variance orders due to design clashes, is currently being lost. A study on clients is required to find the root cause of this lag behind the international industry standard and to test the South African private sector clients' awareness of BIM technology.

1.2 Problem Statement

Variance orders related to clashes between design elements impose a significant cost on construction projects in South Africa. BIM has the potential to minimise this cost by detecting clashes before construction starts allowing the problems to be resolved whilst still in the design stage, as it has been successful in doing so in other countries such as the United States and Britain. In such cases, the adoption has been driven by the pubic sector mandating its use as clients. However, despite the existence of this functionality South Africa has no framework in place to implement this technology. Adoption in South Africa appears to be limited to specialist areas such as process engineering, rather than mainstream commercial buildings. International adoption of BIM has been driven by clients, thus the extent of local client awareness regarding the benefits of using BIM to minimise variance orders, caused by clashes in design information, needs to be assessed.

Thus, there is a need to assess clients' views on the slow adoption rate of using BIM technology to minimise variance orders for the South African Private Sector, specifically for the function of clash detection. This study will also aim to identify possible reasons why BIM is not being demanded by clients.

1.3 Research Question

From the above research problem, the following primary research question can be drawn:

- Are clients in the private sector of the building industry in South Africa aware of the functionality of BIM technology, and are they requesting its use on their projects?

From this, the following secondary research questions arise:

- Do consultants offer BIM as a value added service, or at an additional cost?

- What makes BIM attractive to Clients in the South African Private Sector?
- Are Clients in the South African Private Sector willing to invest in BIM?
- Is a lack of demand from clients the reason why BIM is being adopted so slowly?

1.4 Aim

The aim of this study will be to assess the slow adoption rate of BIM technology for the functionality of the minimisation of variance orders in the South African private sector, specifically for the function of clash detection. This study will identify whether private sector clients are aware of the technology, and if they are demanding its use on their projects. The study will also aim to find out if construction consultants in the private sector are offering BIM as a value added service or at an additional cost.

1.5 Objectives

The objectives of the research are to identify whether:

- Private sector clients know of, and understand what BIM is.
- Private sector clients are aware of the clash detection functionality of BIM.
- Private sector clients are aware of savings in both cost and time that BIM produce internationally.
- Private sector clients demand BIM as a value added service, or if it is offered to them at an additional cost.
- If Property Developers believe BIM Technology has a future in the Private sector of the South African Building Industry.

1.6 Methodology

The type of research that will be undertaken is of a qualitative nature and will be conducted through interviews based on a prepared questionnaire. The sample size will be small as companies generally have a singular procedure thus multiple interviews per company is not necessary. The research is of an exploratory nature as not much is known on the subject. The study will be aimed at clients in the private sector, also known as property developers. A short description of BIM technology with its benefits will be given to the interviewees to read through before the interview begins. Interviewees will also be asked to rate the benefits of BIM usage on an appropriate scale. The data will then be dissected and analysed. The sample

in small and will not be statistically valid, however as a representation of the more sophisticated private sector developers, it covers a significant part of the market.

1.7 Propositions

1. Private sector property developers stand to gain the most of all project stakeholders from BIM clash detection functionality being used on their projects
2. Thus. private property developers should be the driving force around the adoption of BIM
3. The slow adoption of BIM indicates that private sector property developers are not aware of the benefits of BIM to minimise the variance orders on their projects

1.8 Justification of the Research

This study will be done to analyse the hurdles obstructing BIM integration in the South African private sector market, with special focus the role of Private Sector developers. This technology could be (and is internationally) used to lessen the cost risk factors related to construction i.e. clashes. Lower risk investments will thus lure investors to the South African construction industry.

Knowing whether the technology will become essential to contractors will place more pressure on consultants to receive training in the field of BIM, and also for government to implement a growth strategy for the technology. The use of BIM technology has been shown to reduce wastage on site, which is of benefit to all parties, as well as the environment.

1.9 Delineations

This study will focus on clients in the building industry. They are also called owners or property developers.

This study will focus on variance orders that occur due to clashes only.

The Private Sector in this study refers to developers of office space, retail, and mixed use developments.

This study will be limited to the Private Sector of the South African Building industry, with specific focus on commercial building projects in South Africa.

1.10 Assumptions

International studies regarding the barriers to BIM adoption are assumed to apply to the South African built environment.

1.11 Limitations

This Study will not be able to survey the entire market, but rather clients in the private sector of the south African construction environment with large turnover, or involvement in projects over fifty million rand.

This study does not aim to address the role of legislatory requirements of BIM adoption in the South African construction sector.

1.12 Structure of the Research Report

The report consists of the following chapters:

Chapter 1: Introduction: The Introduction sets out to the reader the concept of Building information modelling. This includes the definition of BIM, along with the different levels of BIM, and its history in the construction industry. The introduction will also highlight BIM's proven advantages in the international construction environment.

Chapter 2: Literature Review: Current Literature is used to educate the reader on the current state of BIM adoption internationally and what barriers have been experienced through the transformational period of BIM adoption. In the text the reader will find what benefits of BIM are currently being enjoyed in the USA as well as the United Kingdom.

Chapter 3: Research Methodology: The use of the research methodology, namely qualitative with quantitative properties is justified in this chapter. The reasoning behind the choice of the questions in the questionnaire is also explained.

Chapter 4: Data presentation and Analysis: All information gathered from interviews will be dissected and tabled. The data will be presented in tables and graphs and the findings will be tied back to the literature.

Chapter 5: Conclusions and recommendations: Based upon the data, conclusions will be drawn and recommendations for the industry regarding BIM implementation will be given.

2 Literature Review

2.1 Introduction

"Building Information Models (BIMs) can support **owners**, designers, and builders in their creation and coordination of the design of building systems and planning of construction work, in their processes for fabrication and building, and in their processes for operating and maintaining, as well as decommissioning their facilities." (Tommelein and Gholami, 2010) This chapter sets out to educate the reader on the definition of BIM, along with its functions, and the barriers to BIM adoption that have been experienced in the construction industry up to now. The problems that are associated with clashes, namely variances and time overruns are also investigated.

The same benefits related to BIM internationally will also apply to the South African market. The proliferance and effects of variance orders internationally are assumed to apply locally. Ibbs, C.W., C.K. Wong and Y.H. Kwak, 2001. Project change management system. J. Manage. Eng. ASCE, 17(3): 159-165.

2.2 What Building Information Modeling is.

Building information modelling or BIM is an integrated computer generated n-th dimensional model that represents a building project and simulates the coordination, planning, building and operation of the project (Azhar, Hein and Sketo, 2008)

The n-th dimension of the model represents to what extent building information modelling has been applied. This ranges from:

- 3D BIM (Includes all three dimensions relating to space)
- 4D BIM (as 3D BIM but with the added dimension of time)
- 5D BIM (as 4D BIM, but with the added dimension of Cost)
- 6D BIM (as 5D BIM, but with the added dimension of facilities management)

Through BIM, the entire project lifecycle can be mapped out, and the benefits of this are discussed in detail in this review.

According to a document named Industrial strategy: government and industry in partnership published by the British Government in 2012, (Building Information Modelling, 2012): "Building Information Modelling (BIM) is a collaborative way of working, underpinned by

the digital technologies which unlock more efficient methods of designing, creating and maintaining our assets." BIM in essence then is making use of digital models to design, build and manage a building.

2.3 The need for Building Information Modeling

Industries worldwide have adopted integrated technologies, with the result being near doubled productivity and competitive gain; however, the construction industry has not done the same (Bernstein and Pittman, 2004). According to Ahmed, Damien and Price (2012) BIM technology stands poised to solve many of the shortcomings of the construction industry.

Below is a graph from the Stanford University's Centre for Integrated Facility Engineering, showing that productivity in the construction industry has declined throughout the technological revolution over fifty years:

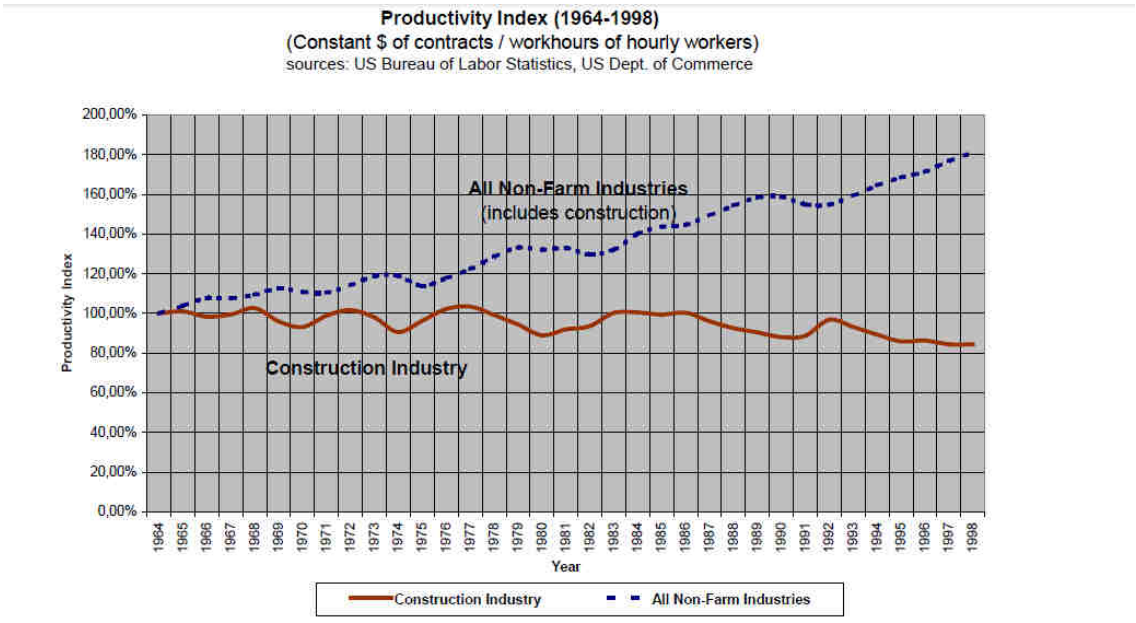

Figure 2.1 The productivity index of the construction industry versus all non-farming Industries (Howard and Andersen, 2000)

From Figure 2.1 above, one can deduce that the average productivity for all industries has steadily been increasing over fifty years, the construction industry has not followed suite, and in fact has declined.

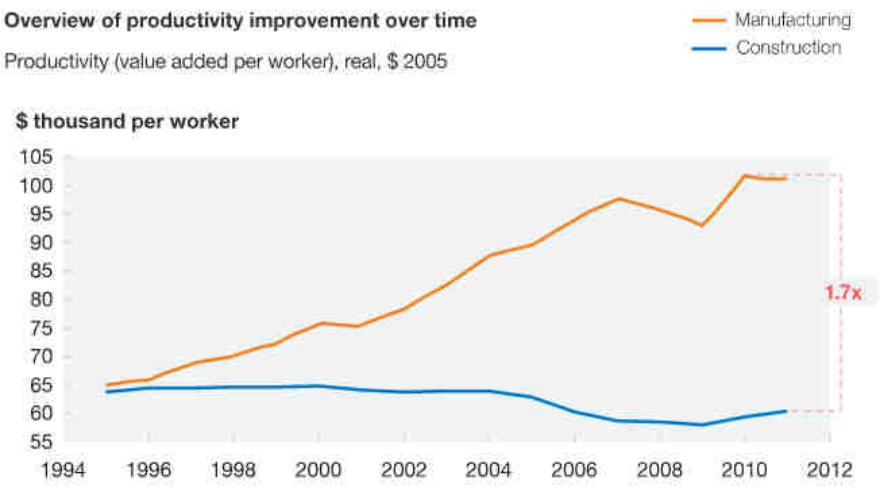

Figure 2.2b (Changali, S., Mohammed, A., Niewland, M. (2015)

The international construction industry is currently undergoing a large scale transformation, and this is due to Building Information Modelling (BIM). This study focuses on large scale property developers, who are generally referred to as the clients in the construction industry.

2.4 The functionalities of Building Information Modelling

Figure 2.2 (Sattineni, 2011) shows that after Architectural Modelling, Clash detection is the most used function of BIM on a project. This speaks volumes for the effectiveness of BIM models. As per the graph below, clash detection is one of the largest benefits of using a BIM design approach to a project.

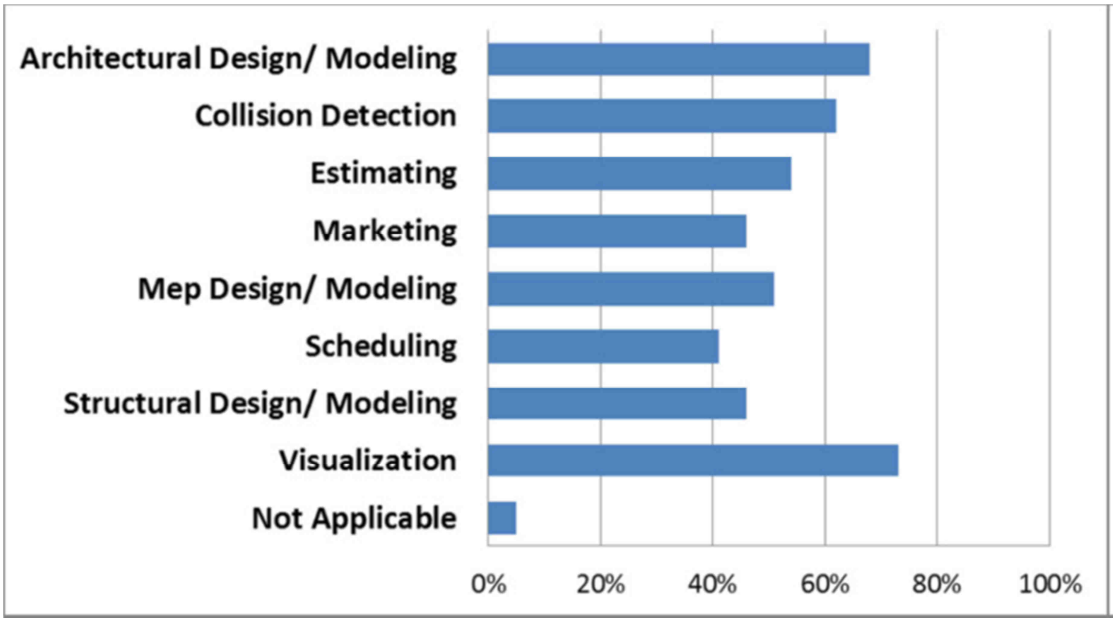

Figure 2.3 The functions that BIM is being used for (Sattineni, 2011)

Apart from clash detection, additional variances can be picked up in a BIM model, which will reduce risks relating to budgets. 'BIM-assisted estimate demonstrated better performance over traditional estimating methods for the entry-level user' (Shen and Issa, 2010).

2.5 The benefits of using Building Information Modeling

The Stanford University Centre for Integrated Facilities Engineering conducted a study (CIFE, 2007) on thirty two large scale projects and found that BIM has attributed to:

- A decrease of up to forty percent in unbudgeted costs on the projects.
- The accuracy of estimates was within a three percentile range
- A decrease in the amount of time required to do cost estimates that equated up to a maximum of eighty percent decrease.
- The contract sum was decreased by an average of ten percent due to clash detection.
- Project times were decreased by up to seven percent.

The significance of this study is paramount, as variance orders due to clashes is a major cost on construction projects. 5D BIM includes the costing aspect of a project. BIM technology has the capability of producing a bill of quantities. By having this information available a Quantity Surveyor can draw up a more accurate estimate of the total cost of the project, as well as reducing the risk of unforeseen costs. Quantity data can also assist the appropriate site

management feature, e.g. site safety, and minimising onsite storage (Arayici, Egbu and Coates, 2012).

The use of BIM technology is a step away from traditional methods. Such a paradigm shift in methods is classically met with resistance in the built environment. Adopting BIM will require consultants and contractors to be retrained, which has cost and time implications for firms. Widespread BIM usage will change the way estimators and Quantity Surveyors work (Whyte, 2012). BIM is being adopted slowly in the UK, the reason being that construction firms are not familiar enough with the technology to use it, which shows a definite reluctance to adopt new methods.

Detailed construction cost estimates require a comprehensive and thorough understanding of the relationships among building systems. (Shen and Issa, 2010). The use of clash detection in the preliminary stages of construction of a project can reduce the need for contingencies. The construction industry is slow to adopt new technologies, as one of the basic rules of reducing risk on projects is to avoid innovative technologies. Ahmad, Demain and Price (2012) states that clients get a better scope and nature of the design, whilst mentioning that BIM helps in construction planning by means of early clash detection (Ahmad, Demain and Price, 2012)

One of the largest risks to most forms of construction contracts is uncertainty, and new technologies bring with them large amounts of uncertainty. This leads us to the question, if a professional has been working in the industry for many years, and has been successful with methods used over his/her career, why would that professional embrace a new technology? "…constructors must retrain their staff to perform estimating activities with the help of BIM technology. The task of training an entire estimating staff is expensive and the question of 'cost of change' is an important one that construction companies must carefully consider." (Sattineni, 2011)

According to Ashcraft (2009) BIM can be implemented in different ways, being split into three general groups:

- The design team (Architects and Engineers)
- In office (a single firm such as the Structural Engineer)
- The project delivery team (including the contractor and consultants)

To effectively detect all clashes the BIM model needs to be used by the entire design team as well as constantly being updated by the parties. The collaboration of all designers of a project is essential for the optimal utilisation of the technology. BIM technology allows for a live model, and as soon as one party updates the model, the other parties become aware of the change, and if need be they can adapt their design as well.

In the USA, many case studies on BIM have been carried out to track the effect that BIM technology has on construction costs, including delays, cost overruns, and misinterpretation of drawings. The average BIM return on investment is 9486%, which clearly depicts its lucrative economic benefits (Azhar, Hein and Sketo, 2009). According to Ahmad, Demain and Price (2012), the cost of BIM implementation is a major limitation to adoption as no clear lines are set out to define the roll out costs. With this knowledge comes the argument that BIM support needs to form part of the consultant's professional fees.

In another study, done on estimators, by Stanetti (2011), Sixty-nine percent selected that BIM has improved the quality of estimating. However, less than thirty percent of larger general contractors selected that BIM has improved the quality of estimating. Ahmad, Demain and Price (2012), argue that BIM can also help with fast financial quantifications of projects. This in itself saves a client money as more designs can be costed so that an informed decision can be made on which design will prove the most lucrative venture.

The building industry is fragmented with each manager using their own methodology, which inhibits the use of a single, coordinated technology. The first reason that BIM is slow to be accepted by all parties privy to its use, is that there is no single platform for professionals to familiarise themselves with. ''The array and deployment of digital tools is thus considered to be fragmentary'' (Bernstein and Pittman, 2004)

Many software companies have their own BIM packages available, and wish to make their product the industry standard. However, these packages are not compatible with each other and as a result many professionals are reluctant to use a different package on every new project. "There is a need to standardize the BIM process and to define the guidelines for its implementation" (Azhar, Hein and Sketo, 2009).

2.6 The Causes of Variance orders

According to Memon, Rahman and Hasan (2014) variance orders can be defined as an "amendment of the original scope of work as in the contract." Variance orders are thus works that need to be executed on site that was not planned or budgeted for.

According to experts in the field of BIM Tommelein and Gholami (2012) there are three types of clashes, and they include:

1. **Hard Clashes:** A hard clash occurs when two or more building components intersect each other on the same plane, hence according to the design they occupy the same space. As this is physically impossible, variance orders come about. Such as when an air conditioning duct has been designed to occupy the same space as a waste pipe.
2. **Soft Clashes:** These clashes are also referred to as clearance clashes. These clashes come about when certain components are closer to each other than what is allowed by building regulations or standards. An example would be when a power cable nearly touches a warm water pipe.
3. **Time Clashes:** These clashes occur when two items occupy the same space at the same point in time, for instance two doors that intersect when opened at the same time.

Engineering and Architectural drawings need to show openings for services, and once a slab is cast or a wall is built, the contractor needs to make use of a coring machine to allow services such as drainage pipes to be installed as designed. The problem originated from a lack of coordination between designers. When clashes between trades are predetermined, Engineers will be able to optimally design their structures without the need to use extra reinforcing to allow for additional core drilling to accommodate clashes between slabs, surface beds, columns, and services. The client therefor saves on the cost of coring as well as reinforcing.

Variance orders can come about in a wide variety of ways. This study will focus on variance orders that occur due to clashes only. According to Tommelein and Gholami (2012) the causes of **hard clashes** include:

Design uncertainty: When a designer has not concluded a final component specification, a placeholder for that item is inserted into the design. The specific component thus potentially has the incorrect dimensions which can lead to a hard clash when the design is completed.
Design rules failure: Designers do not pre determine which service will occupy what spaces on the project, designers thus optimally design for their trade only, and clashes are bound to occur.
Design Complexity: Areas of great complexity may be left for clashes to occur with prior knowledge that the design may change. This is common practice and may have to be resolved during construction.
Deadlines: Designers may leave clashes knowingly, as they have deadlines to meet. This costs the client money, due to a lack of planning by the consultant.
Design errors: This occurs when incorrect dimensions or locations are transferred to drawings that are for construction.

BIM's ability to instantly detect clashes and no margin of error make it more efficient in mitigaring and eliminating hard clashes (Fazli, Fathi and Enferadi, 2014).In regards to soft clashes Tommelein and Gholami (2012) observed preliminarily Place holder items: When two place holder items are used, i.e. blacked out spaces, they sometimes collide without an actual clash occurring. Items may also not allow enough space for access by conventional planning thus an alternative method could be used such as a cherry picker in lieu of scaffolding. The researcher believes that this is also an avoidable error that is caused by human errors like time constraints or laziness.

2.7 The Effect of BIM on variance orders due to Clashes

Clash detection in BIM models can be used to minimise cost overruns due to variance orders. Reise (2011) states that BIM can improve workflow through clash detection and coordination as well as automated quantity take-offs.

According to Suermann and Issa (2007), 70% of respondents agreed that BIM is a potent tool for avoiding errors and minimizing omissions on construction projects. BIM thus can be used to reduce clashes, which in part reduces variances.

2.8 The Value of Design Coordination

Riley and Horman (2001) state that improving design coordination between design consultants project uncertainty can be decreased by decreasing disruption and reducing waste in the construction processes. Hegaszy (2001) argues that detailed design of building projects is a complex multidisciplinary process that needs to produce the required final design documents, and he further states that changes occur often and will need proper management.

Staub-French and Khanzode (2007) states that using 3D BIM as well as 4D BIM for design Coordination has a positive effect on construction Projects and can lead to decreased rework, fewer requests for information, as well as fewer change orders or variances.

2.9 The use of BIM for Design Coordination

From literature it is clear that BIM leads to improved design coordination and can "minimize project uncertainty by decreasing disruption and reducing waste in the construction processes" (Riley and Horman, 2001). According to Riley and Horman (2001) architectural and structural designs are completed before MEP (Mechanical, Electrical, Plumbing) services are designed, leaving only tight spaces for all of these services to utilise.

Design coordination is implemented so that all the services can fit into the required space and traditionally this has been done through manually comparing shop drawings in coordination meetings (Riley and Horman, 2001) and more recently agreed by (Fazli, Fathi and Enferadi, 2014). . To have the entire design team meet and compare drawings takes an immense amount of work and man-hours. With the advent of BIM technology, this can be averted as the model is shared in the cloud and all possible clashes are pre-determined by the program.

2.10 Barriers to the adoption of BIM

There have been many studies on the reasons why BIM technology is not being used, these reasons transcend an unwillingness to try the technology, and delves into problems that are encountered by those willing to test the technology.

The problems encountered by these parties are (Bernstein and Pittman, 2004):

- Data interoperability issues: There are many software solutions available for professionals working on a project. The environmental engineer might use one platform for design whilst the electrical engineer uses an incompatible platform. The data is inoperable and

BIM cannot readily be used to detect clashes. A solution such as a standard format or inter-operable platforms is required.

- Non computable digital design data: Computers are unable to interpret data as humans do, thus manual capture of certain interpretations is necessary. This requires a trained professional to do tedious work. The researcher believes that as the technology becomes more sophisticated, this barrier will fall away.

''… the need for well-developed practical strategies for the purposeful exchange and integration of meaningful information among the BIM model components.'' (Bernstein and Pittman, 2004) The parties might all have data that one party requires, but it might not be readily available to that party. This is where cloud computing comes into play. Cloud computing with relation to BIM is the use of a single model that is loaded on a server and is accessible to all the consultants and other stakeholders. The model is constantly updated and a complete record of changes is kept.

Additionally, Succar (2009) argues that:

- There is a lack of unified implementation plans. Howard and Bjork (2008) claim that parties that have had success with BIM are reluctant to share their process. "Many standards relevant to BIM exist but it was suggested that there is a lack of framework'' (Howard and Bjork, 2008) The reason they are unwilling to share their solutions is a testament to how well BIM works, and how competitive the market is.
- There are legal and contractual liabilities to be considered (agreed by London, 2008). The legal issues include the liabilities that go with the late issue of information, and being able to track exactly who did what and the exact time the design was changed.

According to London, et al (2008) the following barriers have also been observed:

- Cultural and existing work practices. This ties back to the fact that the construction industry is slow to adopt any new technology (which is agreed by Howard and Andersen, 2000), as well as that any new innovations are deemed risky within the industry. Profit margins in building are generally small and an error could make or break a project.
- There is an existent grey area with regards to regulations and ownership of intellectual property. The regulations with regards to BIM need to be accepted and implemented by the relevant governing bodies to negate this risk.

- There are also data security fears, due to the info being available to many parties or stakeholders involved in the project. However the information is not valuable to most. The only rational concern is that consultants fees are based on copywrited information they produce.
- Total cost of implementing BIM for consultants. This point will be one of the main focus points in the analysis of the data gathered from interviewees.
- Client support and business process limitations.

2.11 Shortcomings of BIM

The roll out and usage of BIM technology has not been without disappointments. BIM technology is not a risk free endeavour. An implementation plan and training is required. Furthermore, from London *et al* (2008), the main reasons attributed to BIM failures have been;

- The set up phase was not done correctly, leading to inaccuracies, conflicts, and client disappointment.
- The actual benefits of BIM were not clear, it was also not clear on how BIM was to be implemented on said project.
- There seems to be a common misconception that the entire work practice needs to change. No standards are in place for the BIM environment, and from this information, it is clear to see that there is a need for a BIM manager or coordinator that has the relevant knowledge to steer the project clear of these proverbial pitfalls.

A record of changes to the model might expose late information and open up the consultant to delay claims. ‘’The architects and the engineers may not want to share their models due to risks, liability concerns, unauthorized reuse of intellectual properties and misinterpretation of the information included in the model’’ (Hergunsel, 2011). This may be a reason as to why consultants are reluctant to use BIM technology.

2.12 Design Consultants in the SA Construction Sector

Consultants in the South African construction industry are varied, and include designers, project managers, and quantity surveyors. This study focuses on designers as their services are the ones that clash. According to Designing Buildings(2016) designers in the construction sector include:

- Structural engineers (e.g. WSP and Aurecon): Structural engineers design the frame of the building, ensuring that it can carry the design weights as well as ensuring that openings are in the correct areas.
- Architects (e.g. Paragon, Boogertman, GLH Architects): Architects are responsible for the aesthetics of the building, including the overall design and take ergonomics and anthropometrics into account to create a liveable space that is functional.
- HVAC Engineers: HVAC Engineers are responsible for the heating, cooling and circulation in a building. They require ducts with air conditioners to do this efficiently and correctly. Ductwork often clashes with other services.
- Electrical Engineers: Electrical engineers are mainly focussed on lighting and cabling. To transport their cables they require galvanised cable trays. These can clash with other services.
- Plumbing/Services Engineers: These Engineers are responsible for water reticulation as well as waste water removal from the building. Their services often require coring due to a lack of planning or oversights.

2.13 The current state of BIM adoption in South Africa

According to a 2014 Study completed by Kiprotich, the use of BIM has increased in structural and civil industries in South Africa. Froise and Shakantu (2013) concluded in a study of the South African level of BIM adoption that “twenty one percent of South African Architects were not aware of what BIM technology was, whilst only fifty eight percent were familiar with its use”. See Figure 2.3 below from their research:

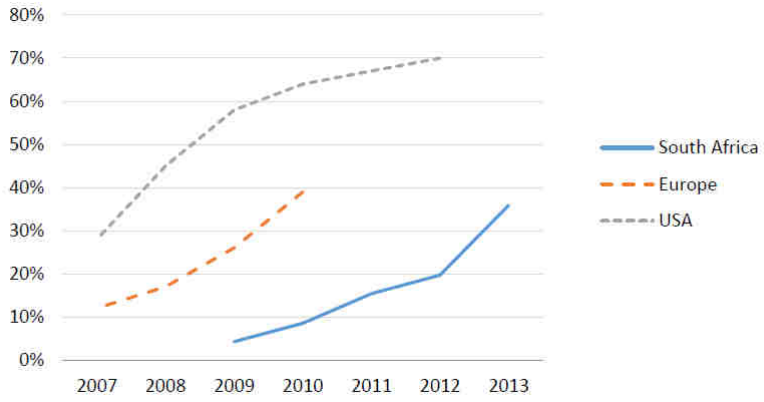

Figure 2.4: BIM Adoption rate in South Africa, Europe, and the USA (Froise and Shakantu, 2013)

The chart above shows the adoption rate of BIM compared with Europe and the United States, one can deduce that South Africa is not on the level of these countries, however recent data from Europe is not presented, and one can assume that the rate of adoption has remained on its trajectory.

2.14 Summary of Key Findings from Literature Review

In conclusion:

- BIM is a digital model of a construction project and simulates the completed design.
- BIM is required on projects to minimise variances caused by clashes.
- The construction industry has historically been slow to adopt change.
- BIM benefits of BIM include better estimates, collision detection, schedule improvements, and better visualisation.
- Variance orders occur due to hard, soft, and time clashes
- Reasons for hard clashes include: Design uncertainty, Design rules failures, Design complexity, deadlines, and design errors. Hard clashes can also occur due to designers using place holder items.
- BIM can be used for design coordination.
- Bariers to BIM adoption include: Data inoperability issues, non-computable digital designs, unavailability of data from other consultants.
- There is no unified BIM adoption plan
- Other BIM adoption probems include : Existing work practices, copyright worries, data security fears, costs associated with BIM adoption, and Client support and business limitations.

These findings form the basis of the research instrument utilised in the empirical study. From the review it is clear that a study is required to identify the disposition of BIM adoption amongst clients for the minimisation of variance orders relevant to the South African building industry.

3 Research Methodology

3.1 Introduction

The researcher made use of existing literature to obtain a detailed understanding of the current status of BIM technology globally and in South Africa. The literature also tested the need for BIM adoption in South Africa

3.2 Research objectives

The researcher's primary objective is to reveal whether clients are aware of the cost saving benefits related to the clash detection functionality of building information modelling. The secondary objective is to find out if designers are offering clash detection as a value added service or as an additional cost item. The sample size is small and interviews will need to be conducted to ensure the interviewees understand the questions and their context, and so that they can expand on their answers when needed. However a prepared list of questions is required to so that data can be presented and analysed in a visual manner, hence in tables and graphs.

3.3 Research philosophy and approach

The researcher aims to identify quantifiable observations and thus the research is of a positivist nature, and is somewhat exploratory. The research approach will be qualitative nature that allows for in depth interviews with key role-players in the industry but with a questionnaire that is prepared. A short introduction to BIM (Appendix 1) will be given to the interviewees before the interview starts to familiarize them with what BIM is as well as its benefits.

3.4 Research methodology (Qualitative with Quantitative properties)

The first step will be to identify the sample of the population that is to be interviewed, which in this case is will be a collection of property developers as well as a small amount of designers. A set of questions relevant to BIM awareness will then be drawn up. The researcher will take care not to ask any leading questions. They questions will then be tested on the researchers report mentor for comment.

3.5 Research method and research strategy

The short introduction to BIM as per Appendix 1 will be given to the interviewees as to familiarise them with the topic. A questionnaire as per Appendix 2 will then be handed to them around which the interview will be based. Each question will be followed by a brief discussion in which the interviewee's personal sentiments will be recorded in excess to the answer to the question. Lastly the interviewee will be able to rank what about BIM appeals to them the most.

3.6 Research Population and Sampling

3.6.1 Population:

The target population is private sector clients in the South African construction industry, also known as property developers. "Property development occurs across many sectors of property which have their own distinct natures (residential, commercial, industrial, hospitality and so on). In addition to this, property development is not of itself 'real estate' but is seen by the author as a particular state of transition or change in the form of real estate toward a different state with an associated change in potential or real value." (Drane, 2013)

The Property developers that are selected will need to be involved with private sector developments that exceed fifty million rand for the construction phase only. At least five such developers will be interviewed and asked to complete the questionnaire.

The clients in the South African Private sector are mostly property developers and these include:

- Eris Property Group: Eris property group was formed in 1998 after RMB Investment Holdings was restructured. They specialise in commercial property and are one of the largest property developers in South Africa.

- Atterbury: Atterbury Property Holdings has a three tiered business model. They are involved in development of property, corporate support, as well as asset management. They have been in the business for over twenty years and are developing such prestigious areas as the Waterfall area in Midrand, including the largest mall in Africa, aptly named the Mall of Africa.

- Menlyn Maine: Menlyn Maine are based in Pretoria and are building Africa's first "Green City". They are developing a precinct based on urbanisation principles. The development will consist of hotels, a mall named Central Square, as well as office buildings and a casino.

- Abland`; Abland specialises in developing property assets. Their portfolio includes commercial and retail developments. They also develop "motor cities" as well as warehousing.

- Growthpoint: Growthpoint is one of South Africa's largest all round property developers. With such projects as the V&A Waterfront in Cape town as well as 100 Grayston Drive Sandton, their knowledge in the sector is unparalleled.

- Zenprop: Zenprop is a large scale property developer with a multitude of iconic buildings in Sandton such as the Alexander Forbs under their belt. They were formed in 1998 and are primarily in the retail, commercial and warehousing centre of the market.

3.6.2 Sampling:

For this study to be successful it is essential that that the correct parties within each company are reached. The target population within each Property Development company will be the person that procures the professional teams leader, the Project manager. Hence the interviewees will be business and project managers within a property development firm. This is not to be confused with the project manager that is part of the professional team of consultants.. Ideally the interviewee will have had experience with BIM, however this is not essential. All interviewees will need to have at least ten years' experience in property development.

3.6.3 Contacting the Research Target Population:

Each interviewee will be contacted individually to set up a meeting lasting approximately fifteen minutes. The interviewees will be identified by the researcher due to his industry experience. The interviewers criteria will be employees at large property developers with projects over 50 million rand, and the interviewees will be in the role of manager for the property developer. All interviewees will need to fulfil all criteria mentioned in the sampling

summary. The researcher will need to travel to all the interviewees place of work as to make the interview convenient for said interviewees.

3.7 Research data analysis

The researcher will interpret the interviews individually and draw conclusions that will then be related to the possible lack of demand from clients is responsible for the slow rate of BIM adoption in the Private sector of the South African building industry. The researcher will also assess whether designers are capable of offering the client clash detection.

3.8 Role of the Researcher:

In order to carry out the research a thorough understanding of the literature was required. The researcher had to rely on the validity of the research of others but was ultimately solely responsible for its validity within this text. The researcher does not see any possible ethical concerns with conducting this research. The research might have a positive effect. This is due to the interviewees being exposed to the findings in the information sheet they are given. As from the literature review Howard and Bjork (2008) claim that parties that have had success with BIM are reluctant to share their process. There is no risk of harming or damaging any individual or company, unless the names of the interviewees is made public.

3.9 Conclusion:

The need for qualitative research mixed with quantitate data capturing and analysis has been made apparent through the literature. It is clear that further investigation is required to identify if BIM is being adopted in South Africa, if Clients are aware of the technology, and if clients are driving the adoption or if they expect it to be a value added service.

4 Data Presentation and Analysis

4.1 4.1 Summary of Research Findings

The interviews were carried out based on a template of standard questions which have been tabled below, however the interviewees were asked to elaborate on their answers if they felt it necessary. These answers will be analyzed and correlated back to the literature. The majority of the private sector role players that develop property have been interviewed, as the researcher set out to interview five of the largest property development companies in South Africa, and a total of eight interviews were conducted. The researcher feels that the market has been successfully surveyed.

One interviewee was unable to complete the interview due to other pressing matters, however I have still tabled the questions answered

4.2 BIM familiarity amongst SA Property Developers

Q1. Before reading the BIM (Building Information Modelling) information sheet, were you aware of the technology?

This question was used to determine if the subject had any previous knowledge of Building information Modelling. This question ties in with the slow BIM adoption rate as discovered in the literature review, and aims to show what the current status is of BIM in South Africa

The interviewees had a choice of either yes, no, or already use BIM on projects. The responses are tabled below:

Table 4.1 Awareness of BIM

Before reading the BIM (Building Information Modelling) information sheet, were you aware of the technology?	**Responses**	**Percentage**
Yes	3	37.50%
No	3	37.50%
Yes and I already use BIM on projects	2	25.00%

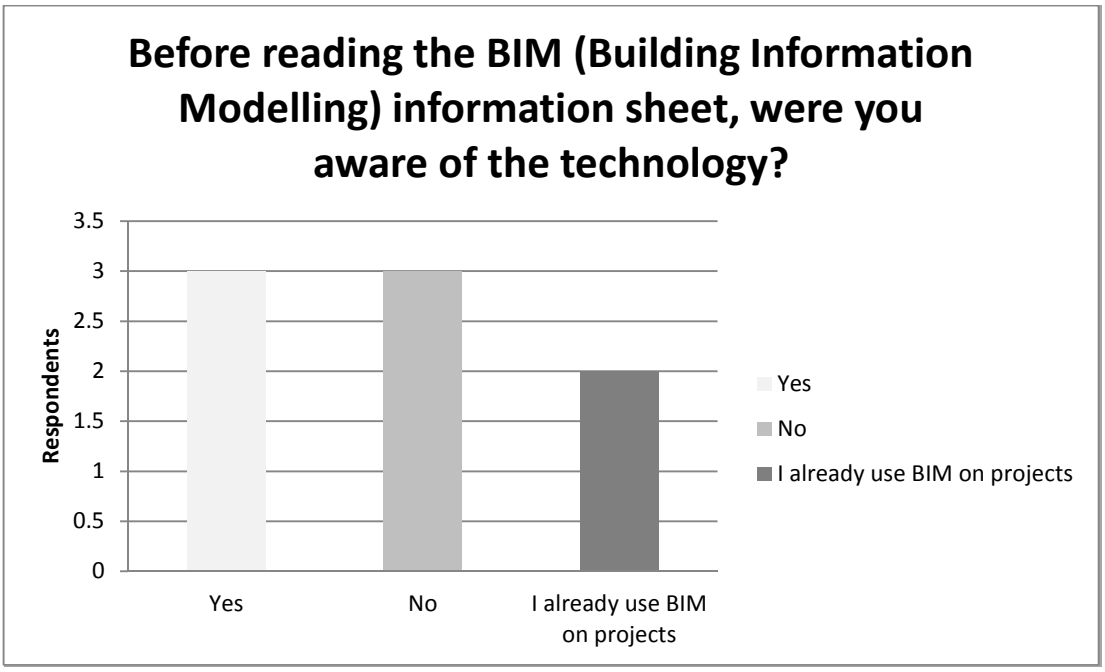

Figure 4.1.1: BIM awareness before reading info sheet

A total of 62.5% of respondents were aware that BIM and clash detection technology existed before reading the information sheet, and 25% of those respondents are already using BIM technology on their projects. 37.5% of respondents had no previous knowledge that the technology existed.

There was a 35% adoption rate for BIM in 2013 (Froise and Shakantu, 2013), and from my findings there is only a 25% adoption rate, however this may be due to the sampling method the researcher used, namely projects over 50 million rand in the private sector. The fact that 37.5% of clients in the private sector are unaware of the technology only accentuates the problem. There was one respondent that was also unaware that clash detection is a function of BIM, as seen in the response in question 2.

4.3 Awareness of benefits of clash detection

Q2. Before reading the information sheet were you aware of the benefits of clash detection?

This question was asked to find out firstly if respondents were aware that BIM technology entails the use of clash detection, and secondly if they knew what the benefits of clash detection were. The responses are tabled below:

Table 4.2: Awareness of clash detection

Before reading the information sheet were you aware of the benefits of clash detection?		
Yes	6	75.00%
No	2	25.00%

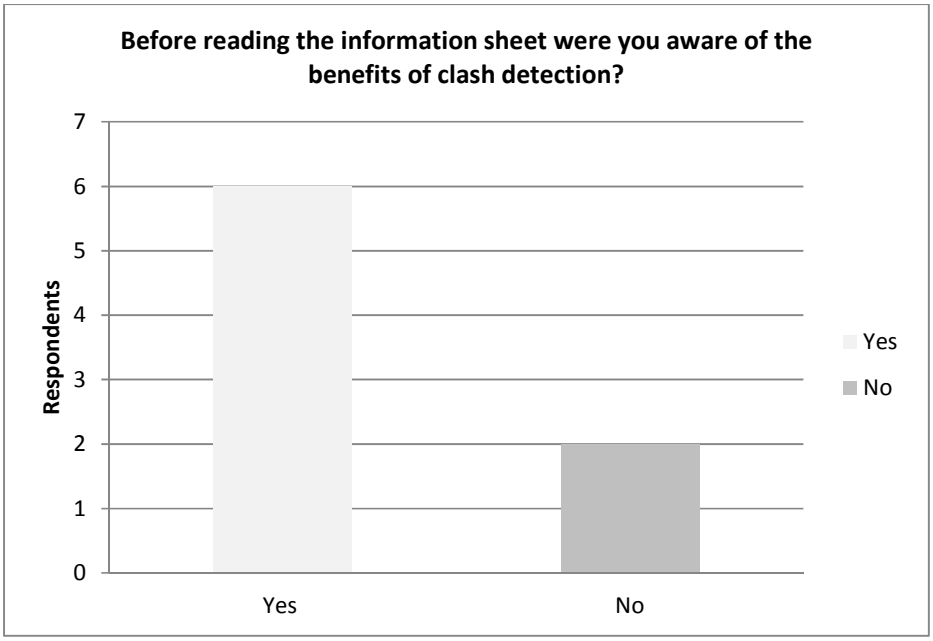

Figure 4.2: Awareness of BIM

The majority (75%) of the subjects knew that clash detection provides a benefit to projects. One respondent was aware of the benefits of clash detection but has never heard of BIM, which shows a disconnect between the clients and the consultants. This may be one of the factors that contribute to the slow rate of BIM adoption in the private sector in South Africa.

The respondents were thus generally aware of clash detection, but not as a function of BIM, but rather clash detection in different forms, ie electronic, on site, or via drawing integration. From the literature it was found that design coordination using BIM has a positive effect on construction projects by decreasing rework and change orders (Staub-French and Khanzode, 2007)

4.4 Awareness of the costs associated with clashes.

Q3. Are you aware of the costs associated with clashes on your projects, and what percentage of the total cost can be attributed to them?

The interviewees were asked this question so that the interviewer could get a clear understanding of how much of their costs are associated with changes due to clashes on their projects. Please note that one respondent skipped this question.

Table 4.3: Awareness of the effect of clashes

Are you aware of the costs associated with clashes on your projects?		
Yes	6	85.71%
No	1	14.29%

All respondents except one claim they are aware of the costs associated with clashes occurring on their projects, however only four of the six positive respondents could estimate a percentage of their costs that are attributable to clashes. The fact that there is a detachment between what the client is aware of, and the actual costs incurred on site, may also be one of the reasons BIM is not being adopted in South Africa.

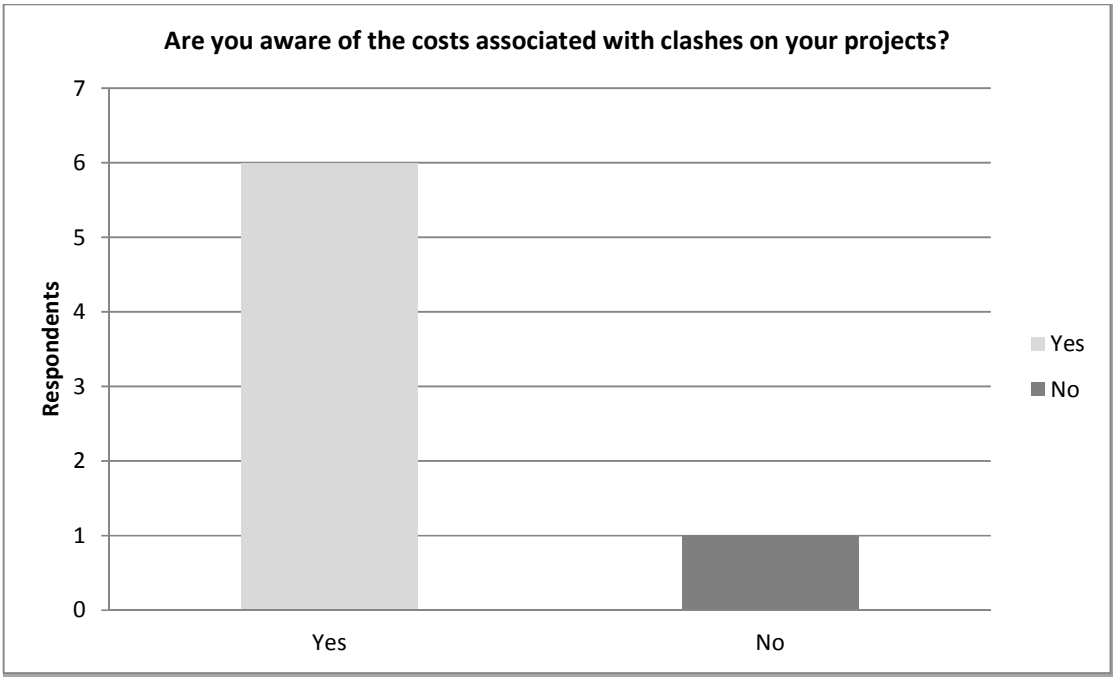

Figure 4.3: Awareness of the effects of clashes

The individual responses relating to the percentage of costs associated with clashes are tabled below:

Table 4.4: Percentage of costs on projects related to clashes

Response	Individual	BIM?
Yes	10-15%	Not a BIM User
Yes	10.00%	Not a BIM User
Yes	5-10%	Not a BIM User
Yes	2.50%	Already uses BIM

From the table it is clear that the BIM user has significantly lower costs associated with clashes on their projects. This is backed up by Reise (2011) who states that BIM models can be used to minimize cost overruns due to clashes. The average cost is about 8% however the BIM user has a 2.5% of project cost expenditure related to clashes. This finding also reinforces the finding from the literature in which seventy percent of respondents agreed that BIM is a potent tool to eliminate errors (Suerman and Issa, 2007).

4.5 The state of clash detection offered as a value added (cost free) service by consultants.

Q4. Is clash detection offered to you as a value added (cost free) service by consultants?

In order for the interviewer to obtain a clear picture of the barriers to adoption, the cost element of BIM needed to be looked at, with consideration to the initial input costs for all parties involved. The results of the question are tabled below:

Table 4.5: Clash detection as a value added service

Is clash detection offered to you as a value added (cost free) service by consultants?	Result	Percentage
Yes	2	28.57%
No	4	57.14%
Unsure	1	14.29%

The respondents that do use BIM both stated that the use of BIM is a value added service and they do not pay anything extra. The remainders of the respondents do not use BIM, and thus their responses are as to be expected. One respondent was unsure of whether BIM was provided, which, as in question 2 highlights the disconnect between the client and the consultants.

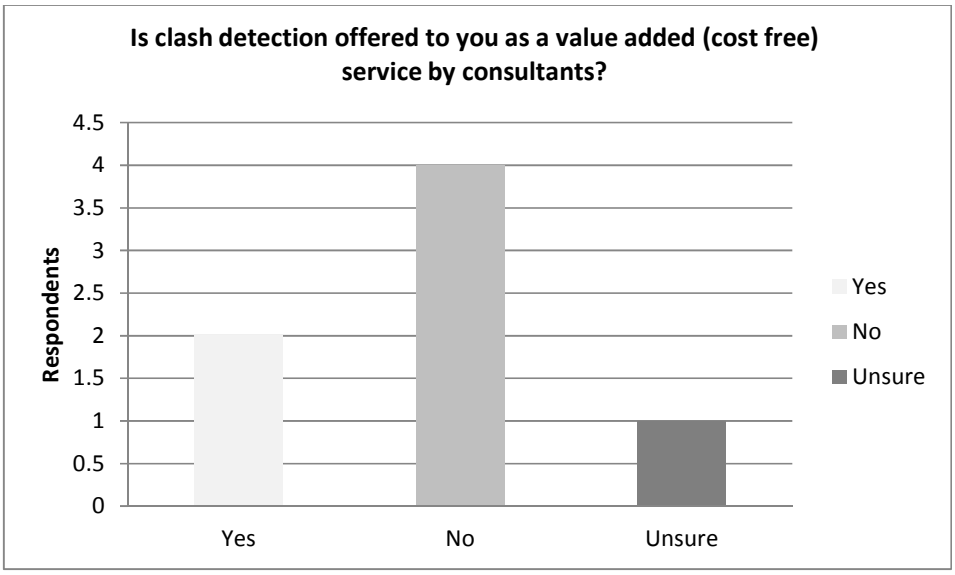

Figure 4.4: Clash detection as a value added service

4.6 Clash detection as a value added service provided by engineers and architects

The reason this question was asked was so that the researcher could gauge whether clients feel like they should be paying for the technology, or if they should receive it on all projects at no extra cost.

Table 4.6: Clash detection as a value added service

Do you believe clash detection should be a value added service provided by engineers and architects?	
Yes	7
No	0

All respondents believe that it is not up to them but rather the consultants to ensure that they are using BIM technology to detect clashes on their projects. All clients believe that it is up to the people they hire to lower costs on their projects. London et al (2008) found that one of the barriers to BIM adoption was the total cost for consultants to implement BIM on their projects.

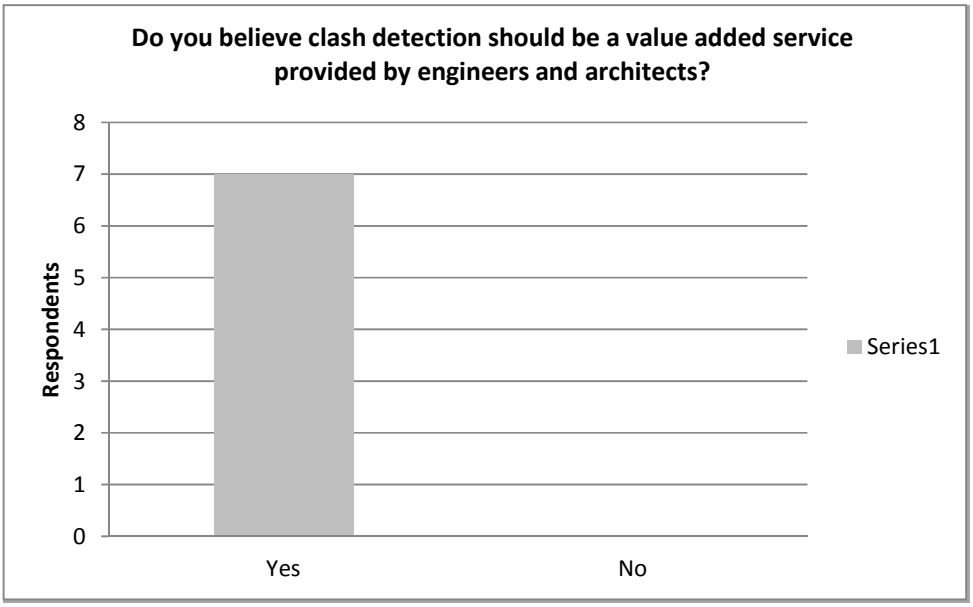

Figure 4.5: Property developers view on clash detection being a value added service.

4.7 Property Developers' willingness to adopt BIM

The researcher asked this question to see whether clients in the private sector would be interested in using the technology on future projects. Interviewees who already use BIM were not asked this question

Table 4.7 Willingness to try BIM by property developers

If you are not implementing BIM on your projects, would you consider using it on a future project?		
Yes	6	100%
No	0	0%

100% of respondents would like to use BIM on their projects in future however 0% of them are willing to pay an additional fee for the service. London et al (2008) stated that one of the barriers to BIM adoption is a lack of client support, which is contrary to what has been found in this study.

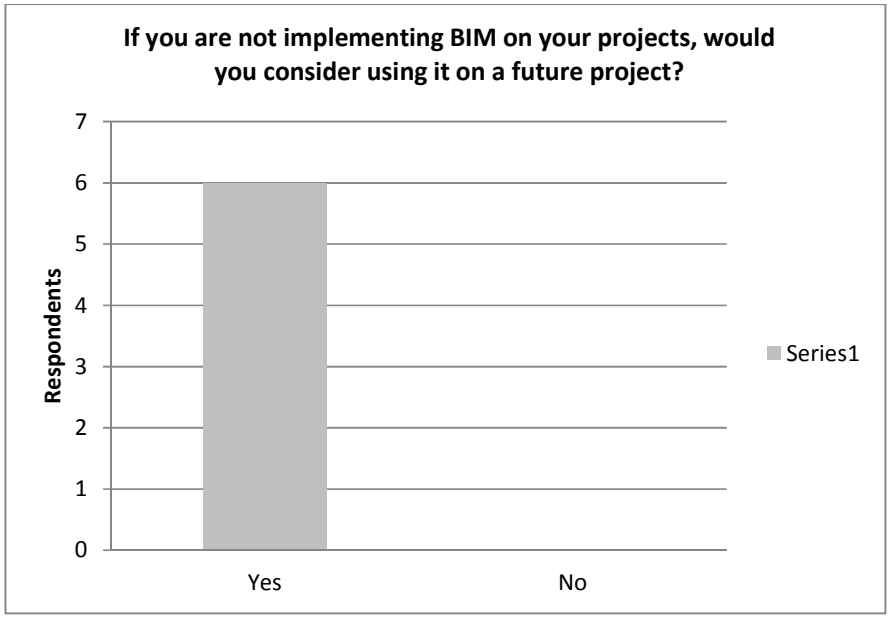

Figure 4.6: Possibility of using BIM on future projects

The interviewer also asked why the interviewees would like to use BIM. The reasons are stated below:

Four respondents agreed that they would benefit from cost and time savings on their projects, while one respondent stated that the benefit of design coordination would minimise arguments between consultants. One responded stated that he was only interested in cost saving as the form of contract used puts the onus of completion on the contractor. A further study into what benefits BIM holds for contractors in South Africa would be interesting.

4.8 Do you believe that Property Developers should be the driving force behind BIM adoption?

This question was asked to find out if clients feel like they have the responsibility of ensuring that their projects are using BIM to minimize cost overruns.

Table 4.8: Property developers as the driving force behind BIM

Do you believe that Property Developers should be the driving force behind BIM adoption?	Responses	Percentage
Yes	2	28.57%
No	5	71.43%

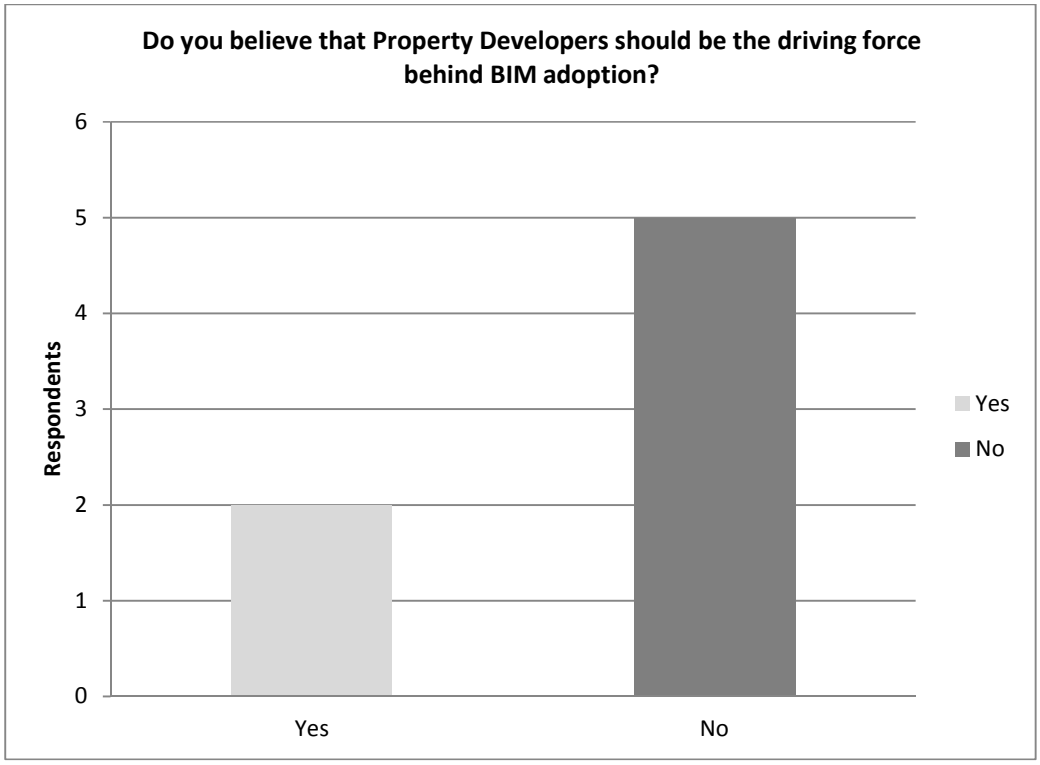

Figure 4.7: Property developers as the driving force behind BIM

All respondents were asked to elaborate on why they feel they should or shouldn't be the driving force behind BIM adoption. The responses are analyzed below.

One respondent, who answered no, feels that BIM should be a standard service offered by consultants.

Two negative respondents feel that BIM "should be driven by the professionals/consultants" and that they pay a premium so that the consultants have their best interests at heart.

Two respondents agreed that the Principal Agent or Project Manager that they appoint should drive BIM on their projects

One respondent who said yes stated that because "Property developers would reap the maximum benefit in terms of Managing Contractors. Clashes will be reduced; hence changes to the Contract will be kept to a minimum."

4.9 The willingness of Property developers to pay for BIM and clash detection training for the engineers and architects.

This question was asked to determine whether clients would be willing to invest in the technology if it meant they would benefit further down the line.

Table 4.9: Willingness of property developers to pay for BIM training

Would you be willing to pay for BIM and clash detection training for the engineers and architects on your projects?	**Response**	**Percentage**
Yes	1	14.29%
No	6	85.71%

One respondent said *"no, the technology is already adopted by our key consultants"*. The researcher then asked if this was not the case, would they pay for the training, to which the interviewee replied that they would not as it is a pre requisite for his company.

One respondent said no, engineers & architects must have knowledge of BIM. *"I would look for an Engineer or Architect who is fully capable of using BIM Software."*

One respondent said no, BIM is in the realm of the professionals. The interviewee stated "They also get other benefits from the modeling."

One respondent said no, professionals must pay for this training as this should be part of the service they offer.

One respondent said no, training should be at own cost.

One respondent said no, they (the consultants) should know as they are professionals.

One respondent said yes, they would pay if it offered a return on investment.

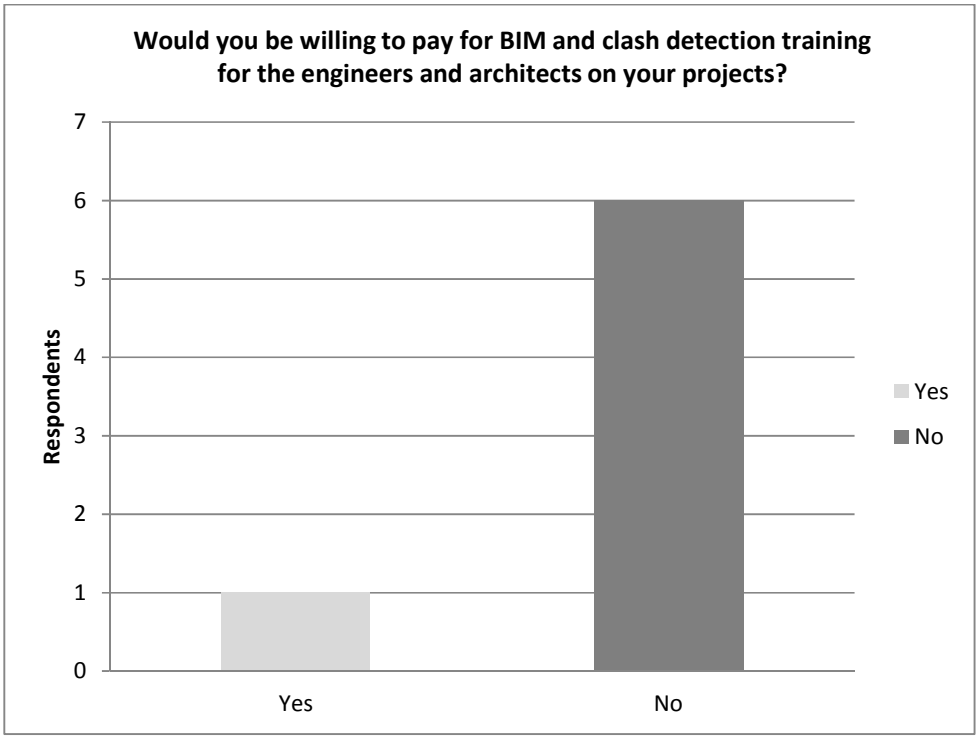

Figure 4.8: Willingness of property developers to pay for training

Only one interviewee was willing to pay for the BIM training, however from a study conducted by Azhar, Hein, and Sketo (2009) found that those that invested in BIM had an average return on investment of 9486%. The lack of a willingness to pay roll out costs for BIM seems to be a large barrier as also found by Ahmad, Damien,and price (2012) , where they list the roll out cost of BIM to be a major limitation.

The future of BIM has a future in the South African private sector as seen by Property Developers

This question was asked second to last as the interviewees had now understood the subject matter, namely BIM. The reason for the question was to see if based on the limited information they had been given on the info sheet, Clients in the private sector believed that BIM had a future in the South African Private Sector.

Table 4.10 Future of BIM in South Africa

Do you believe that BIM has a future in the South African private sector?		
Yes	7	100%
No	0	0%

100% of respondents agreed that if BIM did offer the same benefits as seen globally, it did in fact have a place in the South African construction industry. Their opinions are based on the information that was available on the info sheet given to them, however several respondents seem to doubt the data in the info sheet.

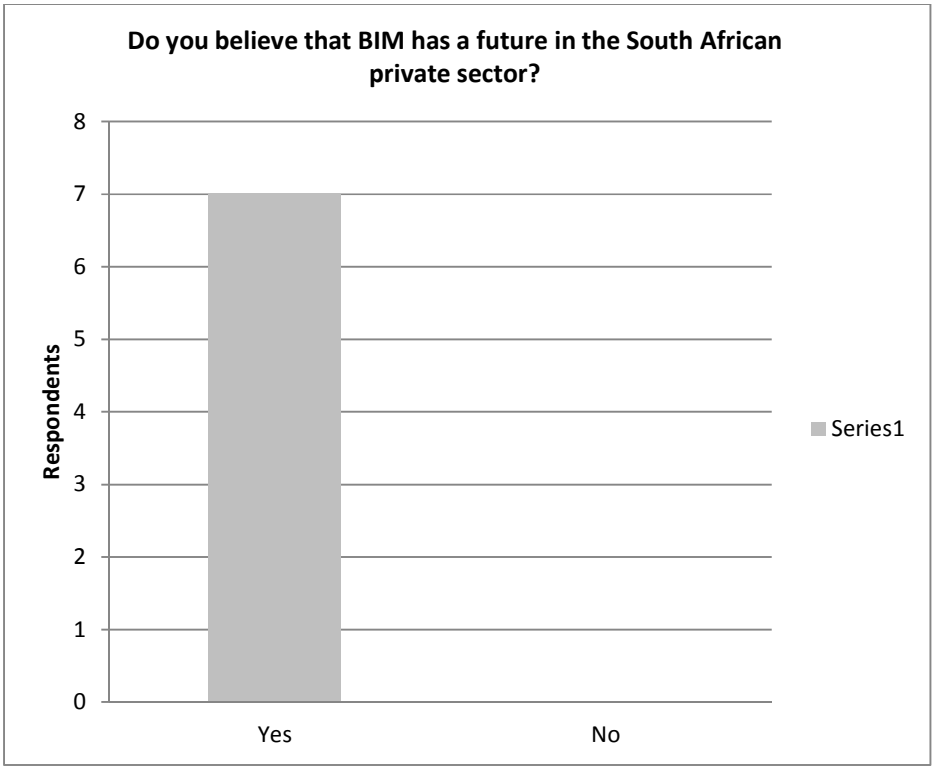

Figure 4.9: Future of BIM in South Africa

All respondents were then asked why they believed that BIM does have a future in South Africa.

Three respondents said that it was due to the potential cost and time savings.

One of the respondents that already uses BIM stated “First world countries are already implementing BIM which in turn will draw attention from countries who are not using this software.”

One respondent stated “Any saving would be welcome. The economy is going through a difficult time and returns are tight. If implementation can save as much as is contested by Stanford then it definitely has a place going forward.”

4.10 Benefit rating Matrix

All respondents were asked to rank how appealing each of BIM’s benefits are to them on a scale of no appeal to extremely appealing.

Table 4.11: Benefit rating Matrix

Benefit	No appeal	Barely appealing	Moderately appealing	Very appealing	Extremely appealing
Reduced project costs			1	4	2
Reduced time to complete projects			1	3	3
More accurate estimates of project costs			1	4	2
Reduced conflict between consultants			1	3	3
Less coordination meetings			4	1	2

Table 4.12: BIM Average appeal of Benefits

Benefit	Weighted Average
Reduced project costs	4.14
Reduced time to complete projects	4.29
More accurate estimates of project costs	4.14
Reduced conflict between consultants	4.29
Less coordination meetings	3.71

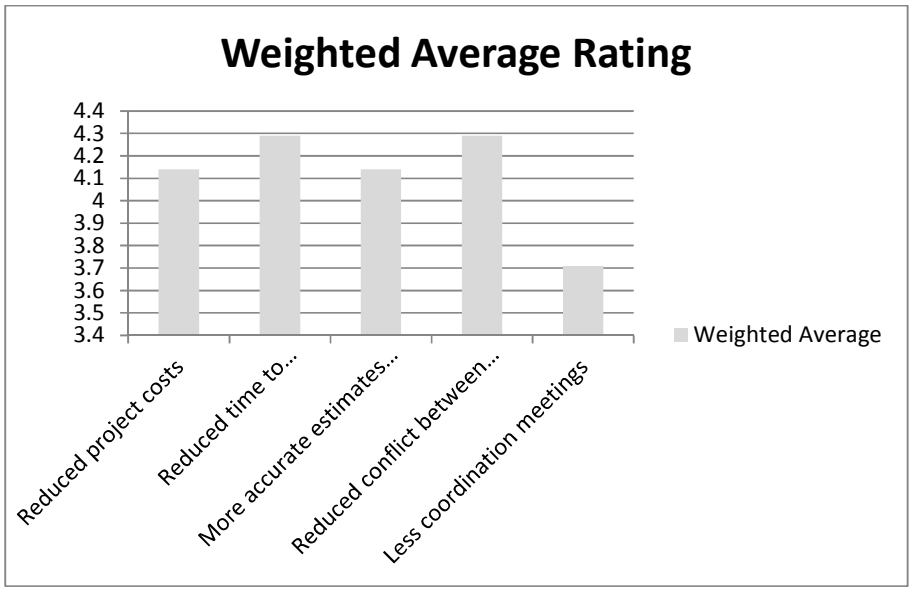

Figure 4.10: Weighted Average ratings

4.10.1 Reduced Project Costs

This benefit scored an average of 4.14 / 5 and is tied for second most appealing.

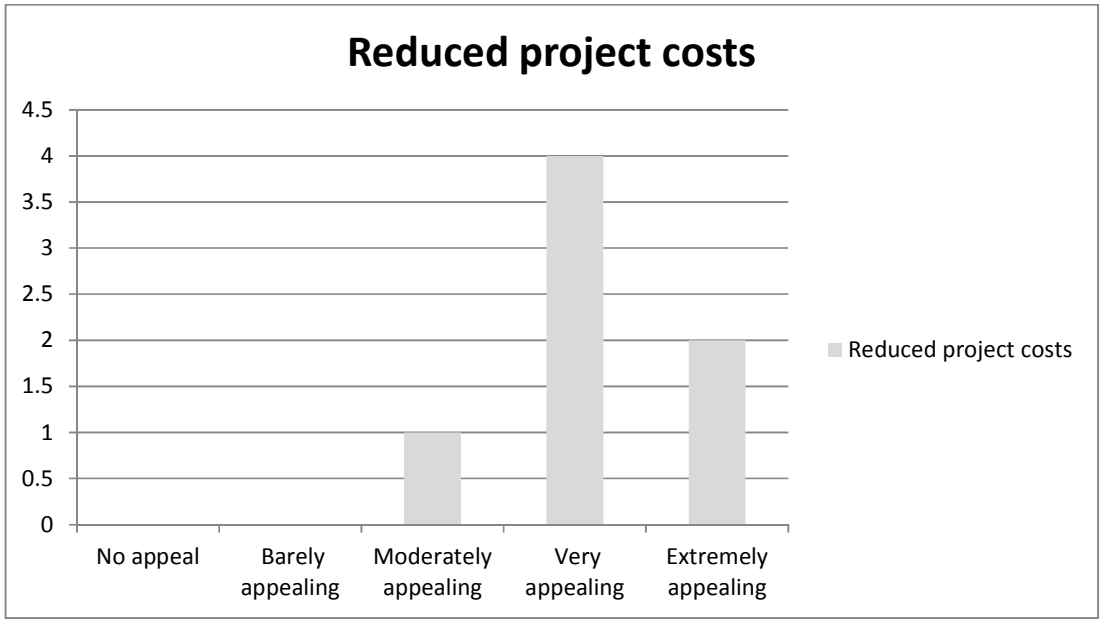

Figure 4.11: Reduced project cost

4.10.2 Reduced time to Complete

This benefit scored an average of 4.29 / 5 and is tied for most appealing.

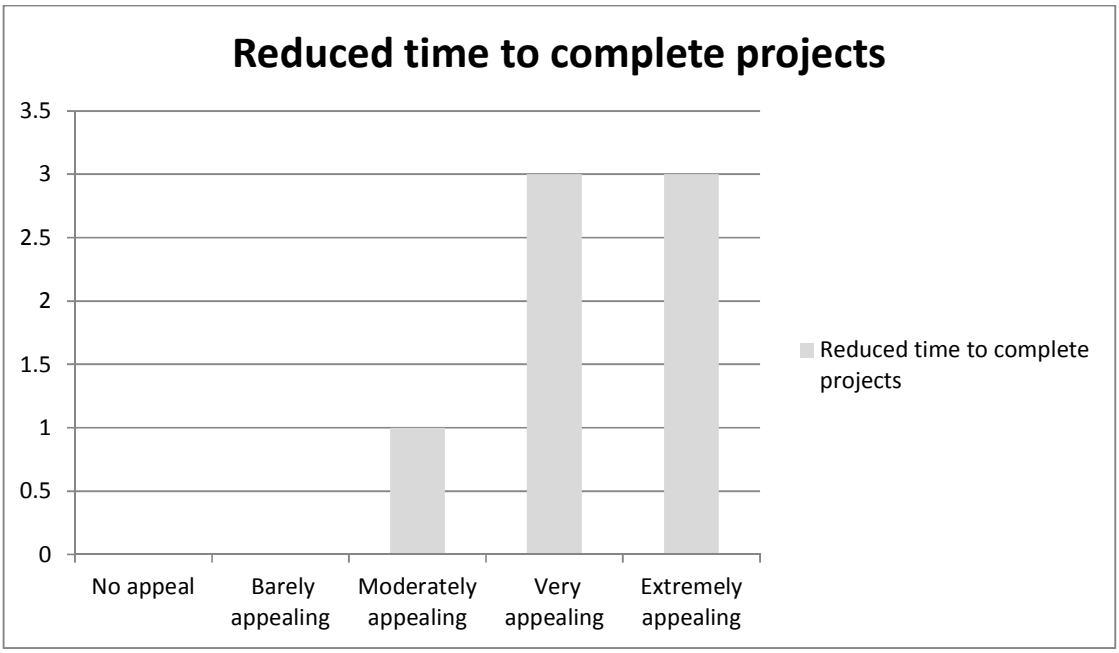

Figure 4.12: Reduced project durations

4.10.3 More accurate estimates of project costs

This benefit scored an average of 4.14 / 5 and is tied for second most appealing.

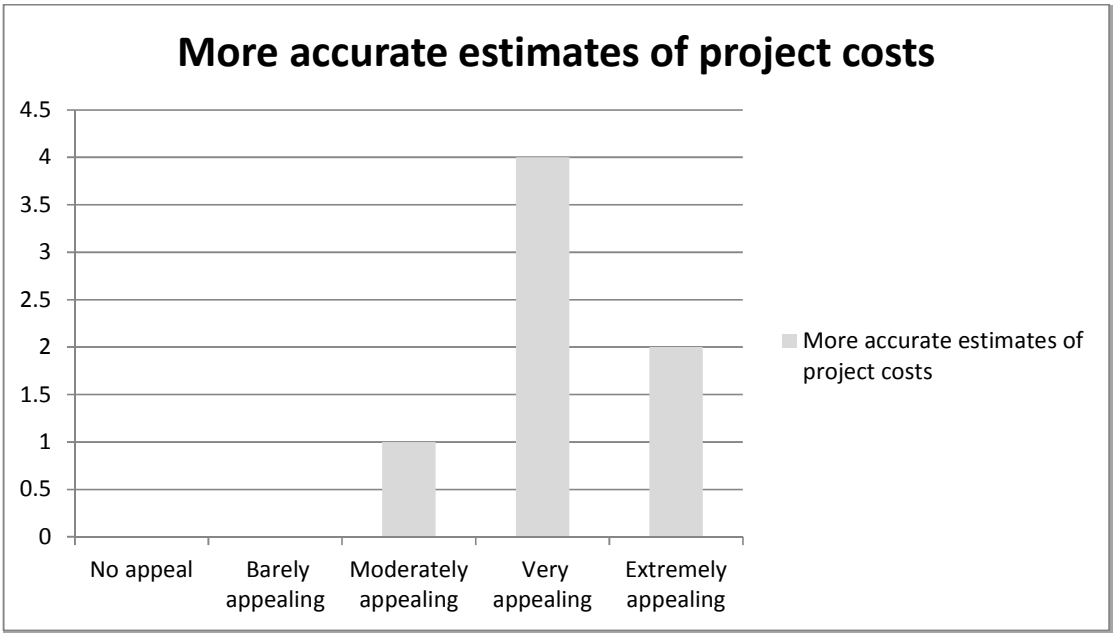

Figure 4.13: Accuracy of estimates

4.10.4 Reduced conflict between consultants

This benefit scored an average of 4.29 / 5 and surprisingly is tied for most appealing

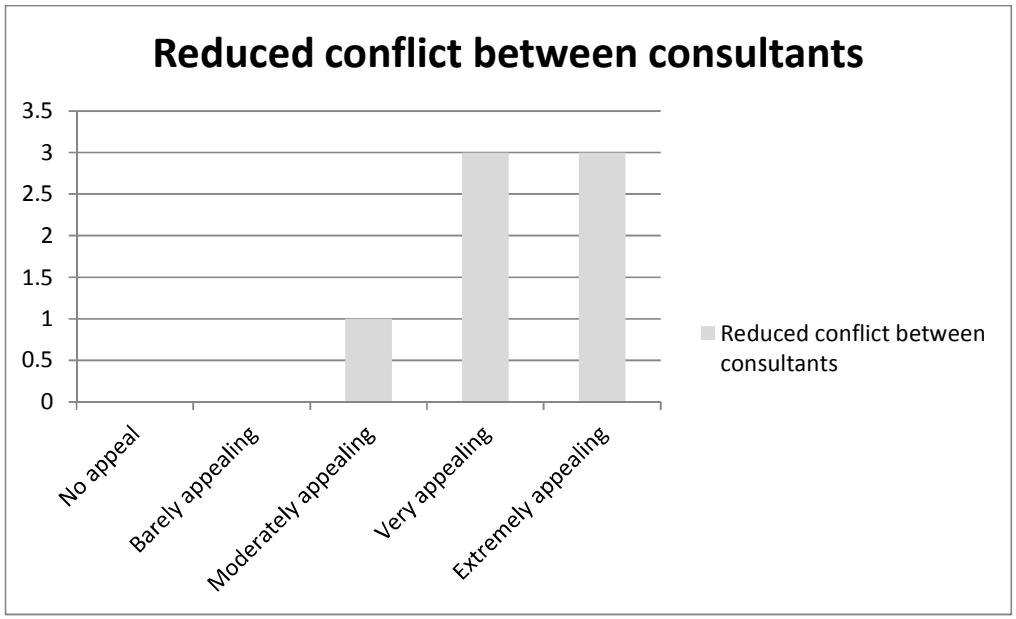

Figure 4.14: Reduced conflict between consultants

4.10.5 Less coordination Meetings

This benefit scored an average of 3.71 / 5 and is the least appealing.

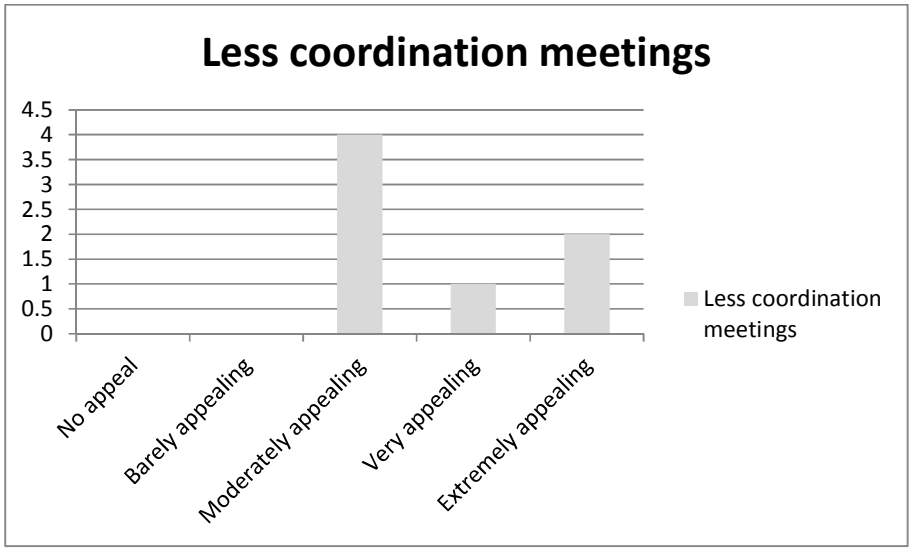

Figure 4.15: Less Coordination Meetings

4.10.6 Summary of Key findings

From the analysis of the data above the key findings that came from the research are:

- 37.5% of respondents had no idea what BIM was.
- The adoption rate of BIM in the target population is 25%
- 75% of respondents knew what clash detection was.
- There is a disconnect between clash detection and BIM.
- Costs associated with clashes are an average of 8% of the total contract value.
- Two respondents already use BIM clash detection and both are given BIM as a value added service.
- All respondents believe BIM should be given to them free of charge.
- All respondents who do not use BIM said they would be willing to try it.
- Only one respondent is willing to drive BIM, the rest believe it should be consultant driven.
- Only one respondent is willing to pay the start up costs for BIM
- All respondents believe that if BIM is all it makes out to be, it definitely has a future in South Africa
- Reduced project durations and less conflicts between consultants were ranked as the most attractive qualities of BIM.
- More accurate estimates and reduced project costs were tied for second most attractive
- Less coordination meetings was seen as the least attractive quality of BIM

5 Conclusions and Recommendations

5.1 Introduction and Purpose

The primary goal of this research study was to find out if BIM technology, and specifically its clash detection function, is being utilized by large property development companies in the private sector of the South African market.

A literature review was undertaken to find out what the current state of BIM adoption in South Africa was. The literature review also identified the benefits of BIM adoption along with the roadblocks that needed to be overcome in other countries before BIM was accepted as a viable method to manage a project.

To achieve this objective, companies that were identified in the research proposal were approached, and their elected agents were questioned. The questions centered on whether the property developers were aware of BIM technology, and if they were willing to be the driving force behind implementation. A questionnaire was created using knowledge gained in the literature review and this was the primary research tool used in this study.

5.2 Objectives

The first objective the researcher set out to identify was if private sector clients know of, and understands what BIM is

The second objective was to identify whether private sector clients were aware of the clash detection functionality of BIM.

The third objective was to identify whether private sector clients are aware of the savings in both cost and time that BIM yields on the international market.

The fourth objective was to identify whether private sector clients demand BIM as a value added service, or if it is offered to them at an additional cost.

The final objective was to identify whether property developers believe BIM Technology has a future in the Private sector of the South African Building Industry.

5.3 Findings

From all the property developers or “clients” that were surveyed, thirty seven point five percent were unaware of BIM technology and its benefits. A further thirty seven point five percent were aware of the technology and do not use it. Only twenty five percent of the clients were using BIM on their projects. Thus seventy five percent of those interviewed do not make use of BIM or clash detection on their projects. This shows that specifically amongst the larger property development companies, BIM is not making any headway. Previous studies that were undertaken showed BIM adoption in South Africa to be at thirty five percent (Froise and Shakantu, 2013), however the target population in this study was narrower.

Only a small percentage of interviewees were not aware of the benefits of clash detection, and clash detection seems to be marketed separately from BIM. The reason for this could form part of a future study.

Almost all respondents claimed that they knew what the extent of costs overruns due to clashes on their projects were, yet only half could estimate a percentage of the total project cost. The average percentage was just over eight percent and the one respondent that already uses BIM placed his cost at two and a half percent, thus there is a significant reduction in overruns on the projects with clash detection, which equates to a four and a half percent saving in total cost of the building. This is in line with the Stanford study that estimated ten percent reduction in costs due to clash detection (CIFE, 2007).

It was found that clients that already make use of BIM on their projects do not pay any additional fees for the service. The service is used by their consultants to stay competitive in the market. Over seventy percent of respondents had never been made aware of BIM technology by their consultants, and do not currently receive the service or have access to that functionality.

All of the respondents agreed that BIM and clash detection should be a value added service that is provided to them by consultants. All respondents who do not currently use BIM said that they would be willing to use it on future projects. This is most likely the root cause of the slow adoption of BIM in the private sector in South Africa. It may be that consultants do not want spend money on training and software, as they will not be compensated for it by the

clients. Clients do not drive BIM adoption as they are not truly aware of the benefits it holds, because consultants do not make them aware.

Eighty percent of clients believe that they should not be the driving force behind BIM adoption. This is another reason for the slow adoption rates of BIM in South Africa. It seems that no one wants to be the ones to put their neck out and try the technology. A future study on why consultants are not implementing BIM and clash detection would be beneficial.

Eighty five percent of clients are not willing to pay for training for consultants. The consensus is that it is the duty of the consultant to provide the best possible service to the client. This highlights once again the fact that clients do not see themselves as the driving force behind the adoption of new ideas and technologies in general.

The most positive outcome of the study was the fact that all respondents, after reading the information leaflet, believe that BIM and clash detection has a future in South Africa. This is due to the cost and time saving benefits that are seen on BIM enhanced projects.

The respondents were asked to rate the benefits of BIM adoption and the outcome from most desirable to least were as follows:

1. Reduced time to complete projects
2. Reduced conflict between consultants
3. Reduced project costs
4. More accurate estimates of project costs
5. Less coordination meetings

It was interesting to see that the time to complete projects was more beneficial to the clients than reduced project costs. This may be due to the opportunity costs of opening their stores/offices earlier to generate revenue faster.

Less coordination meetings was last on the list as clients generally do not have to attend these, and do not know the extent of frustration that is generated.

The reduction of conflict between consultants scored high on the list. This was surprising as it scored higher than total project cost. A future study on this would be highly beneficial.

5.4 Research question answered

Are clients in the private sector of the building industry in South Africa aware of the functionality of BIM technology, and are they requesting its use on their projects? From the study, it can be deduced that less than forty percent of property developers know about BIM. The other property developers are aware of BIM's existence, but their knowledge is limited. This in part is due to the fact that most property developers felt that consultants should be driving the technology because the designer should have his clients' best interests at heart. A common point on all interviews was that property developers refuse to be held responsible for rolling out BIM on their projects and that they are not willing to pay for the service. They are not requesting BIM, because they do not want to be held liable for the costs, as they believe the costs should be borne by the designers.

5.5 Recommendations

Through the course of this study it has become clear that BIM and clash detection is of great benefit to any project, and that all consultancy firms and property developers should invest in the technology to save time and money.

The researcher recommends that consultants make themselves familiar with BIM and train their staff to work with the technology before the clients start calling for BIM implementation, because other firms will start to offer clash detection as a value added service. As seen in the United States as well as in Europe, BIM is here to stay, and those that refuse to adapt will find themselves irrelevant in the very near future.

With regard to the current slow adoption rate, the South African government might have to implement legislation as has been done in the UK. This will increase exposure to the technology by consultants and contractor. Clients do not believe that they should be involved in the adoption process and a South African case study on the effectiveness of BIM and clash detection on a project in the private sector would greatly benefit the cause.

Companies that sell the software will also need to be more aggressive in their marketing, as such a small percentage of clients are aware of the benefits of BIM. If the products were marketed directly to clients, they could insist on its use on their projects, which would force consultants to adopt.

Building information modelling still has a long way to go before it becomes the south African standard, and will require the collaborative efforts of government, clients, consultants, and software developers.

5.6 Reflection

This study has enriched the researcher's knowledge of BIM technology. The reason this topic was chosen at the beginning was because the researcher felt his knowledge of the subject matter was lacking. Through all the weekends and holidays that were sacrificed to complete this research, the researcher feels he achieved what he set out to do, which was to gain knowledge in the field, and contribute in the small way that he has.

Thinking back at the person that started writing the first research proposal and the person that has completed this document, the experience has been enriching. The researcher truly believes that BIM will change the way buildings are built in South Africa and is satisfied that the findings in this paper, or the contact that was had with clients, may convince someone to try BIM on one of their projects or for another researcher to create a case study on BIM in the South African building environment.

5.7 Possible future studies

1. A case study on BIM usage on a project in the private sector of the South African building environment. This would also benefit from a total outlay for BIM versus the total saving.
2. Why clash detection is marketed separately from BIM.
3. Who is considered to be the driving force behind BIM worldwide (clients, government, consultants), and is the same true for South Africa.
4. Why consultants in South Africa do not offer BIM as a standard value added service.
5. A study on BIM legislation in the UK and how that would translate to the South African Market.
6. A further study on the benefits BIM could hold for Contractors in South Africa
7. A study on the proliferance and effects of variance orders internationally and if the same applies locally.

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Questionnaire

Title of Study :

The proliferance of BIM adoption amongst Clients for the minimization variance orders relevant to the South African Building Industry

Introduction:

Thank you for taking the time to participate in this study. We greatly appreciate that you have taken a few minutes of time from your busy schedule to complete this questionnaire. The goal of this study will be to determine why BIM adoption in South Africa is so slow and if Property Developers are requesting this service from consultants.

The study is structured as a questionnaire with 16 questions and should not take longer than 10 minutes to complete. The study focusses solely on property developers in Gauteng, South Africa.

All participants will have the option to remain anonymous and no company or individual names will be mentioned in the analysis of the data gathered. Further all raw data will be disposed of after the study is complete. The researcher will only reveal sources if required to do so by law.

Please contact Tian Weitz on 078 9602 645 if you have any further questions.

Consent Form:

By signing below the participant agrees to participate in the study and that all information gathered from the participant be used in the analysis. The participant further agrees to answer all questions truthfully.

Signature of representative:

Please read through the short introduction of BIM below and then answer all questions:

Summary of Building information modelling for distribution to interviewees:

BIM or building information modelling is a digital model that is shared by all the consultants and designers, as well as the contractor. One of BIM's key features is the ability to detect clashes between services, such as an air-conditioning duct that intersects a sprinkler pipe. Traditionally these clashes are only detected on site.

A 2007 study at Stanford in the United States concluded that BIM was attributed to:

- A decrease of up to forty percent in unbudgeted costs on the projects.
- The accuracy of estimates was within a three percentile range
- A decrease in the amount of time required to do cost estimates that equated up to a maximum of eighty percent decrease.
- The contract sum was decreased by an average of ten percent due to clash detection.
- Project times were decreased by up to seven percent.

BIM is being adopted worldwide, and it is enforced in places like the UK for all projects over one million pounds. Adoption in South Africa has been slow thus far. A chart below shows the rate of adoption in South Africa compared with other countries:

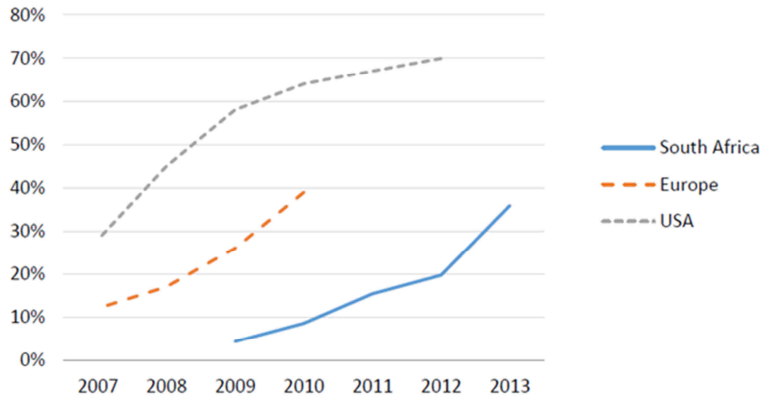

Figure 1: BIM Adoption rate in South Africa, Europe, and the USA (Froise and Shakantu, 2013)

Questionnaire

1. Before you read the summary you were given, were you aware of what BIM is?

   _____

2. Are you aware of clash detection and its benefits?

   _____

   _____

3. What is the percentage of your project cost that is attributable to variances_____ %

4. Are you aware of the cost of clashes on your projects?

   _____

   _____

5. Is clash detection offered to you as a value added service?

   _____

6. Do you believe it should be a value added service?

   _____

7. If you are not implementing BIM on your projects, would you consider using it on a future project and why or why not?

   _____

8. Do you believe that Property Developers should be the Driving Force behind BIM adoption?

   _____

9. Would you be willing to pay for training for the designers?

   _____

10. Do you believe that BIM has a future in the South African private sector?

    _____

What would you find most appealing about BIM technology on a scale of 1 to 5 (1 = negligible and 5 = extremely appealing).

i. Reduced project costs

ii. Reduced time to complete projects

iii. More accurate estimates of project costs

iv. Reduced conflict between consultants

v. Less coordination meetings