

**University of Southern Queensland**  
**Faculty of Health, Engineering and Sciences**  
**ENG4111 Project Progress Report**

**How Building Information Modelling software (BIM) is being  
used in the Architectural and Engineering (AE) industry and how  
the use of this software is impacted by the AE industries own  
understanding of BIM - A South East Queensland (SEQ)  
Perspective**

A dissertation submitted by

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In fulfilment of the requirements of  
ENG4111 and ENG4112 Research Project  
towards the degree of  
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## **Abstract:**

Building Information Modelling (BIM) has been at the forefront of the Architectural and Engineering (AE) industry for nearly 2 decades.

Traditionally, the BIM ‘dimension’ and ‘maturity’ levels relating to the software have been identified as the most utilised aspects to measure the software use. These terms describe using BIM-enabled software to create data that can be used, moved and changed for the lifecycle of a building or structure, and are benchmarks for the capability of the AE industry’s use of BIM.

However, a greater understanding of how the AE industry is using design software is required, particularly in relation to how the use of BIM software relates to the user’s own understanding of BIM software as a management tool, rather than a modelling tool.

This research will better identify the extent of BIM use in design software across the AE industry in SEQ. This could help further the understanding of BIM use, aiding the discovery of better pathways for BIM implementation across the AE industry. It may also help to identify a correlation between user understanding of BIM generally, and how the design software is being used.

This is an important step to help governments or BIM enablers facilitate a BIM environment. These groups aim to produce a common standard that can be utilised by all within this industry to facilitate a platform that could make information sharing, collaboration and performing their roles easier.

An in-depth literature review of preceding research into BIM was used to develop a questionnaire that was delivered to the AE industry in SEQ. The questionnaire used a scaled (Likert Scale) questioning for quantitative assessment followed by a combination of multiple-choice with optional short answer qualitative type questions. These questions were used to gauge the level of BIM design software use.

The data suggests that Small and Medium Enterprise businesses (SME) demonstrate slower levels of BIM software development and use. This suggests that the functionality of BIM software can be greater utilised and further, that BIM can be diversified to include a greater range of users, BIM will remain in its infancy until the opportunity to implement it across all levels the AE industry becomes a reality.

The research also suggested that Government mandates of BIM would be important to furthering the use of BIM across the local AE industry, however, it was found that participants felt that mandates should be implemented cautiously and with sufficient industry guidance, to not do so may to some industry sectors force unachievable goals which could be damaging to the adoption of BIM and how BIM is being use in the industry.

Further research into the potential to facilitate design aspects such as engineering or architectural principals and standards checking within a BIM software framework may expand the use of BIM within the industry.

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## Glossary

ABCB	-	Australian Building Codes Board
AHD	-	Australian Height Datum
AE	-	Architectural and Engineering
AEC	-	Architectural, Engineering and Construction
AIA	-	American Institute of Architects
BE	-	Built Environment
BIM	-	Building Information Modelling
BIMMS	-	Building Information Modelling Modelling Software
CAD	-	Computer Aided Drafting
FM		Facilities Management
GDA	-	Geocentric Datum of Australia
IFC	-	Industry Foundation Classes
IP	-	Intellectual Property
LOD	-	Level of Development
MEP	-	Mechanical, Electrical and Plumbing
NCC	-	National Construction Code
PDF		Portable Document Format
ROI	-	Return of Investment
SEQ	-	South East Queensland
SBCA	-	Singapore Building and Construction Authority
SME	-	Small and Medium Business Enterprises
SS	-	Statistical Significance
UK	-	United Kingdom
US		United States

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# Chapter 1 Introduction

Building Information Modelling (BIM) or model and the concept of BIM has been around for many years, the definition and understanding of what BIM is has also taken on various forms, being understood differently by industry shareholders involved in the Architectural and Engineering industry (AE), such as software companies, AE companies, industry clients and academics.

BIM is being described as: a process to generate and process building data for its life cycle by representing the design as virtual objects which carry both geometry and attributes (Dobelis, M 2013); an intelligent 3D model based process providing the AEC industry insight and tools to better manage and more efficiently plan, design, construct and manage buildings and infrastructure <<https://www.autodesk.com/solutions/bim>> ; a multidimensional, historically evolving and complex phenomenon (Miettinen, R & Paavola, S 2014).

Whatever BIM is to the individual or a collective, the goal appears to be similar, it is a strategy to evolve or progress the construction industry from a 2D documented society to a smart digital model which encompasses the life cycle of a building or infrastructure project undertaken in the construction industry.

Specifically looking at the Architectural and Engineering (AE) industry in South East Queensland (SEQ) Australia, this study looks to move away from the usual BIM studies of adoption for maturity levels and dimensions, by looking more at the way the BIM modelling software is being used to build models, the models being the building blocks of BIM. The industry's expectations and opinions of the software following the initial adoption of the BIM technology.

## 1.1 Brief BIM History and BIM Program Development

The use of computers to develop a drafting or as a design tool has been around since the 1950's, Such as Pronto, a computer aided modelling program invented in 1957 and Sketchpad, invented in 1963, a computer aided drafting (CAD) tool with a graphical user interface (Cherkaoui H, 2017).

However, the father and concept of BIM in its infancy was as a Building Description System (BDS) (Eastman C, 1975). Eastman developed the concept where computers were used to develop 3D models using parametric objects, objects you could input and output data from. Output data from modelled objects in items such as schedules, schedules of cost analysis and/or materials quantities. Moreover, the process would be such that tasks that were currently manually taken from 2D drawings or hard copy documents, would be automated, bringing an efficiency to the construction industry.

Parametric modelling, the basis of 3D and BIM modelling software programs allowed the industry to not only use the same objects at different scales across multiple sheets, saving hours of manual drafting time, but to limit the amount of 2D line drawings required (Cherkaoui H, 2017).

## **1.2 Use of 2D CAD software and BIM enabled software:**

As an example, with Revit and AutoCAD, the difference in just the manual CAD drafting, without even considering BIM is immense. Tedious commands and set up in AutoCAD are quickly and easily completed in Revit.

To upskill from 2D drafting packages such as AutoCAD to BIM enabled software such as Revit it is quite intuitive, however, the ‘time’ and ‘effort’ using the software on projects has always been the way to become efficient with it. Therefore, early adopters of the BIM evolution, the ‘innovators’, have a distinct advantage over the later adopters of the technology, the ‘laggards’ (Ayinla, A & Adamu, Z 2018).

The initial stages of BIM software adoption are generally a backward 2D CAD approach. Tending initially to adapt the BIM Software to mirror internal 2D CAD and documentation standards. Learning to modify off the shelf software company families or objects to create titles, title blocks, sections and detail markers previously used in 2D CAD. To become proficient 2D CAD users of a smart 3D parametric modelling technology.

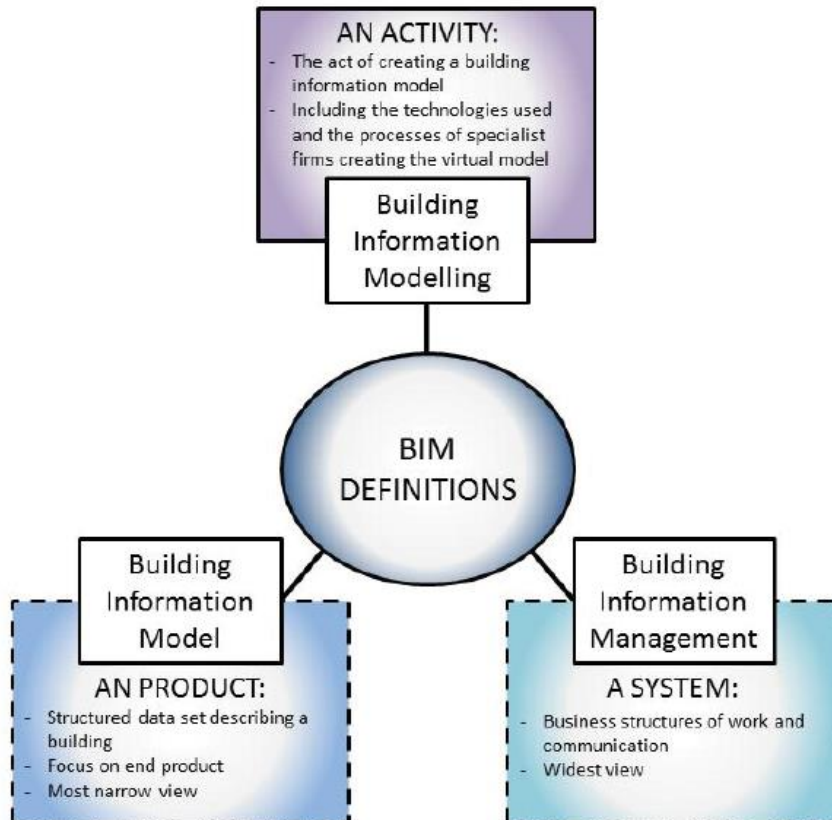
As the user experience grows, through both project completion or external training, the ability to manipulate and even create objects becomes a driver to further the understanding and depth of how the software can work, including letting go of 2D standards from the past. A new vision using the power in the software is developing, modelling processes are driving efficiencies, standards are being created and adopted by all staff.

It is hard initially to see the benefit of BIM and return of investment (ROI) on its implementation, however, with the commitment already made and faith in the new system, further investment is identified and required to develop the program use. Initially this is usually still handled internally not looking at the big picture. It soon realised that an experienced BIM manager is required to bridge the gap between using BIM software and being BIM ready, however, due to the infancy of BIM the experience of the BIM Manager is limited to what worked in previous companies, companies who also went through the same ad-Hoc BIM adoption process.

The sharing of information of how to model with the software to enable a BIM environment has only in the last few years appears to be stepping away from the ‘closed door’ activities, where it is usually not shared to gain a BIM advantage over competitors. In SEQ, organisations like BrisBIM are leading the field to diversify and share industry knowledge to further the BIM environment. BrisBIM is a non-profit group which aims to provide a forum for industry shareholders to come together informally to discuss, learn and share from other likeminded industry representatives < <https://brisbim.com/> > .

## **1.3 Dissertation objectives**

BIM and BIM enabled software covering the processes of BIM are vast, there is BIM software for: Execution Planning; Content Management; Modelling Software; Performance/Analysis Software; and Collaboration, to name a few < <https://www.lodplanner.com/bim-software/> >. This study focuses on the BIM Modelling Software (BIMMS). ‘An Activity’ in the below image which indicates different ways to look at and approach BIM.



***1. Figure.1 Different ways of looking at BIM (Maunula, 2008)***

This study aims to look at how the AE industry is using the available BIMMS to facilitate a BIM environment and if how they are using the software is BIM or a more efficient 2D CAD tool.

This will be undertaken in two ways, firstly by undertaking a thorough literature review on the current research undertaken regarding BIM systems, BIMMS. Secondly by undertaking a questionnaire survey of AE industry partners in SEQ on BIMMS related software use and model creation being used in the industry.

Focussing on the SEQ industry and the BIMMS use, the study will target aspects of BIM modelling software using the authors 9 years of using a BIMMS tool and as a draftsman using CAD software for over 18 years. Combing this experience with insight gained from the literature review the participant group(s) will be found. The results from the questionnaire will then be collated and analysed to be assessed against the project goals.

The questionnaire will link the amount of time an industry partner has been utilising BIM software, how they are using this software to model, to the size of the company and the maturity level they believe they are currently at to develop an understanding of how the industry is reacting to the BIMMS in light of their understanding of the BIM process.

Looking at how the BIM user is modelling and what object parameters are being created will provide insight into how the BIM modelling software is being used as a tool to further BIM development and if the AE industry in SEQ is facilitating a BIM environment.

It will also look at what the change has been in the industries use of BIM modelling software from when first adopted, to find recommendations within the local AE industry and broader community through the research on where the software is letting the AE community down. i.e. letting users 'fend' for themselves in the BIM quagmire of implementation.

#### **1.4 Possible Study Outcomes include:**

To provide an insight into how BIM is developing in the AE industry in SEQ in relation to the experience of the participants BIM use and the literature review, this study looks to identify how the software is being used:

To determine if the local AE industry is satisfied with how the software performs, long term, and when first adopted or change over from popular 2D Cad programs. The software choices for BIM enablement may also elicit responses to better understand how the software because of inherent lack of initial programming smarts, can inhibit and even stop BIM adoption in the industry.

Provide insight to whether BIMMS competent users tend to start seeking out or by word of mouth and BIM specific events, such as BrisBIM, look to undertake works with other likeminded industry, how do these partnerships start.

Indicate indirectly the maturity of BIM within the SEQ community based on models such as those developed by Succar and Bew-Richards and to verify if there is a trend in the industry unilaterally as having an objective to progress to a full BIM environment.

To look at how the Australian AE industry would cope with a similar mandate of BIM by the British Government to implement Maturity Level 2 on all government procurement projects. How would this position the smaller SME in SEQ, or would the mandates exclude these companies from being able to compete in this industry..

To find out if the AE in SEQ are using the widely researched frameworks to enable their own BIM adoption, comparing this data and use to the academic research and trends within the broader AEC industry.

## Chapter 2 Literature Review:

To further the study in BIM and BIMMS it is important to undertake a thorough literature review the preceding works relating to this research domain. The review is to validate the significance of the current study and to assess the impact the study may have on the Architectural, Engineering and Construction Industry (AEC), specifically the AE industry in SEQ.

The research and literature in the BIM domain are vast. With the continual progression of BIM within the AEC industry worldwide, trying to determine the relevant information to the BIMMS meant that an understanding was required of the research areas that have proceeded this study and been accepted or adopted in the broader AEC community.

Most studies looked at being able to measure BIM Adoption; BIM Implementation; BIM Maturity; BIM Dimensions; and the interoperability of the BIM software. The academic research also attempted to provide frameworks for these research areas to enable a roadmap (Hosseini et al, 2018) to the best way to move forward with BIM as a structured process.

It was identified that it would be important that the research used a broad range of AE industry representatives to gain a better understanding of the use of BIM and BIMMS. More recent studies have been evolving the understanding of BIM by ensuring that the areas within the industry, such as Small and Medium Business Enterprises (SME) are also represented in the studies, previously said to be misrepresented (Hong et al, 2016; Hosseini et al., 2018).

### 2.1 What is a BIM Modelling Software (BIMMS)?

Early works by Bazajanic (2004) describe what a BIM, 'Virtual Building' and virtual building environment is. He notes that a model is 'rich' relating to the data contained within it and that the visualisation alone of a 3D 'surface' model of building containing geometry alone is not BIM.

The BIM Handbook. by Eastman et al, provides a definition of what they believed did not constitute a BIM Technology (Ch.1 1.5, p15). It describes that the tool or software to create 3D BIM model, may not, depending on the process or techniques being used necessarily be constituted as BIM.

These are identified and summarised below:

- Models that contain 3D data only and no object attributes (no intelligence built into objects)
- Models with no support of behaviour (are not or don't utilise parametric properties of objects)
- Models that are composed of multiple 2D CAD reference files that must be combined to define the building (incomplete models which therefore contain and display non-intelligent objects, making it not feasible to validate the model's accuracy)
- Models that allow changes to dimensions in one view that are not automatically reflected in other views (make errors in models hard to detect)

Further studies have analysed and compared similar benchmarks to determine if the software is classified as being BIM enabled. These studies have shown opposing views on this subject.

Sketch Up for example, a 3D design software that does not have smart or parametric objects, was defined as **not** being a BIM modelling tool as it does not have the ability as a standalone program, to provide or contain data within the 3D objects (Eastman et al, 2011). However, Onur and Nouban (2019)

included Sketch Up as a choice of BIM related technology in their works, where they researched the various software technologies that are used to implement BIM and a BIM environment.

The important argument presented here is that even though the software may provide the virtual 3D representation of a Building Model, it may not explicitly be used for the process of BIM. Using the 3D capabilities for instance to only produce 2D working drawings, not being used to collaborate with or extract usable data for the construction of or use by the end user, would not necessarily be considered BIM use. This study, by identifying how the software is being used will determine if the AE industry in SEQ, are according to definitions of BIM use, using a BIMMS tool.

BIM technology and the early stage of BIM adoption are primarily focused on the software to replicate and provide 2D drawings for Approvals/Tender/Construction, as a standard computer aided drafting (CAD) package. So, has the use of the software progressed to a level where the 2D capabilities or CAD packages are only a small part of the capabilities of the software (ECAADe, 2004)? Looking at the literature available on BIM implementation and adoption, we can follow this idea further.

## **2.2 BIM Implementation and Adoption**

Early studies into the BIM phenomenon attempt to highlight the barriers to BIM implementation and adoption with the intent to label and break down these sometimes-unfounded barriers.

Focussing on current BIM literature and research topics, a study conducted by Yalcinkaya and Singh (2015), which used a 12-factor data solution to evaluate the papers they researched, found the highest number of academic papers revolved around the implementation and adoption of BIM. These papers trended in 3 main areas: the challenges associated with the adoption and implementation of BIM; BIM implementation related to project delivery and management processes; and stakeholder realisation of the benefit of BIM.

Vidalakis et al (2019) identified that of the English SME companies researched in their study, the main reasons for not implementing BIM included: not properly understanding BIM concepts; the low familiarity of existing BIM software support systems; and limited financial capacity.

The study by Son et al (2015) in Korea found that Architects were only partially using BIM in projects and failed to see the benefits in the investment made in the adoption of BIM based software packages. The return on investment (ROI) in this case being the main hindrance to BIM adoption.

A 2010 RoadMAP was presented in the 'Buildsmart' magazine (Issue 9, Dec2011) by Singapore's Building and Construction Authority (SBCA) to stimulate the local industry. It described both challenges and strategies in the industry for the adoption of BIM. The key challenges to the adoption of BIM were identified as follows: the lack of demand in the industry for BIM; the industry was entrenched in 2D CAD practices; the time to upskill and learn new BIM software; and lack of existing skilled BIM users.

Documentation pain points as cited in article C-Tech-BIM in Structure Magazine 2008, titled "BIM and the Structural Engineering Community" notes one of the barriers is that the software out of the box is not ready for production works and that significant time is spent customising the software to company and industry standards. This study will look at these frustration and customisation requirements associated with the BIMMS software to understand how the users feel about the software when first used, compared to when or if they are making the software work for them in the BIM environment.



There are also legal reasons and whole new Legal frameworks that are required to be not just learnt, but also invented. This is also hindering the widespread adoption of BIM and BIMMS. There is a lack of a standard or legal definition for BIM professionals and their responsibilities (Rokooei, S 2015), specifically the determination of ownership of the BIM data and models and need to protect it through copyright laws (Azhar, S 2011), as well the intellectual property and ownership or copyright to a design in an integrated virtual BIM model (Crow, S 2018; Wilkinson, D & Haywood, M 2018).

The copyright and model ownership are described further in the following section as it has implication with the interoperability of software and act of creating a 3D model. The concept of a BIM dimensions and level of design to be used at various stages of BIM collaboration between consultants and project specific stages.

### **2.3 BIM Maturity Levels**

For the past two decades it has been common for the BIM shareholder to categorise and measure the progress of BIM within the industry, this has been done by creating frameworks to measure the capabilities of BIM by an individual or company, these frameworks are also used to some degree to work as a road map for the BIM user and AE industry, helping to define and drive BIM capabilities following a standard and goal measure against.

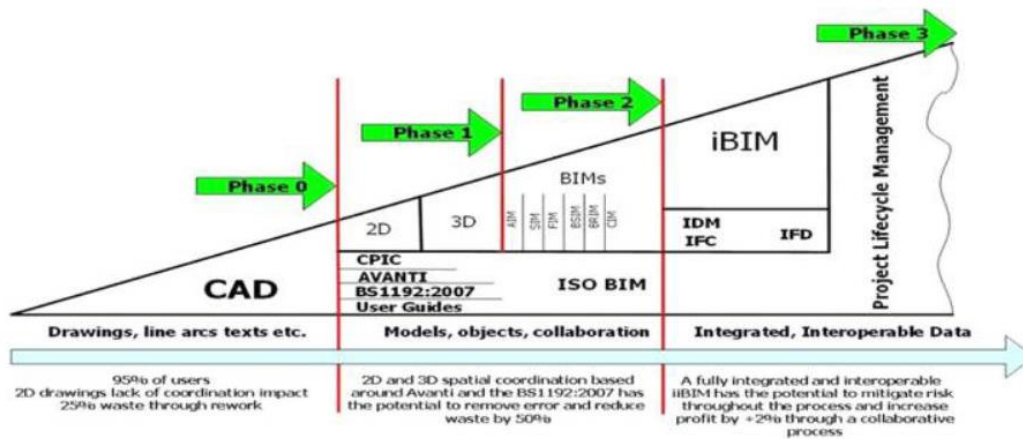
Bew-Richards (2008) and Succar (2009a) are the most widely accepted maturity models for BIM development, shown in the figures below.

The phases in the Bew-Richards model generally align with the corresponding levels in the Succar model. Briefly described below.

Software for CAD drafting without the technology for parametric modelling to be Phase 0 and Pre-BIM.

Levels 1 and 2 are the stages at which the BIMMS are generally being used, the design and build phase of the works, where the BIM enabled software is initially providing both 2D and 3D information. Information is being input into the models and being shared between AE shareholders for design purposes and team collaboration.

Level 3 is the Utopia of the BIM paradigm, where all information, both designed and constructed are being shared as an integrated and available source for facilities management and the life cycle of the works.



Source: Bew and Richards (2008)

2. Figure.1 : Bew-Richards BIM Maturity Model



2. Figure.2 : Succar's Linear 3 Stage BIM Maturity Model

The process from the Phase 1 to the Phase 2 in the Bew-Richards Model and 1 to 2 in Succar's model is the wasteland for AE industry adopters of BIM software. Without the industry collaborating in this level of BIM, the way out of the wasteland can take years. As BIM is described widely as a 'process' not just a 3D model, it leads to reason why there is some misguidance in the industry and hesitation in the adoption of BIMMS as other studies have shown.

## 2.4 BIM Dimensions and Frameworks

From the early stages of BIM development and with the introduction of 3D modelling and later 4D construction scheduling, the expanding dimensions of BIM have been developed as a technological opportunity and generally without limit, the  $n$ th dimensions or,  $nD$  of BIM (Marshall-Ponting, A & Aouad, G 2004;Tanyer A & Aouad, G 2004;Eastman, C et al 2011)).

There are currently 6 widely adopted subsets of BIM (Smith, P 2014) which include; 3D Shape/Modelling, 4D Scheduling/Time, 5D Estimating/Cost, 6D Operations/Facilities Management, 7D Sustainability/Energy Efficiency and 8D Safety/Emergency plans (Josseaux, B 2018). It can be noted that some literature swaps the 6D for 7D and vice versa (Biblus, viewed 31 May 2020), whereas other literature does not recognise the 7<sup>th</sup> or 8<sup>th</sup> Dimension (Ontario Construction News, 2019).

There is even recent debate to the validity of the dimensionality potential of BIM,  $nD$ . Koutamanis (2020) researched what constituted a BIM dimension and argued that there could only be as high as 4 Dimensions, 4D (time and Scheduling). Generally, he notes that dimensions of BIM

*‘...should not be applied ‘metaphorically’ or loosely in the context of BIM and building representations in the existing geometric tradition...’*

Interpreted by the Author that all the information contained with the objects or symbols of the created 4D BIM model does or should already include all the data required for the calculations required by the other dimensions.

Furthermore, the use of additional software to extract the data is inconsequential to the further dimensionality of BIM and the model used.

The use of the software to create the models with the required data and information contained within them, including the detail and accuracy of the model creates a need to research this area further. What other information is able to be extracted past the model’s creation, the construction and ‘As Built’ information required for the lifecycle of the building. Hypothetically the dimensions of BIM comes from the power of the model created in the early phases of a project.

## **2.5 BIM Frameworks and Levels**

The American Institute of Architects (AIA) developed a framework to define the level of development and detail that a model should contain, this also included guidelines for the sharing and collaboration of BIM models, the framework was called, E202–2008, Building Information Modelling Protocol Exhibit(AIA Contracts, 2020; Frausto-Robledo, A 2008). This framework was retired and has been replaced with later versions.

The document detailed a Level of Development (LOD) which associates the phases of a coordinated project to the requirements to the level of detail and information contained within a 3D or Building model during the life cycle of that model. i.e. The LOD describes the accuracy of the model for the lifecycle of the project, from initial Design Development, Construction Documentation through to the ‘As Constructed’ information of the built form. It ranges from LOD100, concept design in which the model is limited to 3D form, to LOD500 which contains all data including the ‘As Built’ information being included in the model and capturing any changes during the construction process.

The BIMForum < <https://bimforum.org/>> is an association which champions an open forum for the advancement and collaboration of BIM. They have recently released an updated LOD specification (2019), this specification uses the basic LOD definitions developed by AIA and note the use of the specification to be:

*‘...a reference that enables practitioners of the AEC Industry to specify and articulate with a high level of clarity the content and reliability of Building Information Models (BIMs)at various stages in the design and construction process.’*

The Australian NATSPEC BIM Paper <[www.natspec.com.au](http://www.natspec.com.au)>, a free resource, further develops the concept of LOD for the Australian market, taking its lead from documents produced by the AIA and BIMForum for local users to develop and use LOD in projects, or at least as a guideline to.

Noting that America and other countries such as the UK, Singapore and Finland have all mandated BIM use in government procurement projects and have done for some time leads to the current state of Australia and where our Government sits in this regard.

## **2.6 International Government Mandates for BIM enablement**

To find where Australia is in the adoption of BIM we need to first look at the approach that other governments have taken. Paul S. (2018) in her article for GEOSPATIAL WORLD, summarises the state of the BIM mandated in governments around the world, briefly described below.

The United Kingdom (UK) is leading the world with their visionary strategy, released in 2011 to mandate a Level 2 BIM across all public procurement in projects by 2016, the Level 2 is based on the Bew-Richards maturity levels. This has led to the widespread uptake of BIM in this country, in both large and small organisations.

Singapore as discussed earlier introduced a Roadmap to BIM adoption in 2010, with objective of over 80% BIM use across the industry by 2015, this was made more successful by mandating BIM electronic submissions and in a BIM format for all regulatory approvals.

This trend has been seen globally with mostly success, although some countries have had less success. The Netherlands being one of the success stories in Europe, their success is associated with the buy in by clients as opposed to Architects or Engineers, large public clients supported and prescribed the use of BIM, the Dutch also established standards to facilitate processes, data formats etc.. like the UK in the use of BIM.

The mandate of Governments to use BIM has been important to facilitate the adoption of BIM in other countries, so where is Australia in this adoption and overall BIM adoption strategy.

## **2.7 Government Requirements and Mandates for BIM enablement in Australia**

In 2016, the Australian Standing Committee on Infrastructure, Transport and Cities released a report into the role of smart Information Communication and Technologies (ICT), in this report two key recommendations were made in relation to BIM:

- The Australian Government should set up a task force, like that of the UK BIM Task Group, who implemented the UK mandate regarding Level 2 BIM adoption by 2016 to facilitate a similar or recommendation on a similar mandate in Australia
- That the Australian Government require BIM to LOD500 for all projects over \$50 million, with the end goal to use these BIM requirements on all public procurement in the long term.

The Australian Government responded in their report released later in the same year, 2016, named 'The Australian Government's Response to Infrastructure Australia's *Australian Infrastructure Plan*' .

The report supports a considered approach to the use of BIM, agreeing it was critical to ensure cost effectiveness and innovative design and delivery, however, it was by a project-by-project delivery method with a considered approach to the additional cost associated with using BIM and how this approach would impact local tenders.

The Queensland Government released a document in 2018 outlining 'Principles for BIM Implementation' (2018) which outlined a strategy to support an 'Open BIM' environment some of these directives were: to support and further BIM implementation on Major state infrastructure projects from Jul 2019; encouraging the implementation on both new and existing infrastructure to values less than \$50 million too; applying these principles to build-assets past 2023; and relevant Queensland Agencies were required to develop BIM implementation plan, reporting and updating the plan annually.

From the recommendations in 2016 by Infrastructure Australia, it is apparent that the Australian Governments, and State Governments are starting to facilitate a BIM environment, although not mandating BIM levels or expectations, by supporting an ‘Open BIM’ environment. The OpenBIM Alliance of Australia supports an open BIM exchange (buildingSMART Australia, 2020)

*‘...This means providing customers with the freedom to choose any BIM software solution, which meets their business needs, knowing that they can share their BIM data easily with others who use different software solutions...’*

## **2.8 Summary of Gaps in the Literature relating to the current study**

The literature review has found that BIM adoption, BIM Maturity and BIM implementation are widely researched topics, specifically, what is hindering the BIM adoption, the ability to gauge or find pathways to a greater BIM maturity and ways to measure the BIM implementation in the AE industry.

The research also identified a lack of research into SME companies, tending to focus more on larger companies, companies that have the ability, time and money to develop BIM levels and maturity. There are links between BIM adoption and BIM mandates, how this has influenced the adoption in the countries where they have been implemented by the government in those countries.

The fundamental idea of the research to date revolves around the measurement of the use of the BIMMS and not how the software is being used to implement BIM. There is no focus on how the AE industry uses a BIMMS tool for the creation of a building model and how this relates to the Maturity or Dimension of BIM.

## Chapter 3 Methodology

This study will use a questionnaire survey to gather data on BIM software use in the AE industry in SEQ.

As data is being gathered from human recipients, ethical approval from USQ is required. The following outlines the questions to be completed as a part of the survey and the relevance of the questions in relation to topic of study.

The methodology will also provide background and discussion for how the survey has been constructed and why.

### 3.1 Questionnaire survey: Quantitative and Qualitative

By definition:

Quantitative: Quantitative research focuses on gathering numerical data and generalizing it across groups of people or to explain a measurable phenomenon (Babbie, Earl R, 2010).

<https://libguides.usc.edu/writingguide/quantitative>

Qualitative: Describes qualities or characteristics rather than measure it.

<https://libguides.macalester.edu/c.php?g=527786&p=3608639>

<https://www.surveymonkey.com/mp/quantitative-vs-qualitative-research/>

The use of a quantitative survey will be used to assess statistically how BIM software is being used in the AE industry in SEQ. Questions will look specifically at techniques for using the BIMMS and how information is being used/inputted in the software, such as methods of creating modelling objects and if the user is presenting the model in real world coordinates. Does their software allow for this?

The qualitative survey aspect of the questionnaire will look at how the software and level of maturity is also linked to collaboration within the AE industry in SEQ, both within project boundaries and between industry partners, looking at what the industry thinks they are or are not doing to facilitate the BIM environment and to verify what additional ideas are being used to further their own use of the software.

These directed qualitative questions which will enable the respondent the opportunity to provide feedback. Feedback on the relevance of the questions provide in the survey and to get an emotive from the individual about their own companies' implementation of BIMMS and BIM, their thoughts about the local industries use of BIM software and the current state of BIM in the AE community in SEQ.

### 3.2 Mixed Method Research:

Using both a quantitative and qualitative research method is known as a 'mixed method' of research. Mixed methods of research have been widely studied. An important early study by Jick (1979) found that when looking at results from these types of studies that, surprisingly, it can be beneficial when results converge or even diverge when analysing the data from such a study. The unexpected divergent result can sometimes lead the researcher to further their understanding of the study by helping to identify unseen contextual factors that had previously not been looked at.

The triangulation of data is the use of different methods to gather data and is discussed by Mathison (1988) who proposes that it is expected that data from two different methods should not be the same, generally, noting that for results to converge would be rare in a mixed method which requires that the researcher needs to try to make the data sensible.

This questionnaire proposes to use a Likert scale which has both advantages and disadvantages that can be less bias if used with a mixed method approach, leading to a broader analysis of the data provided.

### **3.3 Likert Scales (Likert, 1932)**

A 5-Point Likert Scale will be used for the quantitative survey, the qualitative survey will also have a 5-Point Likert scale, but also the opportunity to respond regarding the question and/or option chosen.

Research has found there are advantages and disadvantages of using Likert Scales, advantages being that they do not expect just a yes/no answer, rather allowing varying degrees of opinion, an attitude from the respondent. Disadvantages are that the measurement of this attitude can mean that the scale is compromised due to social desirability (McLeod, 2008). i.e. lying to make themselves seem better.

McLeod goes on to note that to reduce the cases of this social pressure in respondents, offering anonymity in the survey should reduce the bias of social desirability. This idea was used for the questionnaire and the option for anonymity was provided to each participant, however, it was each respondents choice to do so.

### **3.4 SEQ AE Industry Focus**

The study focussed on industry partners involved with the design and coordination of built form. Built form includes all types of buildings as defined by the classification provided in the National Construction Code of Australia (NCC) by the Australian Building Codes Board (ABCB, 2019)

Class 1a: Single dwelling being a detached house or row of houses such as townhouses.

Class 1b: Boarding house, guest house, or hostel with a floor area less than 300sqm.

Class2: Apartment Buildings

Class3: Residential other than 1 or 2 – Boarding Houses; Back Packers Accommodation

Class 4: Dwelling or Residence within a Class 5 – 9 Building

Class 5: Office buildings that are used for professional or Commercial purposes which are not Class 6, 7, 8 or 9 Buildings

Class 6: Shops Restaurants and Café's

Class7a: Carparks

Class7b: Warehouses or storage facilities, buildings for the display of goods for wholesale purposes.

Class 8: A factory, a building in which a process is undertaken for trade, sale or gain.

Class 9a: Hospitals or Health Care Buildings

Class 9b: Assembly buildings where people may gather – Churches, Schools, Universities, Sporting Facilities...

Class 9c: Aged Care Buildings, residences for the aged

Class 10a: Non-Habitable Buildings – Sheds, Carports, private garages

Class 10b: A structure being an antenna, fence, mast, retaining wall, pools etc..

Class 10c: Private bushfire shelter associated with but not attached to a Class 1a Building.

Choosing the industry participants was also focussed on the AE industry participants who were more likely to be using a BIMMS. Details for why the AE industry and not AEC industry were to participate are noted below.

### **3.4.1 Architectural:**

As this sector leads the way in the design of the built form due to the nature of the qualifications, it was important to include as many architects as possible in the study. The Author has found them to usually be at the forefront of client interactions, therefore, the expectation is that the Project Architect would be able to offer valued and informative information on the use of BIMMS for this project.

### **3.4.2 Engineering:**

The engineering participants were chosen from those that predominantly are undertaking built form projects such as Structural, Electrical and Mechanical Engineers. Civil, Environmental and Agricultural Engineers were excluded from the study. Civil Engineers were excluded as they were most likely to be involved in infrastructure or subdivision type work. Not discounting that research has shown an increase of infrastructure related BIM requirements from local councils, the software used such as Civil3D and 12D are not stand alone BIMMS software, more tools for engineering design with CAD capabilities. The ability to be inserted or linked into BIM capable software shall be to an extent looked at in the proposed questionnaire indirectly.

### **3.4.3 Construction:**

From the Authors experience, the construction industry itself is not known to be users of BIMMS software. The Construction sector uses more project management and estimating/scheduling type BIM software. Tracking correspondence, changes in contracts, supply and distribution networks etc...

There would be occasion where construction companies may use CAD, which may be a BIMMS, for instance marking up Hydraulic plans for 'As Constructed' documentation, however, in the authors experience this skillset would be uncommon.

With the 'Design and Construct' philosophy Construction companies the use of BIM Coordination may be more prevalent, however, the Dimensionality of the use the Author assumes would usually be limited to construction phase of the works, as there would be no reason for the builder to invest time in achieving higher levels of BIM

Therefore, the use of construction industry participant was deemed not to be progressive to the works.



### **3.5 Targeted or Random AE Industry Participants**

The questionnaire will use AE respondents from both targeted and random participants within the AE in SEQ, this two-fold approach was considered for the following reasons:

**Targeted:** To help with a more successful completion rate of the survey; because of interest the author has had whilst leading up to the undertaking the study; and if you know people in the industry willing to participate, why wouldn't you use them.

**Random:** A broader range of SEQ AE industry respondents would be looked at; the authors own bias in choosing industry partners with similar skillsets and projects would limit respondents to a smaller niche within such a large and varied profession; and for numbers to participate (the author does not know that many people).

To select random industry participants Engineers Australia (QLD), local BIM user groups such as BrisBIM and the QLD branch of Architects Australia were contacted, as well as online google searches. The study hopes to look at a variety of both Architects and Engineers with different levels of service (size) to provide better statistical data to analyse.

## **Chapter 4 Results and Discussion**

### **4.1 The Questionnaire, distribution, responses and structure**

The questionnaire constructed for the AE industry in SEQ required an Ethics Approval prior to being released. H20REA171 is the approved USQ application ID for the questionnaire.

A copy of the questionnaire delivered to the AE industry can be found in Appendix C of this dissertation.

The questionnaire was delivered to the AE industry in SEQ on Friday 21<sup>st</sup> August 2020 through the USQ survey tool. A total of 97 participants were sent the email on this date.

A further three (3) participants were added following this date, the email addresses of four (4) participants were changed following correspondence with these participants, contact was made through media such as 'LinkedIn' and MSG (text) for contacts in which the author was either a contact with on these platforms or was in direct contact with as the Author new the potential participant professionally.

From the 100 participants emailed the questionnaire, three (3) opted out of the questionnaire and there were 25 responses. However, four (4) did not complete the questionnaire to submit, therefore, there were 21 participants in total who completed and submitted the questionnaire.

The questionnaire was re-sent on two (2) occasions, three (3) times therefore in total prior to closing. The questionnaire was resent to enable the opportunity for more participants to respond. The questionnaire was ended on the 3<sup>rd</sup> of October 2020.

The Questionnaire had 5 groups of questions, the following sections shall analyse and discuss the data for each question group. The headings and figures are directly related to each question within each question group and how they were presented within the questionnaire delivered to the AE industry.

A copy of the questionnaire can be found in Appendix D

### **4.2 Description of Charts Displayed**

The figures indicating results have been provided for selected responses in the dissertation. The 'Y' axis for all figures displays the count/number, from each representative 'X' axis group shown.

There are a variety of distribution indicate on the 'X' axis. They are indicated below:

Industry Sector: Architectural, Building Design or Engineer

Size of Organisation: 0-5; 6-20; 21-50, 50-100; and 100 + employees

Likert Ranking:

- Agreement: Strongly disagree, Disagree, Neutral, Agree and Strongly agree
- Frequency: Never, Rarely, Sometimes, Very often and All the time
- Importance: unimportant, Of little importance, Moderately important, Important and Very important

### 4.3 Question Group A: Basic Information – AE Company Profile

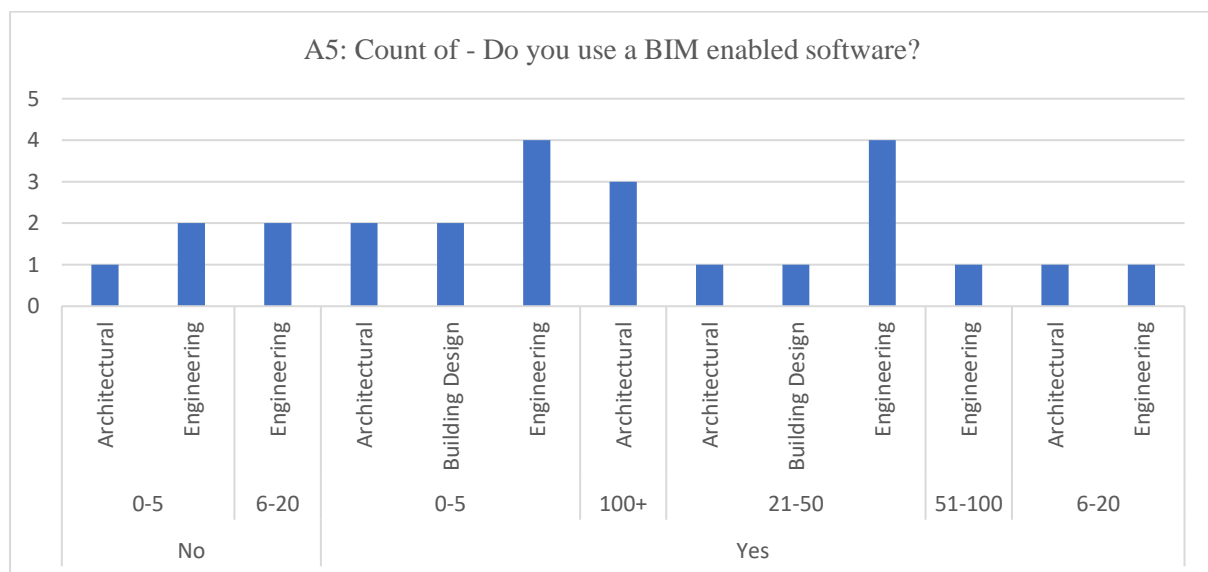
#### 4.3.1 Overview - Participants, AE Industries Represented, BIM use and Platforms

The initial question group requested general information of the participant and their workplace. This information would be used to compare the data in the questionnaire to the relevant industry group such as; Architects; Engineers; and Building Designers

Of the 100 participants sent the questionnaire the distribution of the AE industry represented was as follows: Architects 30; Building Designers 14; Engineering 52, Hydraulic Engineers 3. It is noted that within a participant group more than one industry noted above may have been represented. For instance, an engineering firm may have had a Hydraulic arm, or even a Building Design within their company structure. However, in a random selection of participants the criteria were essentially of the industry noted.

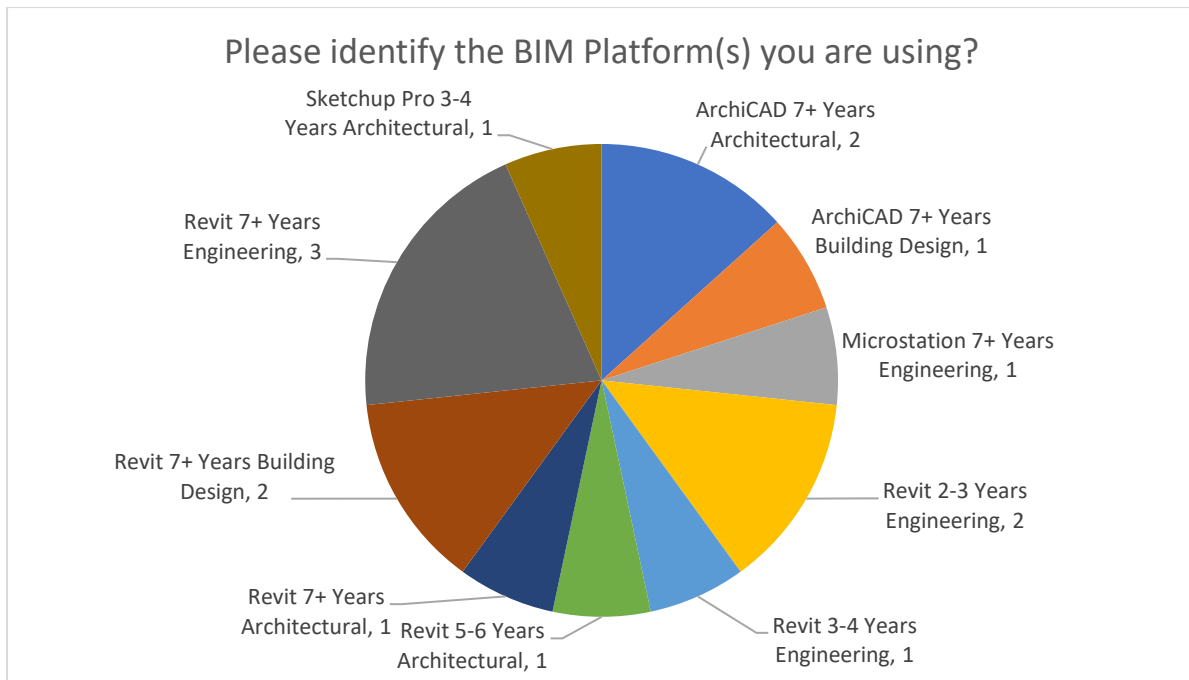
The distribution of participants who responded was reflective of the number of industry type participants sent the questionnaire and supports a well-presented distribution of respondents if based on this characteristic alone. However, looking at the number of respondents that used a BIMMS tool and the length of time it has had been used, is a better indicator that this alone is not a determinate.

Smaller type engineering firms were found to be less likely to be using a BIMMS tool compared to a larger Engineering or Architectural firm. From the respondents 5 of the participants reported not using a BIMMS tool. From the participants who were using a BIMMS tool, most participants had been using the tool for greater than 5 years. This long-term use was seen across both the industry sector and size.



**4. Figure.1 Question A5: Count of yes/no of participants using a BIMMS tool, industry and size of the company**

From the participant group 5 were identified as not using a BIMMS tool and were from the Architectural and Engineering groups. The Architectural group was a smaller company of 0-5 staff, whereas the engineering group varied from 0-5 and 6-20 staff. This was a surprising result considering the larger number of participants that were using a BIMMS tool in both these groups. However, as we do not know the project works specifically undertaken, this could be an indicator that was important in determining a reason not adopting the BIMMS.



**4. Figure.2 Question Group A – Sector/BIMMS Platform/Time Using BIMMS Platform**

The adoption of using a BIMMS was found to be prevalent within the AE industry in SEQ and furthermore had been used more often by the participant for greater than 5 years. This indicates a strong uptake in SEQ of the use of a BIMMS tool in SEQ in the Built Environment (BE).

Architectural and Building Design companies were the only participants to be using ArchiCAD, whereas Revit was being used by all industries represented, being the most widely used BIMMS platform. MicroStation was being used by a minority within engineering sector only. Whereas Sketchup Pro was found in this survey to be only used by a minority (1 respondent) in the Architectural discipline.

The results are a good indication of how the more popular BIMMS programs are being used and which industry group is using them. However, the groups represented must be compared to the whole industry at this point, where if the questionnaire was not targeted to the built environment, the results could have been a lot different.

#### **4.4 Question Group B: BIM Systems and Software Use**

The questions in this group were designed to find out how the BIMMS was being developed by the participants organisation and the use generally in constructing project models with the software.

Figures showing results relating to this group of questions can be found in Appendix F.

##### **4.4.1 Questions B1a & B1b**

B1a - It was not difficult to learn and become proficient in the BIM platform we use when we upgraded from our previous software

B1b - Our transition to a BIM software platform was made easier by the experience of our staff to both learn and advance the new system

These two questions looked at the transition from a CAD 2D software platform to the current BIMMS software being used by the participant group, it also looked at how the staff adapted to this transition. The results indicated that it was not an easy transition between the two platforms, however, the consensus was that the staff were because of their experience able to make the progression between the two platforms less difficult than it may have been with less experienced staff.

This phenomenon could be compared to the same change that occurred when drafting progressed from the drawing board to a CAD platform. The data suggest that the difficulties were no less or more than expected to develop a new tool within the industry group. This is confirmed in the qualitative questions within Question Group E, where it is indicated that the staff have an important role in the adoption and progression of the BIMMS, this will be discussed further in that section.

#### **4.4.2 Question B1c**

B1c - We generally use BIM and BIM processes on all (building) projects?

More than half of the participants reported that BIM and BIM processes were being used for all projects. Looking back at how this question was presented, it was not clear as it could have been interpreted differently by the participants, however, the participants did respond according to how they use the BIMMS when undertaking all project works, as opposed to using different software depending on the project type/size or difficulty.

The question could have been made clearer by asking the participant not 'generally, but 'if', they used BIM processes or the BIMMS on all projects i.e. they do not go back to the older 2D program depending on the project. The Author has found that the size of the project can dictate the use of a BIMMS platform. For example, you would not model a whole building for a small refurbishment if the plans for the building are already in a 2D format, it would not make sense in terms of the scale and fees associated with works of this size and nature.

#### **4.4.3 Question B1d**

B1d - We have internal standards for modelling which are adopted company wide

This question looked at the use of drafting standards which are commonly used for 2D drafting CAD programs, adopting these to the BIMMS and enhancing them to capture the requirements of a 3D model and CAD domain. It was found that all users did have standards in place which had been progressed for the BIMMS tool they were using (refer Appendix F).

The extent or how these standards are being used is touched on in question Group C where we look at Levels of Development (LOD) and how buildings are being modelled.

#### **4.4.4 Question B1e**

B1e - Models are reviewed regularly for conformity of these standards, specifically in how the building is modelled

The results showed that most BIMMS users were reviewing and checking their building models to ensure that the standards in place were being followed. Indirectly this could indicate that the BIMMS users are also refining and changing these standards to create greater efficiencies with the BIMMS and how buildings are being modelled.

This question also leads to the following questions B1f and B1g where the advancement and development of the BIMMS software was looked at. Specifically, to gauge who was on control of this development and whether all technical/BIMMS staff felt they had some responsibility in this development.

#### **4.4.5 Question B1f and B1g**

B1f - The advancement of BIM is in the control of the BIM manager only

B1g - The advancement of BIM is a collaborative process undertaken by all employees

Questions QB1d to Qb1g were asking the participants how the building models were made and controlled using internal modelling standards, specifically questions B1f and B1g looked at who controlled these standards, was it collaborative within a company or controlled by an individual.

The participants were generally using standards that had been created to facilitate the use of the BIMMS and these standards were being checked in projects to ensure that the standards were followed.

Although these standards and development were mostly in the control of singular team member, such as a BIM manager, the participants did feel that as a part of the team using the BIMMS tool they also had input in to the overall development and use of the tool. The extent of this collaboration could be due to the size of the companies, or the culture within the company, a collaborative approach indicating a culture where the opinion of all staff was considered.

The results also indicated a well-developed and strategic use of the BIMMS within the industry to further develop the use of the BIMMS tool. The questions may not have been as relevant to smaller companies where there were 0-5 employees, this is demonstrated by the neutral and below responses to these questions by participants of this size company.

It can be assumed that the larger companies would have more staff to consider when looking at a collaborative BIM approach, this in turn could be problematic as there would be varying opinions on how BIM is approached and used by individuals. The requirement for a BIM manager to oversee and make final decisions in this environment becomes evident.

#### **4.4.6 Question B2a**

QB2a - I have heard of and understand what a Level of Development (LOD) is in regards to a Building Model object/element

Within this question a link was provided to the BIMForum website < <https://bimforum.org/>> which outlines the concept of a LOD and requirements that are adopted and have been understood by the BIM industry. This was done so that the responded to could determine if they knew what a LOD was comparatively to the wider BIM community. i.e. to verify that their own expectation or understanding of a LOD was similar. It was encouraging that most the respondents had heard of or understood the concept of a LOD.

The following questions therefore looked at how the participants were modelling in their programs to develop a higher LOD and if the LOD was being developed for BIM or only a 2D environment.

#### **4.4.7 Question B2b**

B2b - A different LOD is used extensively in our project delivery process for Building Models and based on the project specific requirements

From the Authors experience it has been common practice in the SEQ industry for proposals and project deliverables to be structured to represent or be similar to the LOD outlined as a part of a project scope. Such as Concept Design (CD), Design Development (DD) Construction Documentation (CD). Being a similar discussion to the LOD concept of LOD100, LOD200 etc...

Generally, all participants agreed that a LOD was being used to reflect the type of project being undertaken and the LOD would be varied according to the project scope.

#### **4.4.8 Question B2c & B2d**

B2c - A higher LOD in a 3D object is generally required to reduce 2D drafting and documentation?

B2d - A higher LOD in a 3D object is required to further parametric capabilities to facilitate a BIM environment?

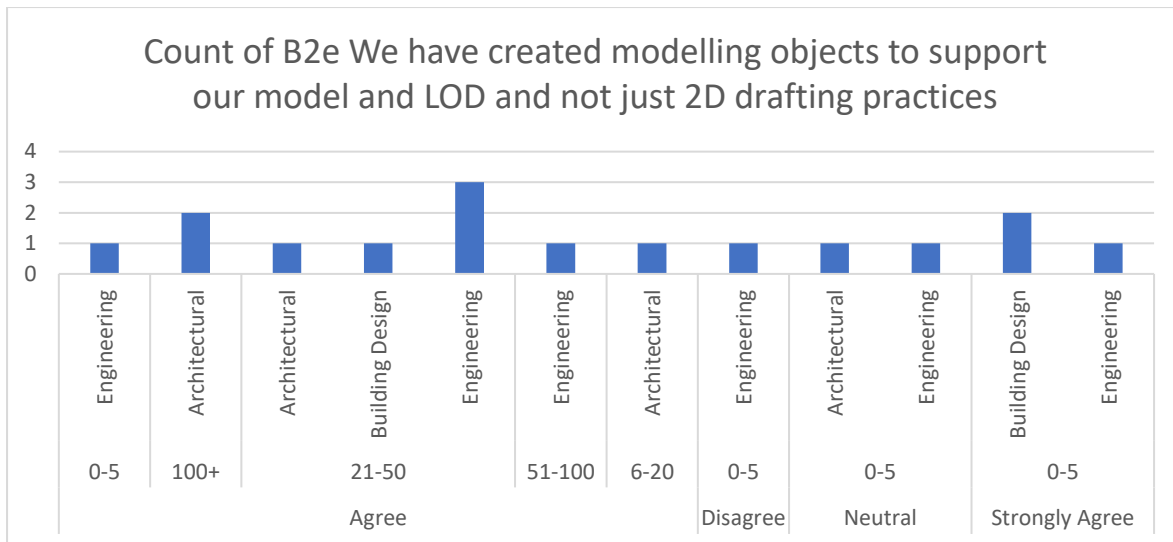
It was assumed that the reason for the development of an LOD or BIMMS program was solely for drafting capabilities. The data indicated that this was a possible outcome, however, the 6 responses noting the neutral and below responses mean that the LOD is not developed only for drafting capabilities. This assumption was tested further in question B2d.

The agreement in the previous question was challenged as a different outcome was supported as the data shifts from a disagreement which shows that the LOD is being used to further the parametric capabilities of 3D objects. This develops the concept that the BIMMS user is split between the development of the modelling capabilities for both 2D and parametric capabilities but also that some users are only developing or feel like they are developing the LOD for parametric and BIM development too.

#### **4.4.9 Question B2e**

B2e - We have created modelling objects to support our model and LOD and not just 2D drafting practices?

The results from QB2c and B2d are further highlighted by the response to the agreement that LOD is being developed for the overall parametric model, indicated in the figure below.

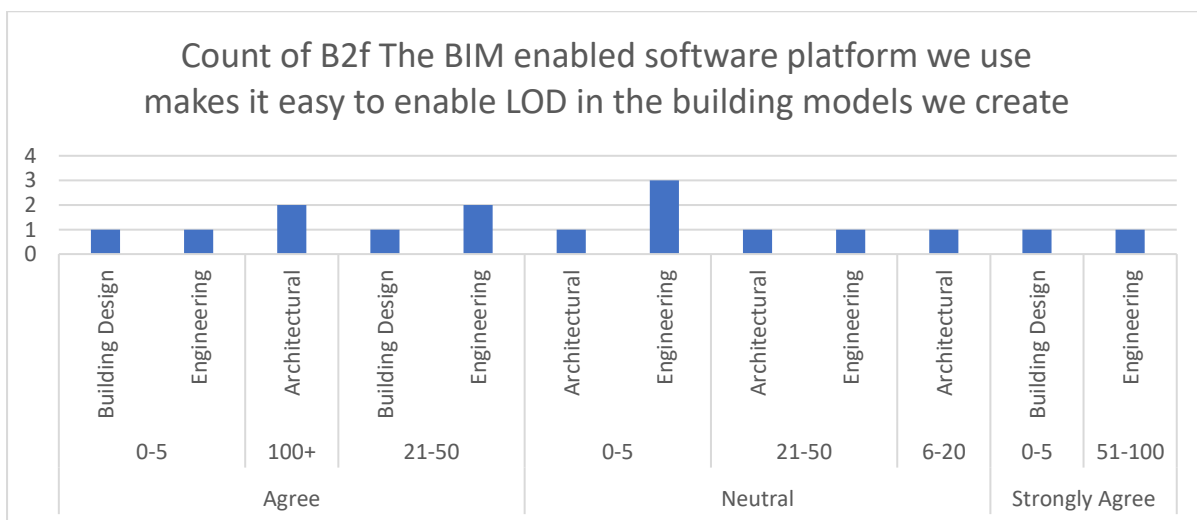


**4. Figure.3 Question B2e: Distribution of User ability to Create a LOD in a building Model Compared with BIM Platform**

**4.4.10 Question B2f**

B2f - The BIM enabled software platform we use makes it easy to enable LOD in the building models we create?

The results indicated in the figure below suggests that all BIMMS does enable the user to create a LOD in building models, however, the high neutral ratings imply that it is not a straightforward process, this is highlighted further as most users had been identified as having used a BIMMS tool for greater than 7+ years, you would expect this development or long time use of the tool would enable the creation of LOD to be easier and more participants would have strongly agreed with this question, however, this was not the case.



**4. Figure.4 Question 2Bf: Distribution of User ability to Create a LOD in a building Model Compared with BIM Platform**



## 4.5 Question Group C: BIM Modelling

This group of questions looked at the way the AE industry was using the BIMMS software to model their projects, it looked at common modelling tools/techniques that are available within most BIMMS programs. The authors experience with the use of BIMMS software was used to look at benchmarks in the setting up of building models from experience to compare it to how other users were creating models.

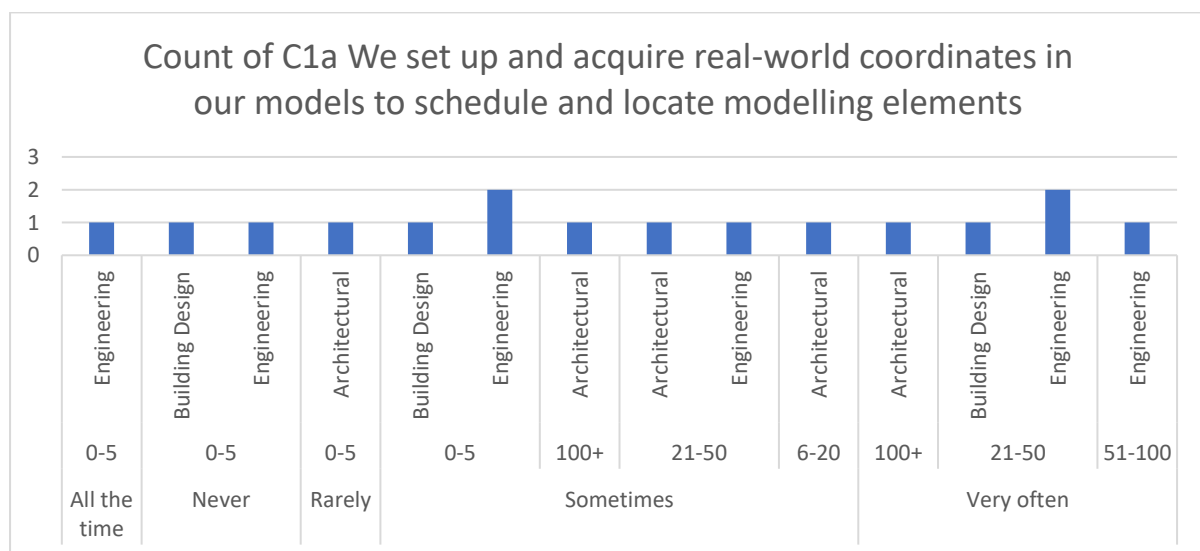
Real-world coordinates in the following question group refers to the Australian Height Datum (AHD) (<https://www.icsm.gov.au/australian-height-datum>) and the Geocentric Datum of Australia (GDA94) (<https://www.icsm.gov.au/datum/geocentric-datum-australia-1994-gda94>) , for the purpose of these works the version of either is less important than whether or not they are being used within a building model or project.

Electronically surveyed data has been used in 2D drafting programs for decades and has been utilised by the AE industry to accurately provide building or project set-out points. The set-out off surveyed elements such as property boundaries with bearings and levels which are defined in the real-world, including points within these surveys which provide easting and northing data that can be picked up by a surveyor and surveying equipment to a high level of accuracy.

Figures showing results relating to this group of questions can be found in Appendix G.

### 4.5.1 Question C1a

Thus, from the results in Figure C1a we can see that the industry is not always utilising this ability within the 3D BIMMS model. It is encouraging that there are a high number of users that do place the project model in the correct real-world location.



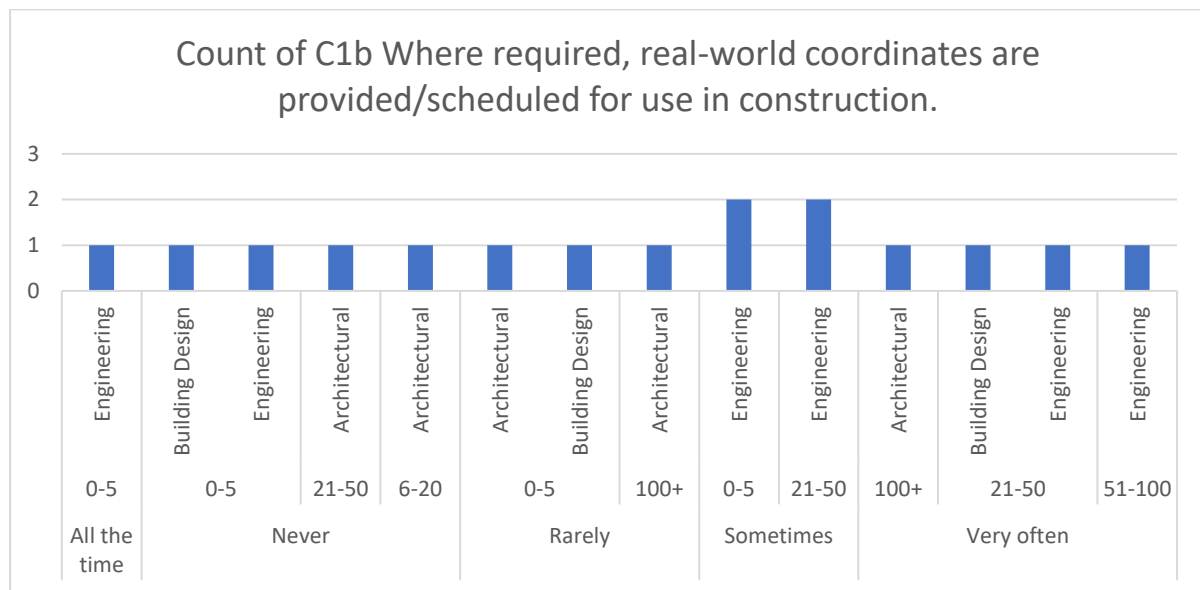
**4. Figure.5 Question C1a: Set up/Acquiring real-world coordinates in building models**

The determinate here would be if the consultant required a survey, or if required the survey was to an AHD and GDA specifications. Setting out a building to a boundary or specific location may not be as relevant to a residential building or extension compared to a commercial building.

The built environment projects the participant undertakes would be a key factor in these results. For commercial Architects, Building Designers and Structural (Civil) Engineers and Hydraulic Designers it would be expected that they would set out the project to align with survey data.

However, within the residential sector or Mechanical/Electrical Engineers I would not expect this set out to be as valuable to the end use or required for the design or construction of the project. Included is the Mechanical and Electrical Engineers as they are concentrated more on the building which is located by the Architect or Engineer in a commercial type building.

This is also true in respect to the use of topographic models or surfaces being created in a model, the relevance to the smaller industry highlighted in the Figure C1b below indicate a similar trend.



**4. Figure.6 Question C1b: Real-world Coordinates are Provided/Scheduled for use in Construction**

#### 4.5.2 Question C1c

We create topographic surfaces in models when a survey has been provided?

The results from this question moved away from the trend shown by earlier questions, more respondents were using a topographic surface within their models. The difference was the creation of a surface from a survey to be able to place the model at the correct height or at a height that is relevant to the project works. The benefit of being able see the constraints in the heights of the surrounding terrain being useful in the overall project work and design.

Topographic surfaces were being used regularly by less than half of the respondents for estimating, scheduling or documenting purposes. However, 7 out of the 11 respondents who were not using it as often still reported using the surfaces within their project works and documentation. The industry sector appears to be the factor determining these results. As noted previously, results were comparative to the Residential or Commercial Built Environment projects.

It is important that the programs can be able to modify these surfaces and that the AE industry does across all sectors utilise these tools.

### 4.5.3 Question C1d & C1e

C1d - We modify topographic surfaces to produce earthworks models for estimating purposes.

C1e - We use topographic 3D surfaces for design and to confirm project levels for modelling elements?

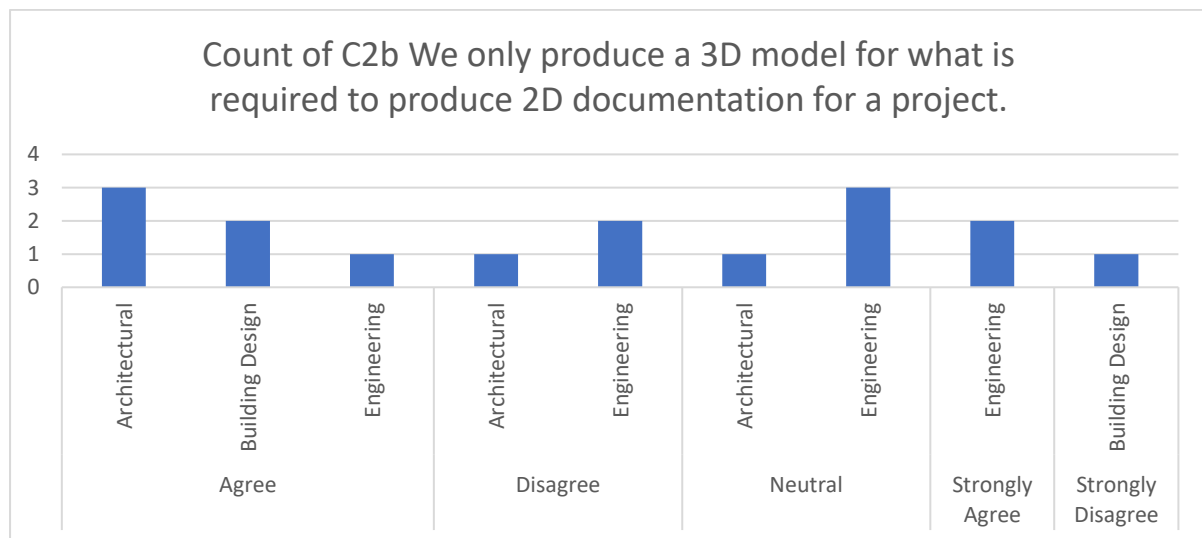
The participants were creating surfaces and modifying them across the industry sectors with less participants using the modelled topography for earthworks quantities. There was only one (1) participant who had never used or created a surface. This suggests there is value in creating and using surfaces within a model for design when modelling a building.

### 4.5.4 Question C1f:

C1f - We commonly use other internal software programs to create surfaces which we insert into our project models i.e. 12D, Civil 3D, AutoCAD

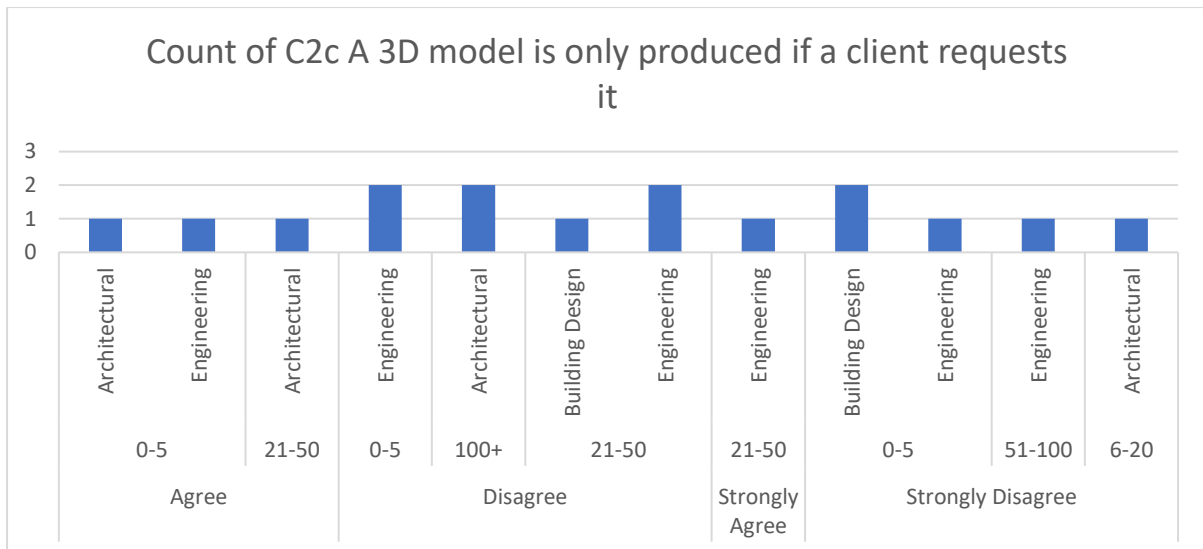
This question was poorly worded, the intention was to verify if the participant was creating or modifying program specific objects/families/libraries/Parts to enable the BIMMS to work how they want them, to enable 2D drafting/documentation requirements. Where program objects refer to the objects that come with the BIMMS.

The scattering of results and across sectors confirms that it was potentially interpreted differently. The other side of this result was that the participant believed that the changes being made were not just for 2D drafting/documentation, but to also further the BIM parametric qualities of the objects.



**4. Figure 7 Figure C2b: 3D Model Creation for 2D Documentation**

The response in the above Figure C2b are split roughly in half to why the model is being produced. Again, this question could have been clearer, when starting to use a BIMMS package the goal is to create the model to enable the documentation to be produced. Which is confirmed in these responses, however, the respondents who created a model for more than just the documentation have taken this use to a higher level. As the details for the model creation are not requested in this question or in further questions, we can only speculate to the reason for the model creation. Initial design and form for client approval such as sketch plans or a 'sketch model', or ideally the models are created to further BIM capabilities be it levels or dimensions.



**4. Figure 8 Figure C2c: A 3D Model is Produced Only if a Client Requests it**

With the ability of BIMMS to generate 3D models, it was expected that a model would be created all the time? However, this is not demonstrated in the responses above. A shortfall in the survey was that the engineering discipline was not also found out from the respondent, this is clear in a few of the questions where the relevance of some of the questions are aimed more towards to the Architectural/Building Design or Structural Engineering sectors.

An example would be a smaller type building with mechanical or electrical engineering requirements. The time required to produce a model in MEP in BIMMS would not be comparable to providing just 2D documentation, also noting that an IFC or other consultants model would also need to be used and manipulated to work for the consultant could also make it not a viable option.

It was not also considered that different sectors within the AE industry use different project structures or rates for deliverable, such as providing a 3D model and animated walkthrough to just 2D plan and elevations, which would cater for all ends of the market sectors.

#### 4.5.5 Questions C2d & C2e

Figures C2d and C2e are similar, asking how BIMMS add-ins are being used and the reason for their use. The results are somewhat similar, notably that add-ins were being used and more importantly were available across most BIMMS platforms, except for MicroStation. The authors understanding of how MicroStation is set up means that I cannot comment from experience. Limited research was conducted but the understanding was that MicroStation tools were solely contained within the MicroStation package(s).

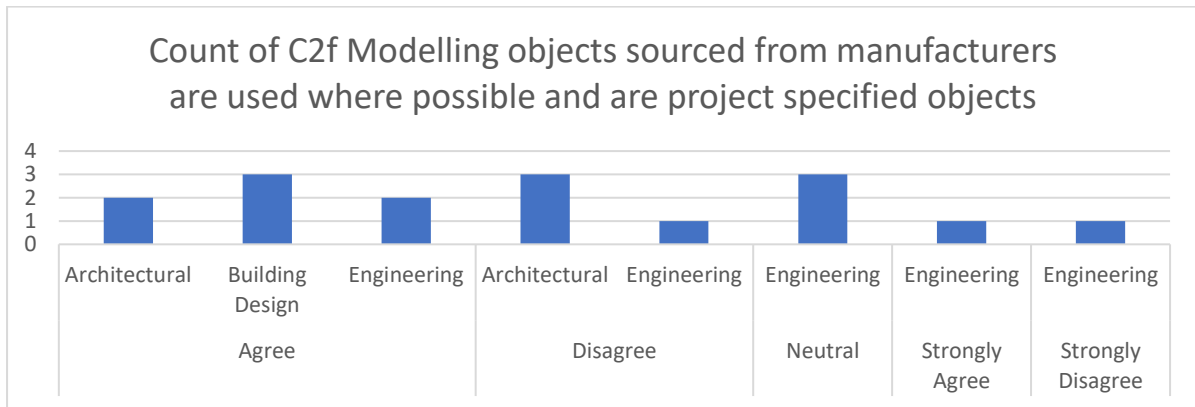
The results did indicate that most add-ins were either designed to be used to improve drafting efficiencies with a few aimed at improving modelling and BIM capabilities. The Authors own experience with Revit using add-ins such as Ideate BIM Link which enabled the import and export of excel spreadsheets in and out of Revit as well the ability to number and tag 3D object parameters for 2D drafting efficiencies to name a few, was one such tool.

#### 4.5.6 Question C2f & C2g

C2f - Modelling objects sourced from manufacturers are used where possible and are project specified objects?

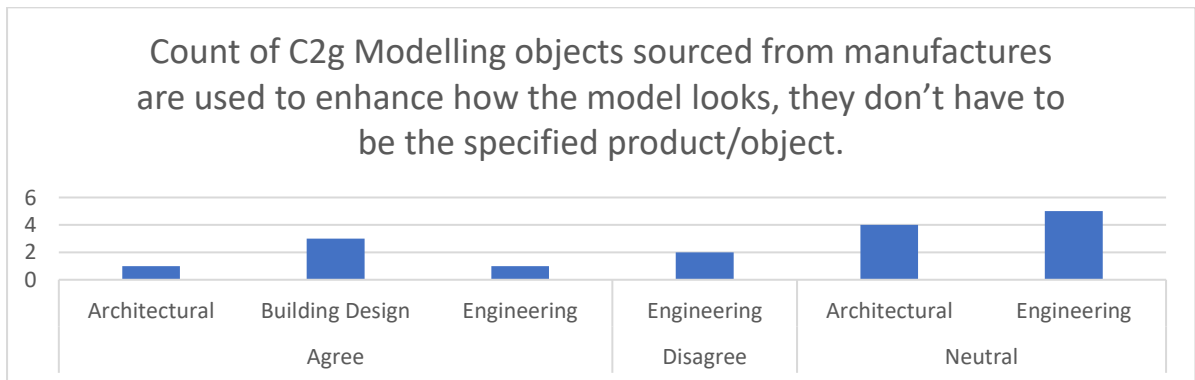
C2g - Modelling objects sourced from manufactures are used to enhance how the model looks, they don't have to be the specified product/object?

The results from Question C2f indicated that the objects used in a model sourced from a manufacture were generally the specified products, this result indicates that outside of the AE industry suppliers and manufacturers are creating objects that can be used in BIMMS programs.



**4.Figure.9 C2f: Modelling Objects from Manufactures are the Project Specified Objects**

Looking at the Figure C2g below it becomes apparent that when a manufacture doesn't have an object able to be used in a BIMMS platform than alternatives are used to be representative of the specified product.



**4.Figure.10 C2g: Modelling Objects from Manufactures are to Enhance the Model Appearance**

The author was approached recently by a local manufacture for advice on the format in which to produce such an object, this occurrence together with the result from the survey about the sourcing of the objects themselves indicates that the broader built environment industry is catching up to the modelling and BIMMS phenomenon and are looking at finding advantages by providing their products in these formats.

#### 4.5.7 Questions C2h

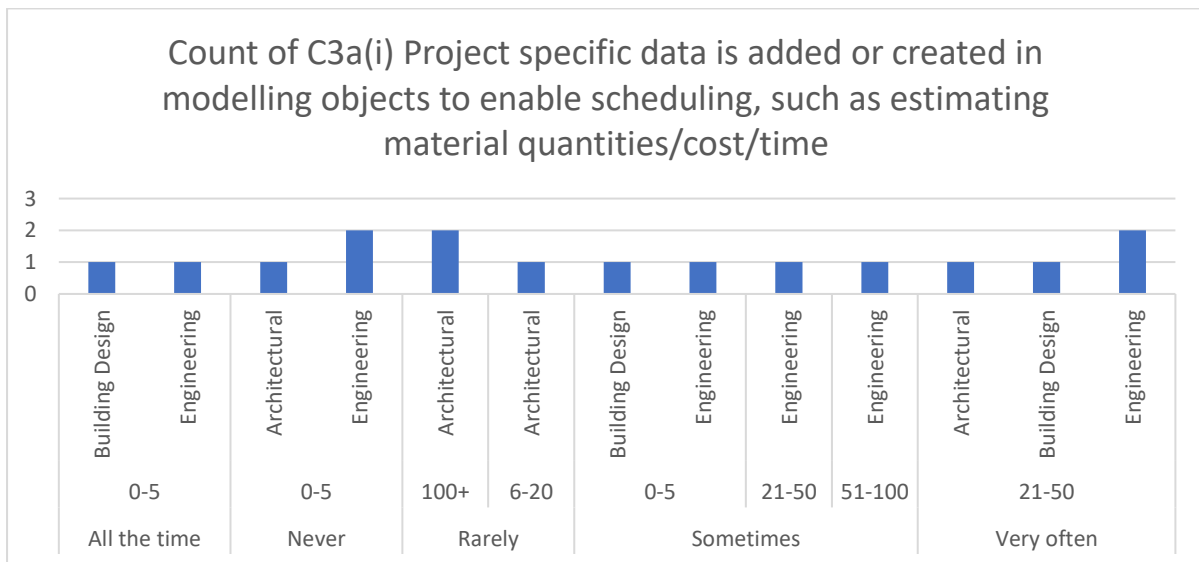
C2h - We pay and/or subscribe to outside sources to supply or create 3D modelling objects for us when required

The figures showing results for question C2h can be found in Appendix G, the results were broken up to display by BIMMS (C2h(i)) and then by Industry (C2h(ii)) to see if there was any key factor relating to the industry that was of consequence of using BIMMS objects from outside sources. There was no clear difference to how the modelling objects were being sourced and created. The Revit users disagreeing with the questions appeared to be creating their own modelling object more often than opposed to sourcing them elsewhere, however, all BIMMS users appeared to be sourcing some objects from outside sources.

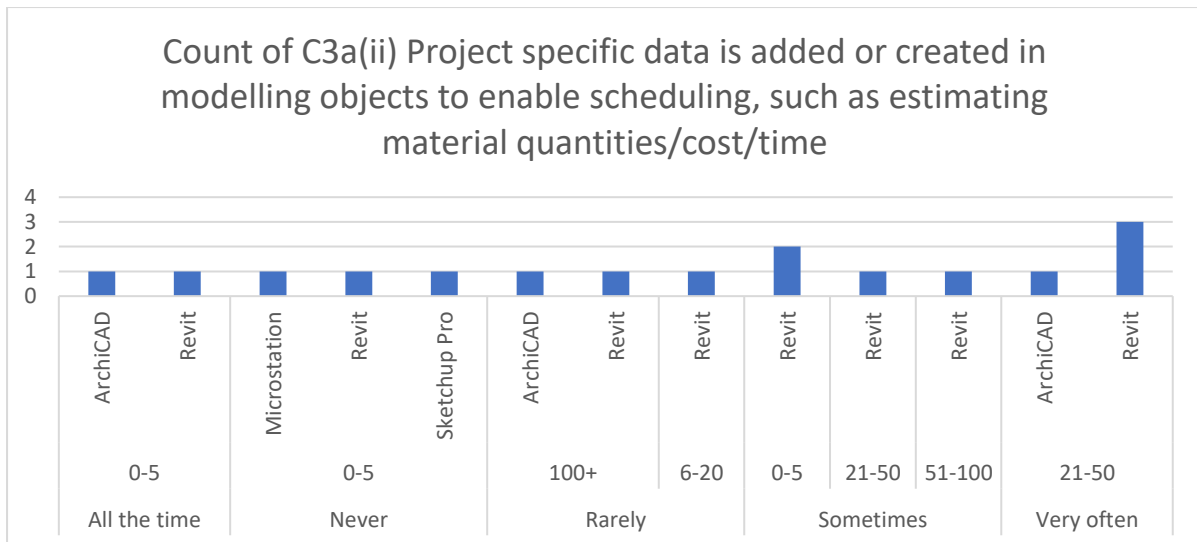
#### 4.5.8 Question C3a

C3a - Project specific data is added or created in modelling objects to enable scheduling, such as estimating material quantities/cost/time?

From the figures below, the Figure C3a(i) indicates the response based on the industry, whereas the Figure C3a(ii) indicates the response from at the size of the organisation. The question requests the participant to verify if information or data is added to objects so that this data can be extracted from the model and then used for estimating or scheduling purposes. An example of what this could be would be adding a parameter to an object like a type i.e. type A, type B referring to a different door, column or pipe size and then being able to schedule each element individually or as a group within a schedule so it could be counted.



**4. Figure.11 Question C3a(i): Project Specific Data is Added/Created in 3D Objects for Scheduling – By Industry**



**4. Figure.12 C3a(ii): Project Specific Data is Added/Created in 3D Objects for Scheduling By Size and BIMMS**

There was a surprising distribution of responses, where the larger organisations 100+ were ‘rarely’ to add data to objects as described above. Whereas the smaller 0-5, 6-20 and 21-50 sized organisation had a more even distribution across the board.

Looking at this further some assumptions could be made. That the larger organisations already have a very well-defined procedure with a greater number of defined libraries of modelling objects which have already been developed to include the information required. That the smaller organisations are still defining and expanding the drafting and modelling techniques which require this development and additional data to be added to objects.

Looking at the comparative size of a company we could assume that the number and variety of projects a larger organisation would have undertaken would greatly outweigh that of a smaller one, with processes that are still in the development due to this sheer number and variance.

#### 4.5.9 Question C3b

C3b - Estimating/cost/time scheduling is always provided to our clients as a deliverable?

The results from question C3b indicate that it is not common for an estimating/cost/time scheduling to be a normal deliverable provided to a client. Within the BE tender process, drawings and specifications are provided for a builder/construction company to take ownership of the quantities and cost to undertake the work. There are risks and contractual issues that could potentially arise if this type of information was provided. The reliability of the information contained within the model could make the consultant culpable if issues were to arise.

#### 4.5.10 Question C3c & C3d

C3c - Estimating/cost/time scheduling is provided as a deliverable outside of your company if requested?

C3d - We make it clear that any information provided in the above manner should be used at the discretion of the client and that all quantities or data should be checked for inaccuracies?

The results from question C3c tied in with the results from question C3d, the responses vary to that of the previous question, the ability for the AE industry to create the schedules from the model is evident as a higher amount of participant would or had on occasions provided this information at the request of the client. The information provided being done so is as seen in Fig.C3d strictly for information only.

The positive from this result is that the models are being created to an extent that the data extracted from them can be used as an indication of various project elements and can subsequently be used for costing or timing of works. The latter could have been expanded on by looking further at the phasing of works or elements within the model but wasn't touched on in these works.

A negative result, or indication the software still needs some development is shown by the AE industry is not willing to confirm the accuracy of the data provided.

#### **4.5.11 Question C4**

C4 - We use the inbuilt analysis tools the software we use has for design: such as structural/MEP or Energy Efficiencies, Sun Studys etc.

The results for this question indicated that the majority of BIMMS users did not use the tools available to them with more than half reportedly not using them at all or rarely using them. From the users that occasionally used the tools they were distributed amongst all industry sectors represented; the Building Design sector however used the tools the most.

This question could have been expanded to request what tools were being used, which could have gauged the usefulness of the tools provided. Most BIMMS come with a multitude of different tools, generally an analysis tool such as 'Sun Studies', which enables shadows and shading, the Author has seen this tool used predominantly within the industry. It would have been beneficial to see if any of the structural analysis tools or mechanical, electrical plumbing (MEP) tools were being utilised. Considering there are industry specific programs that are used to undertake these types of analysis.



## **4.6 Question Group D: BIM and Model Collaboration**

This group of questions was looking at how users were sharing or user other consultants' models, if they were sharing models and the preference of the model type that was being shared.

The figures and results for question group D can be found in Appendix H. They have been presented by comparing the industry and size of the organisation rather than the BIMMS they are using.

The reason for this was that the questions were related to either Native files i.e. sharing files/models in the same format, or other classes of files such as Industry Foundation Class (IFC) type files. It was more relevant look at how the industry sectors was answering the questions as this would define the use of the BIMMS rather than understanding the specific BIMMS program being used. It was also to gauge if models of any nature were being shared and by who.

Figures showing results relating to this group of questions can be found in Appendix H.

### **4.6.1 Question D1a**

D1a - If we can, we use a native format model from another company fully for a project to minimise drafting costs?

This question relates to the use of someone else's model to minimise drafting costs, specifically related to 2D documentation and drafting. It is looking at the possible workflow of using another consultants model in lieu of creating their own models. Architects overwhelming did not or rarely used other consultants' models. This would be linked to the information contained within the models to align with internal requirements and speculatively how models are set up to reflect formats of the specification that are produced by this industry.

Generally, other sectors would not usually or rarely use another consultants model, even in the native format of their own BIMMS for this purpose.

There were a few exceptions where it is was common practice. Without knowing the dynamics of the company or industry in which they operate, such as commercial or residential, there could be other reasons for this. For instance, for a multidisciplinary company with internal business arms that included Building Design, Structural engineering and MEP, it would be common to share models in this way.

The results for this question could have been substantiated with more data.

### **4.6.2 Question D1b**

D1b - We have used a shared cloud based multidisciplinary model in projects?

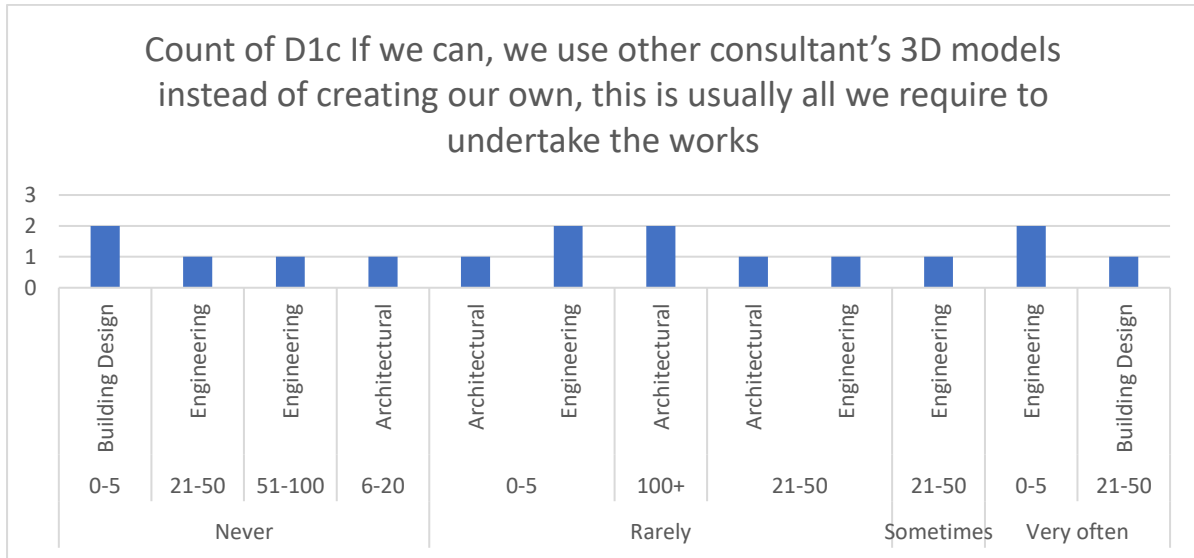
The industry in SEQ appears from the results in this question to be using cloud sharing models, although it is encouraging that it has been occurring in all AE sectors and for differing size of organisations.

There is a need for it within the industry and it highlights that companies do have BIM protocols and workflows in place to be able to manage these types of projects.

### 4.6.3 Question D1c

D1c - If we can, we use other consultant's 3D models instead of creating our own, this is usually all we require to undertake the works

The results shown in figure D1c below are like that of D1a and the questions are related/similar in nature, Architects were less likely to use another client's model but were in some instances using them. As the questionnaire did not distinguish between a multidisciplinary company, this could be a reason why some participants were 'sometimes' using the same model of another Engineering or Building Design industry consultant.



**4. Figure.13 D1c: Use of Other Consultants Models Instead of Creating Own Models**

Another possibility for this could be the size of the project, smaller projects for instance may not require much further input from the industry user to make the model viable for their 'small' scope of works in the project. However, this leads to a question, where are the consultants getting these models from? For a 100+ Architectural Company, how or what model would they be receiving to use and from who?

### 4.6.4 Question D1d

D1d - We will always create our own 3D model, even if we are provided a native format model from another consultant?

The results from this question follow on from the previous question, are the models created by other consultants able to be used by another consultant effectively? Most companies have their own templates and standards that they use to model, draft and in some respect design within the BIMMS platforms they use.

In areas in which the Author has worked the model was always created even when a consultant's model was provided. This was for multiple reasons; such as internal drafting standards and created parametric modelling objects within a model would mean the models needed to be manipulated and changed to work for how you needed the model to work and work with company specific templates. The reliability of the consultants models meant you were taking no or really all the responsibility that the model provided is correct. Re-issuing of the model by the consultant could be problematic, making additional re-work to get the model to a standard where it works correctly each time.

By creating the model, this can be considered a secondary design check to make sure you are satisfied that the set out of your own design element associated with ‘your’ scope of works has been considered. A lot of the time you are also trying to fit your design within another design and then to verify or collaborate any changes required.

#### **4.6.5 Questions D1e & D1f**

D1e - Sharing models (any format) we find to be the best way to facilitate a BIM environment.

D1f - Sharing models (any format) we find to be the best way to facilitate a better project outcome for us and the client?

The results from questions D1e and D1f substantiate, from the positive responses provided, that across the AE industry there is a seen benefit from sharing models and that model sharing is identified as furthering the BIM environment with the ability to provide better project outcomes. The negative results to for this question do show that in some instance the collaboration may not have been as successful or easy than it was perceived it should have been.

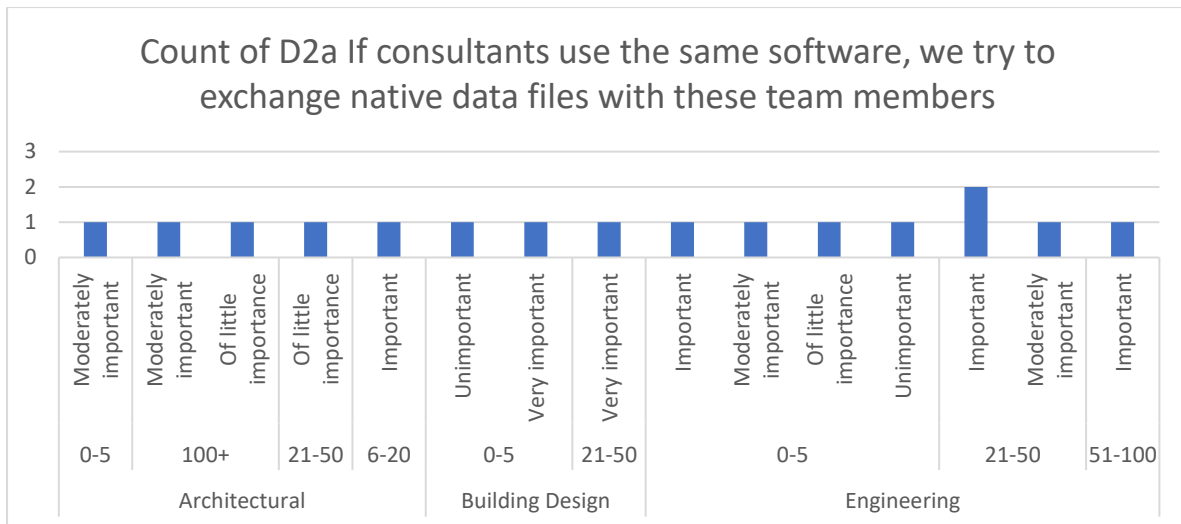
There were some outliers in the results for these two questions, from Figure D1e the rarely response from a small Building Design company and in Figure D1f from a smaller engineering firm. It is hard to determine the reasoning behind the responses without being able to look at the companies in more detail. Possible reasons could be that the companies do not share models often, their BIMMS toll does not allow model sharing to occur a simple way, or when they have shared models, the outcomes have not been positive.

#### **4.6.6 Question D2**

The questions presented in Section D2 were not provided in some instance the best way, responses were to be chosen based on the importance level, although relevant in some of the questions, in other questions it was evident that the frequency i.e. never, sometimes, always response would have been more appropriate. It is suspected that the respondents chose the response that was similar in terms of the correct response, such as unimportant and never, or very important and all the time.

D2a - If consultants use the same software, we try to exchange native data files with these team members?

There was a trend indicated that the AE industry felt it was important that project teams were working with the same BIMMS tool. This was demonstrated by the results in Figure D2a where most respondents felt that it was in some degree of importance for the BIMMS to be the same. There were only 3 responses that found using and sharing the BIMMS to be of little or no importance to their company.



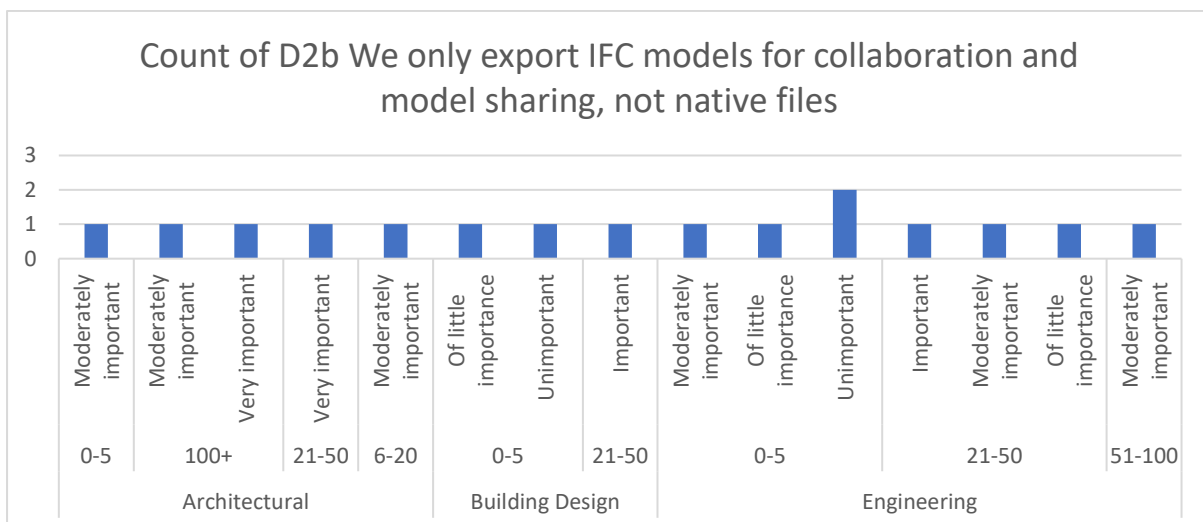
**4. Figure.14 D2a: Exchanging Common Native Data Files with Consultants**

These results are not unexpected, it is easier to share models if they are in the native format, how these models are being used by the project team as demonstrated in earlier questions was a better indication of the BIMMS use. The results do show that there must be some ease within the BIM workflow when sharing native models.

#### 4.6.7 Question D2b

D2b - We only export IFC models for collaboration and model sharing, not native files

The results in Figure D2b below are clearly confusing with the choice of importance level as the response. This question should have been presented differently to provide a better outcome or indication of the use of sharing IFC or Native Files. For instance, if they only provide IFC file even when using a similar BIMMS this would have been more reflective of how the AE industry was sharing the models.



**4. Figure.15 D2b: Exporting IFC files only, Never Native Files**

However, the results suggest that some of the barriers found in adopting BIM discussed in the literature review, such as ownership of models, company standards and intellectual property (IP) are reasons for the AE industry to not share native models with other consultants.

It is possible in BIMMS programs, such as Revit, to purge model files back to just 3D elements, or the bare model. Removing the IP and standards that are used or have been created by a company to further their own BIM capabilities. However, it is understood that this is can be time consuming to do so, the scope of these works therefore needs to be understood.

When initialising a BIM enabled or shared project as noted above, it is therefore important that all project consultants understand the implications to sharing models in this way. Being able to allow the additional costs to do so in the scope of works. It is understood that the current expectation in these early stages of BIM developmental in the AE industry, specifically from what I have seen in SEQ is that these works are not excepted to affect the fee structure or consultants cost for the works in a standard building project. However, this should be progressing with the development of BIM as the requirement to facilitate this environment is better understood and excepted.

#### **4.6.8 Question D2c**

D2c - Other consultants' models are imported or linked into our model for clash detection checking and accuracy only?

The question presented in Figure D2c could again have been clearer, removing the 'only' could have produced a change in the participants response to this question. There also could have been varying results if the question was separated into clash detection and then for accuracy. The results may have been different because how each industry uses or requires the other consultants' models also varies.

For instance, an Architect or Building Designer may use the shared model for clash detection in the case of a MEP model, whereas a Structural Engineer may use the Architects model to ensure the structure fits within the constraints of this model, and the model is therefore used for accuracy.

However, the results were similar to the previous question. Consultants are using the models they share mostly for collaboration.

#### **4.6.9 Question D2d:**

D2d - I find the sharing of BIM models (any format) an integral aspect of working in the Built Environment industry in the current BIM environment

Although some outliers are indicated in the results for this question, it is evident that being able to share models or sharing models is found to be an important aspect of BIM in the built environment in the AE industry in SEQ. The use of the BIMMS and furthering BIM in the current environment requires the ability for consultants to collaborate effectively, model sharing being one of these techniques.

## 4.7 Question Group E: Short Answer Qualitative Questions

This group used a combination of qualitative and quantitative type questions, the latter being requested in the form of short answers or comments. It was not obligatory to provide a comment in all questions, in these instances the respondent was informed that it was only an option.

In most questions comments were made by participants, which was a good reflection of the local AE industry and of the opinion from the respondents of the importance of the BIM in the current built environment climate.

Figures showing results relating to this group of questions can be found in Appendix I.

### 4.7.1 Question E1:

E1 - Governments such as the UK, USA and Singapore have mandated BIM use to varying degrees in their AEC industries. Do you support Australia to do this? Do you think it would further BIM development in Australia? Please also comment if/how you think a mandate would affect your companies use of BIM.

In each AE sector represented it was identified that a BIM mandate by the Australian Government was believed to be unimportant and would therefore not affect those respondents. This can be seen in the figure found in Appendix I.

From the results, three (3) Engineering participants (0-5 employees) believed that a mandate would be unimportant to their specific situation, it was commented by one of the engineering respondents in this instance that:

*We do temporary works engineering.*

*3D BIM modelling is more time consuming to utilise and produce.*

*Microstation is very clunky with IFC models and it cannot reference Revit files.*

*Where 3D modelling is needed it is faster to re-draw portions of a building from scratch using information from 2D plans and elevations provided by the architect or structural engineer.*

*2D CAD files or even just PDF drawings are the preferred method of documents we request from architects and engineers.*

*3D models from other consultants are typically unreliable and un-gainly to work with.*

*3D models have their benefit, but at the end of the day 99% of our documents are 2D details even when created from a 3D model.*

From the detailed comments provided above it suggests that for this user there is a hindrance within the MicroStation platform to use other consultants models, that their specific works are predominantly in the 2D documentation space, that any 3D modelling required was used predominantly to check spatial requirements i.e. ensuring that the works fit within a space.

Another of these engineering participants with 2-3 years BIMMS use, commented that although mandates would not affect the works that they were involved with, they believed in the long run it could affect the BIM development in Australia.

The third engineering participant believed from the comments they provided that to be able to develop the software to perform the way they wanted or thought it would? You had to be a software developer, Commenting;

*'BIM does not appear to help and is a waste of time and money unless you are a software developer'*

With the small amount of survey responses, comments such as this must reflect a common hurdle echoed in the industry when first adopting BIMMS. This respondent had only been using a BIMMS tool for 2-3 years, being in the early development stage of BIMMS use. The frustrations of adopting and adapting to the technology apparently was not progressing to a stage where a return on investment (ROI) was being recognised on a project by project basis.

A Building Designer with a company size of 6-20 who also believed a BIM mandate was unimportant commented;

*'Then reason to use BIM is documented well enough by Autodesk and other industry leaders, The government shouldn't hold back advancement, the industry should drive itself.'*

*'BIM is common on large scale projects where coordination and asset management is required.'*

This is an interesting perception of how in their experience the BIM environment is developing, they have recognised that the industry is forwarding the capabilities of BIM independently from such mandates and that as the industry develops further, the industry use of BIM could or will be self-perpetuating.

Having to wait for Governments to provide mandates that are relevant to the whole industry and not only to larger companies who are more likely to be involved in major infrastructure projects, would be one of the challenges in implementing BIM mandates. The scope of the infrastructure projects mandated and challenges for smaller SMEs were discussed in the literature review.

The other negative response was from a smaller Architectural firm, 0-5 employees, who used Sketch Up, no comment was provided from this responded.

For this question, all other responses from each participant ranged from moderately to very important.

From the moderately important response, an engineering firm, 7+ years of BIMMS use (Revit) and 21-50 employees choose not to comment.

A smaller Building Design firm 7+ years of BIMMS use (ArchiCad) commented that *'...As I don't work in these fields, it is of little importance to me personally, although I can see the advantages for those who do...'* For this responded it is apparent the scale of size of projects they understood that would be affected by a mandate was not relevant to the works they are involved in.

This leads to the question of how a Government will implement a mandate on BIM and how long it would it take for this mandate to be relevant or affect these smaller type firms. The response from this participant suggests they don't believe it would be relevant for some time.

Two other Architectural participants commented that the mandate of BIM to be moderately important to them and to the furtherment of BIM. They both had 7+ years of BIMMS use (ArchiCAD) and had 21-50 and 100+ employees.

The 21-50 office commented:

*BIM is such a broad term and the expectations from parties that do not understand it can be vastly different to what the industry can provide. Policy writers and procurement officers think asking for 'BIM' will solve all their problems. Poorly thought through government mandating places unrealistic requirements for small scale projects.*

And the 100+ office commented:

*Support, but the economic reality of implementation is always forgotten in this discussion. This should be scalable to the size and complexity of project. It's also important to note that larger organisations such as ours have BIM departments to manage/control quality of information, smaller organisations cannot compete with this*

A key point raised by both firms was the importance of how the mandate would be delivered, and what the intent of the mandate was regarding furthering the use of BIM, which must include outcomes they are hoping to achieve by these mandates. Additionally, the mandates implemented should enable BIM requirements to be relevant to the size and scale of a project, such as for a smaller project, less BIM requirements. This may make the requirements of a mandate achievable for smaller SMEs to implement. This could also make tendering on projects with a BIM mandate inclusive to more industry levels.

Another point made was that the understanding of, what BIM is, can be confusing. Confusing between clients, Council and the AE industry's understanding of BIM, including how BIM can solve problems within the industry. If governments are using BIM mandates to solve internal issues within their own departments, without the knowledge of how the industry can deliver in the current BIM environment, this could cause further issues than what they were hoping to solve. Additionally, who is managing the information and what information are they expecting to be delivered by consultants?

The respondents that thought BIM mandates were important or very important believed it would provide the industry with a clearer direction into what was required in a BIM environment, also giving direction in terms of how 3D models need to be created and what levels of detail need to be included in these models. This demonstrates an industry push to further the Levels and Dimensions of BIM.

Another point made was that it would open discussions in the AEC industry around legal issues that had been demonstrated in the literature review that arise around IP, liability and risk. These comments are indicating that the industry does find the limitations of BIM, at least by these respondents and suggests these issues are discussed within project groups or internally within companies.

Pairing this with the data gathered about model sharing and collaboration it begins to provide a better picture of where the local industry is in terms of understanding BIM and common problems associated with its widespread adoption.

An interesting point is the initial comment below where they believe mandates that are enforced on AE industry will lower the standards of the BIM models. This is substantiated by the comments provided where BIM was '*...a waste of money and money...*' Industry representatives that have similar opinions since adopting BIMMS would fall into this category, where they would be forced to adopt BIM even when struggling with the use and early adoption of a BIMMS package.



The comments provided by these participants are below.

*I think that while this will drive more to use it, this will have a few consequences. It will bring some begrudgingly into the use of BIM which may lower the standard of models used (due to those being forced to confirm to something they don't want to). The benefit will be a drive towards better buy in from manufacturers and lead to better BIM development by those who are passionate about it and consequently better models as the buy in will be there from more of the lifecycle of the projects including FM.*

*A mandate would promote discussion about, IP, liability, and risk.*

*I think this will give a clearer direction for the industry in what level of modelling is required. I also think it help give our clients a better understanding of BIM.*

*Europe has accelerated ahead of the US because of Mandates*

It is unclear if the above statement with regards to Europe accelerating ahead of the US is correct. Without further research into this, the Author believes there could be instances where isolated countries or industries within Europe may be developing BIM at a significant and measurable rate to that of the US. However, without a direct comparison, we can consider that Europe has furthered their BIM capabilities considerably since mandates have been implemented.

#### **4.7.2 Question E2:**

QE2 - Please advise if Industry clients/partners have expressed interest or requested the use of a building model for facilities management purposes from your company i.e. the client requested a 3D model with a Level of Development (LOD) to suit a 6D BIM environment Operations/Facilities Management. Please also comment that you understand what LOD is and if you use a LOD in your projects or project workflows

The results from the questionnaire are displayed in table form below (Table E2), the results vary from not being asked or being applicable to being asked about BIM and LOD in project works for facilities management (FM). A similar result is found from earlier responses to questions, where if BIM is requested to be provided by a client or project manager, they do not know what they are in fact requesting.

The respondents have generally related the comments back to their own use of the BIMMS and LOD they utilise in their models rather than the clients and what they have request in a BIM environment. This is can be compared to an earlier comment that noted the industry is or should be driving the BIM development and environment. This is because AE users are the users of the software and have the knowledge of how to apply levels or dimensions within a project that is both useful and relative to a project scop and size.

It becomes clear that the AE industry in SEQ does not believe that the greater community is aware of what a BIM or FM model comprises of, the general feeling is that the a 3D model or image is something tangible for a client to see and spin around, such as fly through animated models, both as a selling point for on-sale or for the realisation of aa concept or idea is perceived as BIM. Whereas the data and other smart information that the AE industry is trying to build within a model, through higher LOD or a more usable model that can be shared between consultants, does not align with these ideas.

The reasons for a FM model or higher LOD had been requested on an occasion at a Government level projects by a participant, however, the project was ‘...unsuitable...’ for the request, without further project specific details being provided, we can assume the was a lack of understanding of what was being requested or required to be delivered.

AE industry sector	Organisation Size	How long has your company being using the BIMMS	Please advise if Industry clients/partners have expressed interest or requested the use of a building model for facilities management purposes from your company i.e. the client requested a 3D model with a Level of Development (LOD) to suit a 6D BIM environment Operations/Facilities Management Please also comment that you understand what LOD is and if you use a LOD in your projects or project workflows
Building Design	0-5	7+ Years	not applicable
Engineering	0-5	7+ Years	We have provided exports our our 3D models, but Microstation is hopeless at exporting BIM information. ie our 3D exports are usually 'dumb' models with no 'building information' in their elements.
Architectural	0-5	3-4 Years	No
Engineering	0-5	7+ Years	Due to the type of work we carry out, it is only on the rare occasion we are asked for models to facilitate an FM role. Primarily the method of maintaining the data is used in other industry standard forms. With this in mind, even when a client doesn't request it, we work to LOD internally as our staging of projects and clash detection as part of our internal quality control
Engineering	0-5	2-3 Years	Some very minor discussions about BIM and facilities management.
Architectural	100+	5-6 Years	This has never been requested of us.
Building Design	21-50	7+ Years	We have only had a few projects where someone has come to us with suggested BIM standards so LOD has not been important to us. We have offered our models in tenders to offer another dimension to the model only
Building Design	0-5	7+ Years	Almost never, and i understand LOD

Engineering	0-5	2-3 Years	Some client request BIM We do not use LOd
Engineering	21-50	7+ Years	I have not had a client request this level of documentation. Most of our models are done to LOD 300.
Architectural	21-50	7+ Years	In the over 15years we have used ArchiCAD, we have always modelled 3D elements. In the past 7-10years we have increased the amount of data we have added to the model primarily for internal specification requirements, and client visulation representation. In this time we have yet to encountered and client who has specifically requested BIM deliverables. A number of government submissions have nominated LOD and a D level, but the projects they were requested for were completely unsuitable for their request. Again clients or procurement officers do no understand what BIM means or entails. We have never provide a model for FM nor has it been requested.
Architectural	100+	7+ Years	Yes, but its not yet a real focus. The real focus is on reducing on site clash issues and speeding up construction, which is why most of our clients from a bim perspective are builders
Engineering	21-50	7+ Years	Occasionally
Architectural	6-20	7+ Years	BIM is driven by the end user. It is our opinion that most don't have a clue what they are asking for or will ever use it. Most appreciate the 3D imagery as a sales pitch or to assist visualisation, but the back end is lost on them. Most of our projects are undertaken to a LOD 300/400 level
Engineering	21-50	3-4 Years	This occurred on occasion, although it tends to get watered down as the project moves forward

**Table E2: Tabulated Response to Question E2**

#### **4.7.3 Question E3:**

QE3 - Comment on the max. dimension of BIM you believe you have used in a project? i.e 3D, 4D, 5D, 6D,...nD. Comment if you are looking at developing your BIM processes or are interested in developing the dimension of BIM that you offer? If you have time, what do you think is required for you to do this? i.e. education, courses, time, money, staff procurement

The results from the questionnaire are displayed in table form below (Table E3), the results vary from 3D which is more prevalent to in some instances 6D, with one respondent noted using up to 5D on all projects, this same respondent provided some great insights in to the process and what is required to further develop the dimensionality of BIM.

Importantly, a large Architectural firm noted not knowing what dimensions they have used. This is significant assuming the size of the projects a firm such as this would have been involved in. It was more important to maintain a quality within the model and to ensure the file size of the models created were usable.

AE industry sector	Organisation Size	How long has your company been using the BIMMS	Comment on the max. dimension of BIM you believe you have used in a project? i.e 3D, 4D, 5D, 6D,...nD Comment if you are looking at developing your BIM processes or are interested in developing the dimension of BIM that you offer? If you have time, what do you think is required for you to do this? i.e. education, courses, time, money, staff procurement
Building Design	0-5	7+ Years	I use BIM for 2D and 3D documentation and presentation as well as using the building model to create schedules such as window / door schedules and finishes schedules
Engineering	0-5	7+ Years	Do you mean "scope" of BIM?? Some of our temporary works are 100% 3D modelled. I am always interested it ways to make 3D modelling easier, faster and most importantly re-usable. Time is required. Education is difficult to find because there is so much garbage to learn along with the needle in the haystack of information that you actually need or will use.
Architectural	0-5	3-4 Years	3D
Engineering	0-5	7+ Years	6D on a few occasions, a minimum of 5D on every project. We are always looking to develop our BIM processes. This requires time, money, staff procurement, industry group collaboration
Engineering	0-5	2-3 Years	3D. Not interested in furthering BIM Dimensions, can see some processes developed to aid in project outcomes i.e. cost efficiencies
Architectural	100+	5-6 Years	Max would be 4D. Not looking to go further.
Building Design	21-50	7+ Years	I think that more development time needs to occur to bring further dimensions to models. When more

			clients come to us looking for these elements to be added into the models we create, then further investment across the industry will occur in developing this side of the software. There is no known standard BIM add on for asset management and these type of items need to develop further to develop BIM
Building Design	0-5	7+ Years	5D
Engineering	0-5	2-3 Years	3D
Engineering	21-50	7+ Years	4D
Architectural	21-50	7+ Years	3D. nothing has ever been required. ArchiCAD currently is unable to realistically handle anything higher than this (5D possibly, but there are limited QS's in Brisbane working with a true 5D model take-off) Our current system would be able to accommodate the advancement, but I expect it would be developed once projects start specifically requiring it (and know it is actually required)
Architectural	100+	7+ Years	Unsure, our main focus is on controlling the quality of our models at this point and the size, to ensure the complexity of our projects doesn't slow down our staff productivity. This is an obvious gripe of many organisations (refer to Autodesk Revit discussions over the last 3 months), with the return on investment of BIM modelling low, for the increased labour required.
Engineering	21-50	7+ Years	Unsure
Architectural	6-20	7+ Years	...
Engineering	21-50	3-4 Years	5D, self-motivated staff staff can minimise the costs

**Table E3: Tabulated Response to Question E3**

#### **4.7.4 Question E4:**

Question E4: If you had a choice, would your preference be to work with consultants using the same BIM enabled software? Please provide comments why or the relevance to work with consultants using the same BIM software. Is it relevant?

The results for this question can be found in Appendix I.

It was found that most of the participants preferred working with consultants using the same BIMMS tool. This is contradictory to the concept of OpenBIMM where the workflow is to exchange IFC files, enabling model sharing. Comments such as '*... it tends to be easier if everyone has the same software ...*' support this idea.

A participant also noted that with sharing of models in the industry today, they would, if they had their tie again, change the BIMMS tool they chose, ArchiCAD, with Revit as they are finding the majority of consultants are using this platform.

#### **4.7.5 Question E5**

Question E5: Interoperability between projects, open BIM and sharing IFC models, means we are required to re-model and update models regularly. If you have time, please comment.

Question E5 had two parts, a Likert Scale type question with an optional short answer response, a graph of the responses is shown in Appendix I.

There were varying short answer responses to this question, which demonstrated that the question may have been interpreted differently by the participants. Most participants had provided a neutral response. This would suggest that the BIM process and sharing of models does not contribute to the amount of changes required in a model.

From the neutral responses most noted that there always was an amount of coordination required and/or expected as a part of the project works, the reason for this varied between participants, however, the reasons were in most cases similar, such as preliminary coordination and design.

There was one response where it was noted that the extent of coordination and changes, expected or required, should be accounted for when scoping the works i.e. as a part of the fee.

This is an important point, at what stage does making changes to a model start becoming an additional or unaccounted cost. In the Authors experience the changing to building models are accepted to be changed up a stage within the project scope, such as design development. When the project is entering the documenting stage for tender and/or working drawings, these changes are no longer accepted. If changes were requested, this could be identified as a change in scope and thus a reason to request a variation to the original proposal. How a variation is managed or in some cases identified is often the difficulty within a project.

This response also leads to the LOD and what part it plays in the understanding of BIM and BIM processes. Ensuring that the LOD is understood for project milestones and how these are identified as project modelling milestones would need to be understood by the project team.

An engineering participant using MicroStation (7+ years) strongly agreed that the interoperability between models caused major changes being required, their comments are noted below;

*'Unless two companies agree on a set of CAD and software standards before they start a project, it is almost impossible to share BIM effectively. There are too many variations in how software libraries are setup. Most companies we deal with share 2D files and only provide 3D IFC or revit models for visual purposes.'*

MicroStation is a platform that is not well known by the Author, considering this, the sector in which it is used may be somewhat different to the 'normal' platforms generally encountered within the BE sector. There is a common trend within the questionnaire by the MicroStation user, where it is was not found to be as compatible with other BIMMS platforms or even IFC models. This is an issue that could be looked at further or in further works focusing on the engineering industry.

Importantly, the above comments can be related to broader areas of project interoperability and collaboration by ways such as those described by the Australian Institute of Architects which describe a BIM Management Plan (AIA, 2012) and how they can be used to determine the 'standards' required in the industry when sharing or using BIM platforms.

#### **4.7.6 Question E6:**

Question E6: Which industry sector do you believe is progressing the BIM environment in SEQ? In regard to your answer above, please comment why you believe that industry is progressing the use of BIM.

A table of the Responses for this question can be found in Appendix I.

From the results there were some well-presented arguments and ideas to who is furthering BIM in SEQ. Generally, each industry group represented, Architectural (which includes Building Design) and Engineering thought their own industry to be at the forefront of BIM Development.

The more pragmatic answers were that all industries were developing the use of BIM. This is a logical answer as no one industry is using each BIMMS in the same way or for the same outcome.

BIM modelling is being developed within a project needs response, the development is therefore slow and independent by a company or participant group. i.e. non-collaborative.

Looking at engineering as the industry sector leading BIM development is difficult to gauge from the responses for this question. It is hard to gauge because there are many disciplines within this industry group working in the Built Environment (BE) space which was not identifiable within this questionnaire.

From the Authors experience, structural engineering has been using the BIMMS more effectively to further BIM than the Mechanical, Electrical, Plumbing (MEP) engineering fields of study. Noting that the structural engineer's scope within the BE space is usually greater than that of MEP, this is not unexpected.

A participant supported this idea by responding that:

*'In general engineering firms are ahead of Architectural firms. Services consultants have been slow to pick up BIM but are now starting to get serious'*

Therefore, not being able to distinguish between the engineering sector within the questionnaire is a shortfall that has been identified. Being able to distinguish between Structural and MEP engineering would have been beneficial to the outcome of the works.

A larger engineering firm (21-50) had a different opinion to the aforementioned, where they believed the MEP engineering sector was ‘...doing well...’ in the advancement of BIM. An important point made by this participant was that the modeller was often the designer, they also noted they used the analytical tools and use of graphical scripting within their models too. This use of the BIMMS tools for analysing the works is encouraging and, in this instance, the advancement of BIM in by this participant can assumed to be high.

#### **4.7.7 Question E7:**

Question E7: I was confused by the questions provided and/or they were not relevant to my industry. Please comment briefly. If you have time, please comment on improvements that could be made to this questionnaire to make it more relevant to the use of BIMMS software and BIM for the AE industry. This information may be used to assist further studies into BIM and the software use to facilitate a BIM environment.

The results from the final question can be found in Appendix I, the result was generally positive.

There were shortfalls in the questionnaire that were identified by the Author after the initial release. These included: Grammatical errors; poorly worded questions; questions with wrong Likert Scale Choices; the questionnaire being able to account for multi-disciplinary industry participants and software.

Some of these shortfalls were highlighted by the participants, the author acknowledges these shortfalls within the works.

It was identified by the Author early in the works that the questions would not be relevant to all participants too. The questions were structured to gauge the use of BIM software in the AE industry in SEQ. The AE industry in SEQ is broad, as were the participant groups targeted in the works. It was expected that some participants would not find the questions relevant. This was confirmed by a participant who completed the survey.

The two responses below were appreciated and provide a great insight to the industry and possible future works in this field.

*‘The mandating of BIM, while a fantastic outcome would need some caveats in my opinion. For commercial project it is a feasible possibility to create the models, however the concern comes as to how the models remain updated in high maintenance environments. For instance in a hospital where there may be 20-30 trade contractors on maintenance, is it the responsibility of the hospital to employ someone to update every change made or is it the responsibility of each contractor to have a copy of the software and update the model and send the changes. If so how do you ‘vet’ the quality of data being received to ensure no degradation of the data over time. For residential projects, my concern is financial feasibility. The cost of modelling every element is not fiscally responsible and almost impossible to get a 5D or 6D of each building element without blowing out the cost. While I think mandating BIM is a good idea, I think a measured approach is required to ensure it is applicable an of use.’*



The above comment was made by an engineering participant who was a BIM manager with 0-5 staff. This insight suggests a well-developed use of BIM within their company. From the response it is evident that the uptake of BIM and facilities management as described would require the creation of new roles or job descriptions, for which there are no current educational courses to be qualified to undertake these roles.

When we look to the future of BIM, we are looking at an industry that is changing and also creating new understandings, workflows and processes that all need to be better understood, which was also highlighted in the literature review, where the adoption of BIM and processes were required, and for which had not been invented.

*'To improve the BIM industry, further marketing should be targeted at the 5th/6th dimension - ie. end user and having them interact with the model, changing wall colours, furniture etc via mobile app. Further development in this will quickly push investment and the need for BIM and make it standard for the integration of the virtual world with the real world assisting augmented reality.'*

The comment above was made by a Director of a Building Design company with 21-50 Staff. Where interaction was noted as a key development to get customer and client 'buy in' to the building development or design and the potential within the industry to develop methods to facilitate a need for the 3D model.

Do clients care if they see a 3D model, I think they do, as it has been observed by the Author that some clients are unable to understand a 2D plan drawing or elevation. Being able to interact with a model will further a client understanding which could also lead to the acceptance of additional costs to be able to do so, by furthering the input and control of a design or understanding their project.

## **Chapter 5 Further Discussion of Results:**

The questionnaire and groups of questions were designed to follow in the Authors opinion a logical process: general data; adoption; development and creation; collaboration; and opinion. A discussion of this is below:

### **5.1 Data**

Group A questions were used to verify the participants data, data to be used for the analysis of the results. Such as the sector they identify with, size of the organisation and BIMMS tool they use.

From the data we found that 20 out of the 25 participants in the AE industry in SEQ were using a BIMMS tool, and that these tools were being utilised by participants from companies of all sizes and industry sectors.

A greater participation rate would have provided a better indication of the prevalence of BIMMS use in SEQ, however, if we look at these figures, we find that from the five (5) participants who did not use a BIMMS tool, four (4) of these had 0-5 staff and one (1) had 6-20 staff. If we assume that companies greater than 21 staff are more likely to have adopted a BIMMS tool, we can identify that it is the SMEs that are falling short on adoption of BIM.

As identified in the literature review there was only a small amount of research into SMEs and their adoption of BIM and BIMMS. This questionnaire directed the participant to submit the questionnaire with a selection of No to the use of a BIMMS tool. This was a missed opportunity, if the participant was directed to an option to allow an explanation or comment to why they had not adopted BIM, this would have provided a better result, providing the insight on why they had not followed the trend to adopt a BIMMS tool.

### **5.2 Adoption**

Group B questions were designed to find out how the participants were using the BIMMS tools, their transition from previous CAD applications, standards being used to model in the software and the development of the tool to further both BIM and 2D drafting standards.

It was shown that the adoption of the BIMMS platform from the traditional 2D CAD programs was not for most participants an easy one. With only four (4) participants agreeing it was not difficult. Two (2) participants noted that having experienced staff did not help make this transition easier. We can look at this in a few ways, the ability of the staff to adapt, or the 'free' time the staff must find to invest in the transition.

Every business has different needs, budgets and 'culture'. A commitment from all staff members is usually required to complete a project. A project is generally defined by a limited budget and time for completion to meet that budget. A similar limit could be associated with the adoption of BIM, such as if there is project time allocated or budgeted for BIM development, or, is it then the staffs 'own time' that is required to undertake this development. It was commented in the Group E questions that the development was undertaken by 'motivated staff', inferring staff that due to their enthusiasm took on the development in their own time.

The question group then moved on the creation of LOD within the modelling elements, the reason for the development of a LOD, how the BIMMS enabled the creation of this LOD.

The results showed that most participants knew what a LOD was and were using it in the models they were creating. They also indicated that the industry, noting that most participants had been using a BIMMS tool for 5+ years, were creating objects with an understanding that the objects could serve more than one purpose. To not only reduce drafting time but to also increase the parametric qualities of an object to enable BIM development. Such as being able to use the data to produce schedules or the like, furthering BIM development regarding dimensions. i.e. from 3D to 4D or even 5D. (3D Shape/Modelling, 4D Scheduling/Time, 5D Estimating/Cost).

The results from this question suggested that further studies could be undertaken which look at the LOD development in more depth. The questions in this study only touched on the understanding of a LOD, but, how a LOD is being used in relation to both a project and model creation could be insightful to companies who are thinking of adopting a BIMMS or what stages a BIMMS development may require.

The Author believes that a lot of time in the early development is wasted trying to mimic 2D drafting capabilities in a 3D scenario. Being able to develop both an object for a 2D and 3D purpose with an understanding of the LOD or BIM dimension may enable less time later in the development stages, increasing a ROI faster. A lack of ROI having been discussed as a hindrance to the adoption of BIM in the literature review.

### **5.3 Development/Creation**

Group C questions looked at what the participants would usually model, such as surfaces/topography, and how or when they would use these modelling elements. If the participants would use the ability to place the model in a 'real world' environment.

It was important to the Author to find out whether certain modelling objects such as topography and location, 'real world' coordinates were being utilised within a BIM model. From the authors experience, when project models had been shared (native files) it was evident that the consultants were modelling in 'space' with no thought to the geospatial location., this was surprising and reflected in the results, especially considering from the Authors experience it is not an arduous task to set up a model off a survey to do this.

As noted participants generally didn't set up models in this way, it was reported more often that it was only done sometimes, however, when we look at how often the information was issued as delivery to the client or builder the reasons become clearer. If you are not going to provide easting, northing, earthworks quantities or heights within a schedule in the project documentation, then the reason to set up a model in this way becomes redundant. Possibly being seen in the AE industry as an unnecessary use of project time and one which may affect project budgets.

We then moved on to the creation of modelling elements or objects, the reasons to create additional objects, if the objects were created from modified program objects, created by the participants or sourced elsewhere, such as online by manufacturers or by specialists who create objects.

With these objects it was then important to understand what parametric data was being added to these elements and when or if this data was then being used as a project **delivery**.

This group of questions also touched on the use of the analysis tool in-built within the BIMMS tool which was discussed in section 4.5.11.

## 5.4 Collaboration

Group D questions looked at the collaboration of the BIMMS software with other consultants, the sharing of native files or IFC files and how or what these shared files were being used for.

This was an important question group as the results gave an opportunity to look at the use of a BIMMS program for collaboration and the maturity levels of a participant too.

The results raised further questions about the concept of an 'Open BIM Platform' which can be found at BuildingSMART Australasia website < <https://buildingsmart.org.au/>> , it describes an Open BIM format as being the sharing of an IFC model as the concept for an OpenBIM workflow environment. Further describing the IFC model as an equivalent of a PDF exported from a Microsoft word document. The information contained within an IFC is a copy of the building model but does not contain the data that the original model has.

How does this Open BIM workflow contributed to furthering the dimension of BIM past 3D? When the consultant's models, with the intelligence and data within it, is not brought together into a final design model containing all the information? A cloud-shared model would essentially have all the information contained within it. Notably, most of the participants had never used a model in this way. The preference was to exchange IFC files for sharing even over native files. Where building models were generally always created from scratch even if native files models had been exchanged too.

However, the collaboration in SEQ is reflective of the industry expectations both nationally and internationally and are complying with the OpenBIM standards that are discussed as the workflows of BIM. How will Government mandates affect the Open BIM standard regarding model delivery, model ownership and project deliveries using this OpenBIM workflow concept.?

## 5.6 Opinion

Group E was both quantitative and qualitative in the approach, looking at the opinion of the participants around: BIM mandates; understanding of clients need for a BIM model; the level of BIM being utilised and reasons; preference of file sharing interoperability and the further progression of BIM.

The Government mandates and importance of them was discussed in section 4.7.1. There was mixed opinion on the importance of mandates being introduced, general concerns were around the relevance to the wider industry not just larger consulting firms, being able to introduce mandates that don't bring smaller (and larger) industry representatives unwillingly to adopt BIM and to the detriment of BIM. Industry collaboration being a possible conduit to enable mandates to be introduced effectively was suggested.

Discussed in the literature review was the success of BIM in Europe, specifically in Holland, where this success was attributed and even driven by a client 'buy in' to the BIM phenomenon. It was identified in these works that most of the participants had not been requested by a client to provide a BIM environment within a project. This was in some cases due to the works that they undertook. However, on the occasion where it had been requested by a client or in Government tenders, the participants noted that the understanding of BIM was either not clear, or not aligned with the requirements of the project.

Where is the discrepancy in the understanding of BIM in Australia coming from compared to that in Europe? Is there a discrepancy? Are the BIM mandates that were implemented in Europe or the UK also engaging the greater industry? It is suggested by the results that the link between Government

mandates not only engages the AE industry, it also engages users of the AE industry such as developers or end users, to generalise, of the built form. The mandates may not appear to be relevant initially to the AE industry and somewhat problematic. However, the exposure that BIM receives from the greater audience due to the mandates could be attributed to the success of BIM in other countries, where these mandates have been in place for some time.

Most participants were using the BIMMS tool in projects for 3D, shape and modelling, as expected. However, because of the LOD developed within the project models created, participants noted they were able to develop or use the model for 4D or 5D, in some instances it was indicated that this development was not the priority, the focus was the quality of the model and how the model, due to its complexity affected the project productivity. However, the major hindrance to developing the BIM dimensions was the demand. The demand from clients is not being requested or is requested with little understanding of BIM, making it difficult for participants to see a ROI to putting further effort into the development of BIM.

The results indicated that there was a preference to use the same BIMMS tool, however, there was also a significant amount of participants who thought it was not as important, this can be related to the OpenBIM workflow concept for sharing models in IFC format. Respondents did advise that it did make the workflow easier when working with native files. ‘

How BIM is shared and developed is becoming integral to the progression of BIM in the AE industry in SEQ. The questionnaire also looked at how the interoperability affected the workflow, there is an expectation that re-modelling is required, but the extent of this is dependent on how the changes affects the design of each consultant. For instance, if a non-loadbearing wall was moved in an Architectural model, it would not necessarily be moved in the structural model as it did not alter the overall structural design. This leads to the requirement of a BIM management plan to be agreed upon within a project team early in a project. The BIM management plan would need to outline the expectation and extent of the re-modelling so that it is understood by all members, with this understanding the scope or fees for a project can also be captured by the project team.

It was requested that the participant provide their opinion on which industry was progressing the use of BIM in SEQ. Most participants chose their own sector, however a few participants looked at this holistically, noting it was all sectors that could be seen to be progressing BIM. Architects are progressing BIM to include data that can be related to the project specification, Engineers are pushing the modelling boundaries in the detail provided in objects, being able to use the models for 2D and 3D documentation to reduce linework required and schedule quantities. Analysis tools are reportedly being used by the MEP Engineering sector in the design phase of the works and manufacturers are producing objects that can be used across multiple platforms.

The AE industry are using the BIMMS tools for numerous reasons and across a myriad of projects, the development of BIM changes as the project outcomes vary. Being able to share this information freely across the AE industry would potentially open BIM to those who have not adopted it. However, the techniques developed by users of BIMMS at this point remain the intellectual property and, in most cases, the competitive advantage for these users.

BIM user groups are opening up the technology being developed by BIMMS, however, this technology is generally aimed at long time users of the BIMMS tools. For industry sectors looking only now to adopt BIM, the information provided within this framework is not relevant. The industry needs to find

ways to educate, by providing avenues for these laggards of the BIM phenomenon to see the technology as a possibility.

### **5.7 Shortcomings of Questionnaire:**

Some participants commented within the questionnaire that;

- the questions were poorly worded
- the questions were not relevant to their industry
- the questions were bias. The author believes participants may have felt trapped into responding to a question they did not find relevant
- the questions did not account for multidisciplinary companies or if companies used more than one BIMMS platforms

Additionally

- Likert rating provided for some questions were incorrect, this was confusing for the participants i.e. the frequency was used instead of the importance  
Retrospectively to many questions were mandatory, if options were provided to skip questions that were not relevant, it may have yielded a better completion rate (noting 4 participants did not complete the questionnaire).

The Author was able to identify shortcomings within the questionnaire and overall study. Some of these shortcomings were from the lack of experience using the USQ survey tool and creating questions that are relevant to a wider audience. When we try to construct questions to uncover results or data in this format, we can use what we know or have learnt, such as reviewing previous literature or from personal experience.

In practice, without prior experience in undertaking works in this format, it is hard to determine what the best question may be to elicit a meaningful result, having experience creating a survey as this one, the Author believes you would give you awareness of subtleties such as these to create a better questionnaire.

### **5.8 A Focus on the Participants**

The questionnaire was originally intended to limit the participant groups to those who had office only within SEQ or Queensland. However, as the participant response was poor, it was decided to use all the results and not to limit the study based on the above. Two(2) Architectural firms with 100+ staff, a Building Design firm with 21-50 staff, all who used a BIMMS program and one engineering firm with 0-5 staff who did not use the BIMMS platform had responded they had offices outside of Queensland.

The results recorded by the participants above who used a BIMMS platform were invaluable to the study, the insight of the BIM use of these and other larger companies within SEQ was extremely beneficial to the study. Importantly, the small SMEs who had adopted a BIMMS tool, from their responses, were also looking at the progression of BIM and BIMMS tools in a similar way to the larger companies. There were of course some exceptions as shown in the discussions above where the uptake of BIM was not as positive.

The questionnaire also requested the participants role within their company to be provided, when analysing the results, it was found that this data did not specifically benefit the study, however, it may be used by others when constructing a questionnaire in the future in regards to the target audience or participant. A chart of which is shown below,

It is encouraging as seen in the figure below that for the AE industry in SEQ, a BIM Manager was identified in each range of organisational sizes. This suggests that a need within the industry has been identified at all industry levels.



**5. Figure.1 Question: Count of company role and size of company.**

## Chapter 6 Conclusion:

The study of BIM and the use of BIMMS is a complex one. The quantitative results although poor in their significance have provided an overview across the AE industry in SEQ. The participants were from Architectural, Building Design and Engineering sectors across the BE project space. Encouragingly participants were from companies with a range of employee sizes, ranging from SMEs to companies' 100+ in size.

The study suggested that there was a high adoption of BIM and use of BIMMS tools across the AE industry in SEQ, however, with this adoption there are also varying feelings about the usefulness of the BIMMS as some participants are still trying to see the benefit and ROI since this adoption. The objects within the BIMMS tool are being used and developed for both 2D and 3D parametric advancement in BIM. This object development tends to go hand in hand with the 2D development corresponding to 3D modelling efficiencies.

It is evident from the results that there is mixed opinion about the use of BIMMS in the AE industry. It is not isolated to SMEs. Across the AE industry the participants were adopting and adapting BIMMS to suit their own company needs. The use and opinion of the BIMMS varied across disciplines, where larger companies undertaking larger projects have their focus on model sizes and functionality, rather than the dimension of BIM they are achieving. Smaller SMEs are adapting to the use of BIMMS tool; however, some are still trying to find a ROI since this adoption. Most participants were using the BIMMS tool to 3Dimensions, with the ability when required to provide up to 4Dimensions and even 5Dimensions. Which suggests a strong development of BIM in the AE industry in SEQ.

These dimensions of BIM were an important aspect when looking at the use of BIMMS, the dimensions being utilised were strongly tied to the goals of each participant which was varied. Operational needs, functionality, workflow, project scope, LOD and profitability all important aspects required to be taken into consideration when looking at the use of a BIMMS tool. Collaboration of these tools in a project environment is predominately being used for coordination such as for clash detection, with the preference to work with other consultants using the same BIMMS tool. However, the IFC model exchange is predominantly used, which follows the recommended OpenBIM workflows documented widely documented.

The BIMMS use in the AE industry in SEQ is currently in the hands of the individual(s). BIM appears to be moving out of its infancy in SEQ as more companies are adopting the BIMMS software. What software to adopt and choices around compatibility, sharing models and interoperability are all areas where BIMMS can advance.

Education, standards and sharing of the use of BIMMS is an important move forward to advance BIM in SEQ. Changing the closed door attitudes due to competitive advantage would benefit the smaller SME groups of BIMMS users to see a benefit be it from ROI or client/customer satisfaction a key element for progressing BIM and BIMMS.

Importantly, there is a mixed opinion for the advancement of BIM to be in the control of Governments via mandates of BIM in project environments. Larger sized companies in the study could see the benefit and the hazard in this forced adoption. Careful planning by industry (BIM) experts being noted as being important to the discussion and implementing of any mandates presented.

The Author believes through this study that Government mandates, that are implemented through industry discussion would be a way to progress BIM from its infancy in SEQ. Looking at how mandates



in other countries appear to have motivated the end user, clients, developers etc seems to have put an emphasis for BIM in those countries which has contributed to their BIM use and BIM development.

An OpenBIM and technology sharing industry is important to the advancement of BIM, however, current groups who are in support of this, such as BrisBIM appear to be aimed at the industry representatives who have already been using the BIMMS tool effectively and for a long period of time.

We need to try to encourage users who are not using BIMMS to adopt BIM. This is what is required to progress BIM across all industry sectors.

To highlight this, the Author recently was in a meeting with structural engineers who noted they had tried to adopt Revit, however, with a lack of ROI they quickly shelved the program as it was not effective in their working environment.

Where does the Author see the advancement in the AE industry in SEQ. From my experience, the 2D tools within the BIMMS technology surpass' that of the traditional 2D CAD software. Not adopting BIM, even as a laggard is not realising the advancements and advantages the BIMMS tools provide.

Further Government mandates in Australia, even if they are for a select industry group, was suggested by these works to reach more than just the industries using the BIMMS tools. They reach the broader community, giving BIM a chance to advance from outside of the AEC industry directly. Opening discussions and interest in the BIM philosophy, which can only benefit the advancement and demand for BIM.

## Chapter 7 Further Works

There are a lot of avenues for these works to be progressed. Most of these can be developed from the shortfalls within this study and the understanding gained from this research on how the local AE industry in SEQ is developing.

These include:

- Targeting a specific industry sector. This study did not include the construction industry; however, the participant group was broad as it included Architects, Building Designers and Engineers. If the study group is narrowed down for example to look at only engineering disciplines, the results may provide useful data within that sector which are more relevant. This fact was identified as a shortfall within the questionnaire as it did not allow the participant to identify the engineering discipline i.e. structural, MEP. Because of this It was harder to gauge for example within this sector the variance in the uptake and use of BIMMS.
- Look specifically at multidisciplinary companies and how they develop the BIMMS software. How do these companies use the BIMMS across projects and their own company needs? This could lead to an understanding of what methods are being used and if the methods used have been successful or not. A study that can identify failures and success could benefit all BIMMS users.
- A Continuation of this study, however, looking at more successful ways to engage and provide a greater response from participants. The method to use targeted and random AE industry participants was not successful. A better way to engage the participant group so that they undertake the questionnaire or works is required. Calling or contacting the company prior to releasing the questionnaire may lead to a greater participant rate and statistical significance.
- Direct a questionnaire to the AE industry focusing on LOD and how modelling objects are created in a BIMMS program to develop or use a higher LOD. What is the motivation behind how or why the BIMMS user is creating and using objects.

There are many opportunities found within this study to broaden both the local, national and global understanding of BIMMS use and BIM.

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## No table of figures entries found. **Appendix A: Project Specification**

ENG4111/ENG4112 Research Project:

### PROJECT SPECIFICATION

**For:** Craig van Neuren

**Title:** How Building Information Modelling software (BIM) is being used in the AEC industry and how the use of this software is impacted by the AEC industries own understanding on what is BIM - A South East Queensland Perspective

**Amend Title:** How Building Information Modelling software (BIM) is being used in the Architectural and Engineering (AE) industry and how the use of this software is impacted by the AE industries own understanding on what is BIM - A South East Queensland (SEQ) Perspective

**Major:** Civil Engineering

**Supervisor:** David Thorpe

**Sponsorship:** NIL

**Enrolment:** ENG4111 – EXT S1, 2020

ENG4112 – EXT S2, 2020

**Project Aim:** To determine what BIM software available is being used by the AE(C) industry and how this software is being used. Focusing specifically on the AE industry in SEQ

To determine if how the software being used has been impacted by the industries understanding of what BIM is to gain a perspective of the level of BIM in South East Queensland (SEQ).

Programme: Version 1, 20<sup>th</sup> March 2020

An initial meeting was held at the office of David Thorpe on Friday 21<sup>st</sup> February 2020. During the meeting it was discussed to focus more on the Architectural and Engineering (AE) side of the AEC industry, the reasons were as follows:

- There has been a lot of research into the use of BIM in the construction side of the AEC industries, less so into the use of the programs used by the AE industries to facilitate the broader BIM levels
- The research area would be to broad within a dissertation to focus on all three industries
- The construction industries use of BIM is usually limited to Estimating (4D) and Construction Programming (5D), this would limit the usefulness of the research into the broader levels of BIM

- 1) Literature review.
  - i) Outline a brief history of BIM
  - ii) Discuss levels of BIM
  - iii) Research the use of BIM programs and impact on understanding of BIM in the AE industry has on the use.
- 2) Development of Questionnaire Survey:
  - i) How is the survey going to support the research and project aims?
  - ii) Collate a list of AE targets to send questionnaire survey.
  - iii) Look at target number of surveys and responses to be useful, timing to allow for industry targets to respond
  - iv) How the survey will be distributed/collected
  - v) Develop questions from research and industry knowledge
- 3) Submit 'Project Progress Report'
- 4) Submit initial questionnaire to relevant USQ supervisors for approval/comment
- 5) Get Ethical approval for questionnaire survey to be distributed
- 6) Distribute survey and follow up with respondents, gather surveys.
- 7) Analyse data provided from the survey, compare and make connections towards research dissertation topic.
- 8) Provide conclusions from the evidence provided.
- 9) Make comments on further studies within the field to further the field of study

If time permits:

- 1.) Statistical development of methods of BIM adaption based on 'personal business' perspective, relative to a worldwide adoption of BIM within the AE industry.
- 2.) Provide checklist for companies to use to self-assess their use of the programs to see if their own understanding of BIM is aligned with how the technology and industry itself is moving forward in this field of study.

Contribution:

I believe the study could help identify shortfalls in both the adaption and understanding of what BIM is within the AE community locally and possibly worldwide.

The study could help to broaden the understanding of BIM within the AE community so that communication in developing a unilateral or mutual understanding can be utilised across projects, remove misconceptions of what different sectors, Architectural/Engineering/Construction perceive the other sector is or should be operating as a contributor to BIM in projects.

## Appendix B: Project Completion Programme

# Project Completion Programme

Project: ENG4111/ENG4112

Version: 1

Date: July 2020

ACTIVITY	Week Number	9	10	11	12	13	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
	Week Ending	MAR				JUN				JUL				AUG				SEP			OCT						
		1	8	15	22	29	7	14	21	28	5	12	19	26	2	9	16	23	30	6	13	20	27	4	11	18	25
1.0 ENG4111 - Project Progress Report																											
1.01 Amend for comments provided by project supervisor																											
1.1 Research, Literature Review and Methodology																											
1.11 Amend for comments provided by project supervisor																											
1.2 Development of Questionnaire																											
1.21 Submit for peer/ethics review																											
2.0 ENG4112 - Dissertation																											
Write up and Draft submission																											
Professional Practice 2																											
Civil Design Practice																											
2.1 Send survey to prospective industry																											
Collect Surveys																											
2.2 Collate and analyse results																											
Findings, comments																											
2.3 Further works on topic																											
Submit final draft for grading																											

## **Appendix C: H20REA171 Human Ethics Application**





# Human Ethics Application

Application ID : H20REA171  
Application Title : How Building Information Modelling software (BIM) is being used in the Architectural and Engineering (AE) industry and how the use of this software is impacted by the AE industries own understanding of BIM - A South East Queensland (SEQ) Perspective  
Date of Submission : 13/07/2020  
Primary Investigator : Mr Craig Van Neuren; Principal Investigator  
Other Personnel : A/Pr David Thorpe; Co-Investigator

## Instructions

### Instructions

Click the **green arrow** to go to the next page.

## Pre Application

### 1 Application Type

Ethics category\*

Human Research Ethics Application

**1.1** Has this application been reviewed and approved by another Human Research Ethics Committee (HREC)?

Select "Yes" if your project has already been approved by a human research ethics committee (HREC) that is not operated by the University of Southern Queensland, (i.e. you wish to register your ethics approval with USQ).  
Select "No" if the University of Southern Queensland Human Research Ethics Committee will review and approve your proposed research.

\*

Yes  No

**1.2** Does this research project involve?

Tick all that apply.

\*

- Direct recruitment and/or observation of human participants
- Use and/or disclosure of existing data sets and/or archival data
- Use and/or disclosure of existing biospecimen collections
- Any form of genetic testing or analysis of genetic material
- Clinical trial

Review outcome comments for **1 Application Type**.

*This question is not answered.*

Click the **green arrow** to go to the next page.

### 2 Potential Participant Group

**Does this project involve (a) the direct recruitment of participants that specifically targets, and/or (b) the use of existing data and/or tissue of participants from a project that specifically targeted...**

**2.1** Women who are pregnant, the human foetus, or human foetal tissue?\*

Yes  No

**2.2** Children or young people under the age of 18 years?\*

Yes  No

**2.3** People with a cognitive impairment, an intellectual disability, or a mental illness?\*

Yes  No

**2.4** People considered to be a forensic or involuntary patient?\*

Yes  No

**2.5** People with impaired capacity for communication?\*

Yes  No

**2.6** Prisoners or people on parole?\*

Yes  No

**2.7** People highly dependent on medical care, including a person who is unconscious?\*

Yes  No

**2.8** Military personnel?\*

Yes  No

2.9 Military veterans?\*

Yes  No

2.10 People who would not usually be considered vulnerable but would be considered vulnerable in the context of this project?\*

Yes  No

2.11 Aboriginal and/or Torres Strait Islander peoples?\*

Yes  No

2.12 Hospital patients?\*

Yes  No

2.13 People in other countries?\*

Yes  No

2.14 People who would consider English to be their second language?\*

Yes  No

Review outcome comments for **2 Potential Participant Group**.

*This question is not answered.*

Click the **green arrow** to go to the next page.

### 3 Proposed Procedures

**Does this project include...**

3.1 Any physical, psychological, social, economic, and/or legal risks greater than inconvenience or discomfort, in either the short or long term, resulting from participation in, or use of data in this project?\*

Yes  No

3.2 The collection and/or analysis of any biological material obtained from a person (e.g. tissue, blood, urine, sputum, or any derivate of these such as cell lines) in laboratory based research?\*

Yes  No

3.3 Generating, gathering, collecting, conveying or using genomic data, information, or biological materials (such as germline/germ cells or somatic cells) that has **hereditary implications** and/or **is predictive of future health** in research involving participants, relatives and other family members?\*

Yes  No

3.4 Research intended to study and/or expose illegal activity?\*

Yes  No

3.5 Radioactive substances and/or ionising radiation?

*(e.g. DXA, X-ray)\**

Yes  No

3.6 Sensitive and/or contentious issues? *(e.g. suicide, eating disorders, body image, trauma, violence, abortion, etc.)\**

Yes  No

3.7 Toxins, mutagens, teratogens or carcinogens?\*

Yes  No

3.8 Deception of participants, concealment or covert observation?\*

Yes  No

3.9 Seeking disclosure of information which may be prejudicial to participants?\*

Yes  No

Review outcome comments for **3 Proposed Procedures**.

*This question is not answered.*

Click the **green arrow** to go to the next page.

#### 4 Operational Requirements

Does this project involve...

4.1 collection or use of information or data from or about **USQ Students**?\*

Yes  No

4.2 collection or use of information or data from or about **USQ Staff**?\*

Yes  No

4.3 International travel for data collection purposes?\*

Yes  No

4.4 Collecting data in a rural and remote setting?\*

Yes  No

4.5 The collection, use or disclosure of IDENTIFIABLE personal information (eg, names and contact details on consent forms)\*

Yes  No

4.6 The collection, use or disclosure of RE-IDENTIFIABLE personal information (eg, when identifying details are replaced by codes, pseudonyms, etc)\*

Yes  No

4.7 The collection of information by observing participants **WITHOUT** their knowledge?\*

Yes  No

Review outcome comments for **4 Operational Requirements**

*This question is not answered.*

Click the **green arrow** to go to the next page.

#### Application Detail

##### 5 Project Title and Summary

Researchers are encouraged to read [Chapter 3.1](#) of the National Statement of Ethical Conduct in Human Research, 2007 (updated 2018). A critical feature of good research is clarity regarding how the research project will meet the ethical requirement that research has merit, as described in paragraph 1.1 of the National Statement. **The Elements of Research**, outlined in this chapter, offer advice and guidance about meeting this obligation and will assist you in completing this application across the following sections:

Element 1: Research scope, aims, themes, questions and methods

Element 2: Recruitment

Element 3: Consent

Element 4: Collection, use and management of data and information

Element 5: Communication of research findings or results to participants

Element 6: Dissemination of research outputs and outcomes

Element 7: After the project.

##### 5.1 Project Title\*

How Building Information Modelling software (BIM) is being used in the Architectural and Engineering (AE) industry and how the use of this software is impacted by the AE industries own understanding of BIM - A South East Queensland (SEQ) Perspective

5.2 Using plain language, provide a succinct description of the background and the potential significance of the research project.\*

In the Architectural, Engineering and Construction Industry (AEC), the last 20 years have found a new phenomenon taking over the industry, Building Information Modelling (BIM). This is a worldwide phenomenon. with governments, companies and individuals all using and being involved with and adopting new technologies to facilitate a BIM environment.

At its essence, BIM is the use of software to create a 3D structure in which all objects within the model are able to be quantified, qualified, categorised, scheduled, costed, constructed, refurbished and demolished. Further than just a 3D model, it is widely identified as a process. A process which is able to assist in all facets of a construction project, from concept, design and construction, to facilities management and through to the assets demolition,

This study aims to look at how BIM, be its maturity or dimension is understood in the AEC industry and more specifically the Architectural and Engineering (AE) industry in South East Queensland (SEQ). How the understanding of BIM is reflected in the way the AE industry uses the software to create 3D models.

This study is significant as it is looking at a correlation between the understanding of BIM and the use of BIM enabled software to facilitate a BIM environment. Previous studies have primarily looked at key indicators surrounding the maturity and dimension of BIM based on collaboration between other consultants and project outcomes relating to the maturity and dimension of BIM,

Focusing on the software brings the study back to the individual users, although not specifically looking at small and medium business enterprises (SMEs), focusing on SEQ moderates an industry that represents both SMEs and large industry which could provide a good insight to a worldwide perspective on BIM,

### 5.3 Clearly state (a) the project aims; and (b) the research questions and/or hypotheses.\*

This project aims are to identify if there is a disparage between how the Architectural and Engineering industry understand building information modelling (BIM) and how they use software to facilitate a BIM environment,

To see if there is a connection between their understanding of BIM and if it is relevant to the use of the BIM software. Identifiers to see if there is a correlation to understanding BIM and BIM use.

One hypothesis is that although the concept of BIM is understood, the niche in the market is not there to facilitate a large scale BIM software adoption.

Review outcome comments for **5 Project Title and Summary**.

*This question is not answered.*

Click the **green arrow** to go to the next page.

## 6 Investigators

**6.1** Enter the Academic Organisation Unit (AOU) (six-digit project code) that will be aligned to this project.

Search for the AOU by entering a portion of your school or centre (e.g. eng, health, psy, edu, sci) in the text box, then clicking on the magnifying glass. Choose the appropriate AOU code from the list returned and tab out of the text box. Attempt to select AOU that reflect school-level units rather than broader faculty-level units.

If the Principal Investigator for this project is NOT affiliated with the University of Southern Queensland, enter "EXTERNAL".

\*

### 6.2 Principal Investigator

The Principal Investigator **must be a USQ Employee**. Additional investigators (including student researchers) can be added in section 6.3 of this eForm application.

The Principal Investigator (PI) of this project will hold ultimate responsibility for the ethical conduct of the research project in accordance with the University's [Research Code of Conduct Policy](#), [The Australian Code for the Responsible Conduct of Research, 2018](#), and [the National Statement on Ethical Conduct in Human Research, 2007 \(updated 2018\)](#).

The PI must ensure that all investigators involved in the conduct of this research project understand and accept their roles and responsibilities.

#### To complete this section...

Click on the hyperlinked investigator's name and complete all required fields (indicated with \*). Ensure the "Primary Contact" is checked to "Yes". Click on "OK".

1	Order	1
	RIMS Code	0000189866
	Position	Principal Investigator
	Title	Mr
	First Name	Craig
	Last Name	Van Neuren
	Full Name	Mr Craig Van Neuren
	Student Researcher?	Yes
	Primary Investigator?	Yes
	Primary Contact?	Yes
	ORCID ID (if known)	
	Email Address	U1004476@umail.usq.edu.au
	Secondary Email	craig_honora@inet.net.au
	Mailing Address	
	Address Line 1	23 Halimah Street
	Address Line 2	
	Address Line 3	
	Address Line 4	
	Suburb/City	Chapel Hill
	State	Queensland
	Postal Code	4069
	Country	Australia
	Contact Phone	0449 935 370
	Mobile Phone	0449 935 370

### 6.3 Other Investigators

List all investigators associated with this project and their role (including supervisors of student research projects).

#### To complete this section...

Enter the investigator's first name in the text box and click on the magnifying glass. Choose the correct investigator from the list returned. Repeat this step to add all investigators.

For each investigator listed, click on the hyperlinked investigator's name and complete all required fields (indicated with \*). Ensure the "Student Researcher" question has been answered and that the Primary Contact is checked to "No".

Click on OK.

To add an External Collaborator, click on the "Add External Person" button and complete all required fields (indicated with \*) and OK.

1	Order	2
	RIMS Code	0000157221
	Position	Co-Investigator
	Title	Associate Professor
	First Name	David
	Last Name	Thorpe
	Full Name	A/Pr David Thorpe
	Student Researcher?	No
	Primary Contact?	No
	Person Type	Internal
	ORCID ID (if known)	
	Email Address	David.Thorpe@usq.edu.au
	Secondary Email	
	Mailing Address	
	Address Line 1	
	Address Line 2	
	Address Line 3	
	Address Line 4	
	Suburb/City	
	State	
	Postal Code	
	Country	Australia
	Contact Phone	
	Mobile Phone	

Review outcome comments for **6 Investigators**.

*This question is not answered.*

Click the **green arrow** to go to the next page.

## 7 Benefit and Risk

**7.1** Outline the benefits to participants and/or to the community as a result of this research being conducted. \*

I am unsure of any direct benefits from the study to individual participants or the community. The intention would be that if the participant was interested in the results or findings of the study they could read the dissertation. Aligning with the anonymity of the study, results of the questionnaire would not be accessible..

**7.2** Define the risks, in either the short and/or long term, of participation in this project (e.g. *physical, psychological, social, economic or legal risks greater than inconvenience or discomfort*)\*

The risk associated with this questionnaire has been identified as an inconvenience of time imposition.

All information would be provide confidentially and not subject to public investigation or findings unless released by USQ.

Participants may have to undertake outside of normal business hours or in there lunch break to not affect company profit or objectives.

**7.3** Are all of these risks outlined in the Participant Information Sheet or within the explanatory statement at the beginning of a data collection instrument, and (where relevant) on the consent form?\*

Yes  No

**7.4** Outline the arrangements planned to minimise the risks involved in this project.\*

I intend to make the questionnaire anonymous so that respondents are not mentioned or affiliated with any discussion resulting from the data obtained from the questionnaire. Although aspect of the questionnaire request comments, any comment used directly in the dissertation will be attributed to 'the study'.

**7.5** What will you do in cases where unexpected events or emergencies occur as a result of participation in this project?

For example, what facilities or services are available to deal with events such as adverse drug reaction, revelation of child abuse, illegal activities, participant becomes distressed during or after data collection.\*

N/A

**7.6** Is an appropriate list of referral services available within the Participant Information Sheet or explanatory statement?\*

Yes  No  Not applicable

**7.7** Outline the strategies that you have in place to reduce any risks to the researchers.\*

I am not interviewing USQ staff.

Review outcome comments for **7 Benefit and Risk**.

*This question is not answered.*

Click the **green arrow** to go to the next page.

## 8 Type of Research

### Type of research - 1

**8.1** Are you, as the Principal Investigator, a current USQ employee or student?\*

Yes  No

**8.1.1** Will this project be undertaken **predominately** in a student capacity?\*

Yes  No

**8.1.1.1** Program level:\*

- Honours  
 Masters  
 Doctoral  
 Other

**8.1.1.2** Program name:\*

Bachelor of Engineering (Civil Engineering)

**8.1.2** Will this project be undertaken as a **USQ Course project**?\*

Yes  No

**8.1.2.1** Course code:\*

ENG4112

**8.1.2.2** Course name:\*

Research Project Part 2

### 8.2

#### Type of research - 2

Tick all that apply.

\*

- Action research  
 Clinical research  
 Qualitative  
 Social science  
 Other  
 Epidemiological  
 Mental health  
 Public health and safety  
 Quantitative  
 Case study  
 Clinical trial / use of drug or therapeutic device  
 Medical research  
 Oral history / biographical



Review outcome comments for **8 Type of Research**.

*This question is not answered.*

Click the **green arrow** to go to the next page.

## 9 Conflict of Interest

**9.1** Do any of the investigators on this project have an actual, perceived, or potential personal or financial conflict of interest in the outcomes of this research, or in any of the organisations involved with, or funding this project?\*

Yes  No

Review outcome comments for **9 Conflict of Interest**.

*This question is not answered.*

Click the **green arrow** to go to the next page.

## 10 Funding

**10.1** Has funding been obtained for this project?\*

Yes  No

**10.1.1** Are you applying for funding for this project?\*

Yes  No

Review outcome comments for **10 Funding**.

*This question is not answered.*

Click the **green arrow** to go to the next page.

## 11 Data Access and Security

**11.1** Outline the minimum recommended Research Data storage options (i.e. 1 x primary and 2 x back-up) that you will utilise for the duration of your research project and beyond. Refer to the University's [Research Data Management Policy](#) and [Research Data Management Procedure](#) to ensure your proposed practice is suitable.\*

1 x primary, USQ Cloudstore and 2 x back-up, Nectar VM Storage and QRISCloud, these have been accessed via USQ loggin and set up for use.

**11.2** Will any individual or organisation external to the University of Southern Queensland (i.e. a third party) have access to the Research Data during the conduct of this research?\*

Yes  No

**11.3** Do you plan to make available (or share) all, or part, of the Research Data via open access, restricted access, mediated access or as metadata only?

**Note:** It is recommended that unless your data can not be shared for ethical, privacy or confidentiality matters, that you incorporate the future use of data in your research design and include a statement within the participant information sheet/explanatory statement to this effect.\*

Yes  No

**11.3.1** Outline the research data to be openly or publicly available and the strategy of how this will be shared (e.g. open access, restricted or mediated access, metadata only).\*

open access

**11.4** Are the data access and security arrangements detailed in the Participant Information Sheet or explanatory statement?\*

Yes  No

**11.4.1** Outline why the data access and security arrangements will not be detailed in the Participant Information Sheet or explanatory statement.\*

There is no information in the data that is damaging or personnel in nature that could be used to influence or used against the participant in any way.

**11.5** Will the Research Data be securely retained indefinitely for future use?\*

Yes  No

**11.5.1** Outline where the data will be securely retained and who will have access to this.\*

The University of Southern Queensland will hold within their secure system and have access to the data.

Review outcome comments for **11 Data Access and Security**.

*This question is not answered.*

Click the **green arrow** to go to the next page.

## 12 Communication of Research Findings to Participants and Dissemination of Project Outputs

**12.1** Indicate in which format/s the research findings will be communicated to participants and research outputs disseminated  
*Tick all that apply.\**

- Thesis
- Journal article
- Book / book chapter
- Conference
- Dataset
- Reports to participants
- Report to organisation
- Report to community or group
- Other

**12.2** How will the identity of participants be disclosed in the dissemination of research outputs?\*

- non-identifiable data
- re-identifiable data
- individually identifiable data
- other

**12.3** Describe how participants and/or other interested stakeholders will be able to access the research findings and/or request a copy of a summary of the results

**Note:** Provision of a theses/dissertation/exegesis to a participant is not considered to be timely and appropriate summary of the research findings or results.

\*

A summary of findings and draft dissertation shall be available/delivered as requested and identified in the participant survey.

**12.4** Will participants be subjected to any physiological or psychological testing during this project? \*

Yes  No

Review outcome comments for **12 Communication of Research Outcomes**.

*This question is not answered.*

Click the **green arrow** to go to the next page.

## No. of Human Participant Groups

### Participant Group Recruitment

**PG** - How many groups of participants will you be recruiting and/or observing for this research project?\*

1.00

This question is asking you to think about how many groups of participants you are likely to recruit as part of this project. The method of participant recruitment and how they will provide consent may change depending on the participant's age and how you propose to conduct that part of the project.

For example:

- If you are conducting an online survey, followed by interviews with some of the survey participants, it is likely that you will recruit "2" groups. This will be the "survey group" and the "interview group".
- If you are conducting multiple focus groups with the same focus group questions, it is likely that you will recruit "1" group, but offer the same content multiple times. This can be conveyed in the next section.
- If you are conducting interviews with different groups, for example, students, teachers and school principals, then it is likely that you will recruit "3" groups.

The number of groups of participants you enter here will provide specific questions in the next section relevant to that group. That is, Group 1 = G1, Group 2 = G2, Group 3 = G3, and so on.

Sufficient space has been provided for up to **five** participant groups. If you propose to use more than five participant groups in your research, contact the [Ethics Officer](#) for further advice.

Review outcome comments for **Participant Group Recruitment**.

*This question is not answered.*

Click the **green arrow** to go to the next page.

## Group 1 - Participant Recruitment and/or Observation

### G1 - Participant Overview

**PG1.1** Participant group 1 working title. (e.g. student focus group; teacher survey)\*

Architectural and Engineering Industry Survey

**PG1.2** How many participants are expected to be recruited in this group?\*

60.00

**PG1.3** Describe who the participants in this group are.\*

Architectural and Engineering industry undertaking works involving built form. i.e. NCC type construction Class 1 to 10 inclusive.

**PG1.4** Where will this group of participants be recruited from?\*

Industry representatives from South East Queensland, Australia

**PG1.5** Are the participants in this group likely to be under 18 years of age?\*

Yes  No

**PG1.6** Is there a pre-existing (unequal) relationship between the participants and anyone involved in recruiting and/or collecting data from this group of participants? (e.g. teachers and/or lecturers/students, doctors/patients, employers/employees, etc.) \*

Yes  No

**PG1.7** Do these participants have any cultural needs? (e.g., specific consent arrangements or sensitivities, etc.)\*

Yes  No

Review outcome comments for **G1 - Participant Overview**.

*This question is not answered.*

Click the **green arrow** to go to the next page.

### G1 - Recruitment Method

**PG1.8** Do you have any criteria for the selection, inclusion or exclusion of participants for this group to take part in the research? (e.g. minimum age requirements)\*

Yes  No

**PG1.9** Indicate which method/s you will use to recruit these participants:\*

- Email
- Personal contacts
- Telephone
- Advertisement
- Mail out
- Snowballing
- Participants from another study
- Participants approached in person by research team
- Participants will NOT be actively recruited - they will be observed <b>without their knowledge</b>
- Other

**PG1.10** Indicate how you will obtain the contact details of these participants.

- From the participants themselves
- From a public domain source
- From a private or third party source
- Other

**PG1.11** Explain who will invite these participants to be involved in this project.\*

The USQ Survey group will be provided with a list of email participants to include in the distribution list. The Questionnaire will be distributed to this list. The email list will come from participants known by the student co-researcher and from public domain sources.

**PG1.12** Will you be offering payment or any other incentives to this group of participants?\*

- Yes  No

Review outcome comments for **G1 - Recruitment Method**.

*This question is not answered.*

Click the **green arrow** to go to the next page.

## G1 - Data Collection Methods

**PG1.13** Will you collect data via questionnaires / surveys?\*

- Yes  No

**PG1.13.1** For each **questionnaire / survey** that will be administered to this group of participants, provide details about the name and purpose of the instrument, how the instrument will be administered (e.g., paper based, online), and how it will be returned.

Attach a copy of your survey instrument in the document upload section.\*

The USQ Survey tool has been utilised to undertake this questionnaire.

**PG1.14** Will you collect data via interviews or focus groups?\*

- Yes  No

**PG1.15** Will you collect data via observation?\*

- Yes  No

**PG1.16** Will you collect data via photography / videography?\*

- Yes  No

**PG1.17** Will you collect data via psychological inventories or any other published, standardised test?\*

- Yes  No

**PG1.18** Will you collect data via collection of human biospecimens?\*

- Yes  No

**PG1.19** Will you collect data via responses to tasks, stimuli or simulations?\*

- Yes  No

**PG1.20** Will you collect data via administration of a substance?\*

- Yes  No

**PG1.21** Will you collect data via any other procedure not outlined above?\*

Yes  No

Review outcome comments for **G1 - Data Collection Methods**.

*This question is not answered.*

Click the **green arrow** to go to the next page.

### G1 - Data Collection Procedure and Competence

**PG1.23** Provide details about what you are asking participants in this group to do or what is to be done to them. Include a step-by-step description of what participants will experience if they choose to take part in this project.\*

I am asking participants to respond to questions relating to the study, the questions require a Likert scale response. The opportunity will be provided in some of the questions for the participant to add their opinion or experience in regard to the question being asked. This is optional in all cases where this option is provided.  
They are asked to use their experience in the field of study and in their current work place to respond honestly to the questions presented.

**PG1.24** How much time are you asking of participants in this group and when will this time be required? (e.g. 30 minutes after class).\*

10 to 20 minutes. To be completed when convenient. It is conceivable it may be completed during work hours, the questionnaire has been designed to take as little time as possible and to provide a thorough data set for the study.

**PG1.25** Where will the data be collected (venue and geographical location)? (e.g. front of 'venue')\*

The data will be collected from the Architectural and Engineering industry participants in South East Queensland, Australia.

**PG1.26** Does the research involve the administration of any tests or procedures that require particular qualifications?\*

Yes  No

**PG1.27** Does the research involve measures or procedures that are **diagnostic** or **indicative** of any **medical** or **clinical** condition, or any other situation of concern? (e.g. anaemia, bulimia, anorexia, anxiety, suicidal tendencies, aggressive behaviours, etc.)\*

Yes  No

Review outcome comments for **G1 - Data Collection Procedure and Competence**.

*This question is not answered.*

Click the **green arrow** to go to the next page.

### G1 - Consent Method

**PG1.28** Are these participants able to consent for themselves?\*

Yes  No

**PG1.29** Will you use a written Participant Information Sheet or Explanatory Statement to inform participants about this project?\*

Yes  No

**PG1.29.1** Outline how the project will be communicated to participants.\*

The questionnaire will be emailed to random and targeted industry participants requesting for them to undertake the questionnaire if they wish to do so, the opening link to the questionnaire will provide details about what the questionnaire is for and research data that is being gathered and why it is being gathered, to explain the project a brief account of the information gathered from the literature review will be provided to help inform the participant about the research.

**PG1.30** Will these participants be fully informed about the true nature of the research?\*

Yes  No

**PG1.31** Indicate how you will obtain consent from this group of participants.\*

- Implied consent  
 Consent form (must be attached with this application)  
 Opt-out consent  
 Other

Consent may be expressed in a number of ways. **Implied consent** is taken to mean that consent is expressed through, for example, the return of a survey, or other conduct implying consent. However, the nature, complexity and level of risk of the research, together with the participant's personal and cultural circumstances should be taken into consideration. It may be more appropriate to choose another method for consent, such as expressing it orally, or in writing if your research involves more than negligible levels of risk.

**PG1.31.1** Outline how you will gauge that consent to participate has been implied by this group of participants.\*

By completing the full questionnaire it would imply consent. Results of surveys would be returned on the completion of the survey, partially completed surveys would be returned for statistical analyse to further future studies, however, would not be used in results/dissertation. .

Review outcome comments for **G1 - Consent Method**.

*This question is not answered.*

Click the **green arrow** to go to the next page.

## Supporting Documentation

### Supporting Documents

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Below is a list of documents that may be required with this application. Upload each applicable item against the matching document name. If you require more than one document to be uploaded per item please use the 'Add New Document' button .

**\*\*Note\*\*** there are multiple pages in the grid below, use the change page buttons at the bottom of the grid to browse each page.

Allowable file extensions are pdf, doc, docx, xls, xlsx, msg, jpg, ppt, pptx.

Description	Reference	Soft copy	Hard copy
Invitation letters and/or emails	Proposed questionnaire_participation email.pdf	✓	
Participant Information Sheet and/or Explanatory Statement (as required, for each participant group)	Participation Information Sheet Questionnaire v02.pdf	✓	
Copy of instrument(s) - for collecting data via surveys/questionnaires	ENG4111 Draft Project Progress Report Questionnaire.pdf	✓	

Review outcome comments for **Documents (1)**.

*This question is not answered.*

Review outcome comments for **Documents (2)**.

*This question is not answered.*

Review outcome comments for **Documents (3)**.

*This question is not answered.*

Review outcome comments for **Documents (4)**.

*This question is not answered.*

Review outcome comments for **Documents (5)**.

*This question is not answered.*

Click the **green arrow** to go to the next page.

## Declaration

### Declaration

### USQ Principal Investigator Declaration

I the undersigned declare that I:

- have considered engaging with the peer review of this ethics application, in accordance with the [USQ Statement on Peer Review](#);
- accept ultimate responsibility for the ethical conduct of this research project in accordance with the principles outlined in [USQ's Research Code of Conduct Policy](#), the [Australian Code for the Responsible Conduct of Research \(2018\)](#), and the [National Statement on Ethical Conduct in Human Research, 2007 \(updated 2018\)](#);
- have ensured that all people involved in this research project understand and accept their roles and responsibilities;
- undertake to conduct this research project in accordance with the protocols and procedures outlined in the proposal as approved by USQ's Human Research Ethics Committee (USQ HREC);
- inform the USQ HREC of any changes to the protocol after the approval of the Committee has been obtained using the USQ HREC Amendment Application procedure AND inform all people involved in this research project of the amended protocol;
- have read and agree to comply with [USQ's Research Data Management Policy](#) and pursuant policies and procedures and have a plan for managing and/or sharing Research Data securely; and
- understand and agree that project files, documents, research records, and data may be subject to inspection by USQ HREC, a research integrity officer, the sponsor or an independent body for audit

### 18 USQ Principal Investigator Declaration

1	Full Name	Mr Craig Van Neuren
	Position	Principal Investigator
	Declaration signed?	Yes
	Signoff Date	09/07/2020

## **Appendix D: Questionnaire Survey**

**Title of Project:**

**How BIM software is being used in the AE industry and how the use of this software is impacted by the AE industries own understanding of BIM - A SEQ Perspective**

**Human Research Ethics Approval Number: H20REA171**



# How BIM software is being used in the AE industry and how the use of this software is impacted by the AE industries own understanding of BIM - A SEQ Perspective

## Project Details

**Title of Project:** How BIM software is being used in the AE industry and how the use of this software is impacted by the AE industries own understanding of BIM - A SEQ Perspective

**Human Research Ethics Approval Number:** H20REA171

## Description

This project is being undertaken as part of a final year undergraduate bachelor's degree in civil engineering with Honors.

The purpose of this project is to explore how Building Information Modelling Software is being used by the Architectural and Engineering sector to facilitate a Building Information Model environment and how this use represents the understanding of Building information modelling in South East Queensland.

The research team requests your assistance because your company has been identified as important to the field of research, more specifically, you are an Architectural, Building Design or Engineering firm practicing within the built environment sector in South East Queensland (SEQ).

## Participation

Your participation will involve completion of an online questionnaire that will take approximately 25 Minutes of your time.

Questions will include; The size of your organization; The Software you use and how long you have been using it; How you use this software to build 3D models; Collaboration between your company and other consultants in a 3D environment.

Your participation in this project is entirely voluntary. If you do not wish to take part, you are not obliged to. If you decide to take part and later change your mind, you are free to withdraw from the project at any stage. You may also request that any data collected about you be withdrawn and confidentially destroyed. If you do wish to withdraw from this project or withdraw data collected about you, please contact the Research Team (contact details at the top of this form).

Your decision whether you take part, do not take part, or to take part and then withdraw, will in no way impact your current or future relationship with the University of Southern Queensland.

## Expected Benefits

It is expected that this project will not directly benefit you. However, it may benefit future research in the study of Building Information Modelling in the Architectural and Engineering industry by other academics.

## Risks

In participating in the questionnaire, the following risk(s) have been identified:

- an inconvenience of time imposition.

## Privacy and Confidentiality

All comments and responses will be treated confidentially unless required by law.

The names of individual persons are not required in any of the responses.

As a participant the data collected may be made available for future and similar research purposes. The data will be stored and shared as non-identifiable data.

If you would like the project summary of results you can request them by contacting the Research Team (contact details at the bottom of this form).

Any data collected as a part of this project will be stored securely as per University of Southern Queensland's Research Data Management policy.

## Consent to Participate

Clicking on the 'Submit' button at the conclusion of the questionnaire is accepted as an indication of your consent to participate in this project.

## Questions or Further Information about the Project

Please refer to the Research Team Contact Details at the top of the form to have any questions answered or to request further information about this project.

## Concerns or Complaints Regarding the Conduct of the Project

If you have any concerns or complaints about the ethical conduct of the project, you may contact the University of Southern Queensland Manager of Research Integrity and Ethics on +61 7 4631 1839 or email [researchintegrity@usq.edu.au](mailto:researchintegrity@usq.edu.au) (<mailto:researchintegrity@usq.edu.au>?subject=How%20BIM%20software%20is%20being%20used%20in%20the%20AE%20industry%20and%20how%20the%20use%20of%20this%20software%20is%20impacted%20by%20the%20A%20SEQ%20Perspective) The Manager of Research Integrity and Ethics is not connected with the research project and can facilitate a resolution to your concern in an unbiased manner.

Thank you for taking the time to help with this research project. Please keep this sheet for your information.

**Research Team Contact Details**

**Principal Investigator Details**

Mr Craig van Neuren

Email: [u1004476@umail.usq.edu.au](mailto:u1004476@umail.usq.edu.au) (mailto:u1004476@umail.usq.edu.au?)

subject=How%20BIM%20software%20is%20being%20used%20in%20the%20AE%20industry%20and%20how%20the%20use%20of%20this%20software%20is%20impacted%20by%20the%20%20A%20SEQ%20Perspective)

Mobile: +61 449 935 370

**Research Supervisor**

Associate Professor David Thorpe

Email: [David.Thorpe@usq.edu.au](mailto:David.Thorpe@usq.edu.au) (mailto:David.Thorpe@usq.edu.au?)

subject=How%20BIM%20software%20is%20being%20used%20in%20the%20AE%20industry%20and%20how%20the%20use%20of%20this%20software%20is%20impacted%20by%20the%20%20A%20SEQ%20Perspective)

Telephone: +61 7 3470 4532

There are 22 questions in this survey.

## Basic Information - AE Company Profile

General information for data partitioning and analysis to the components of BIM performance management.

### What AE industry sector do you identify with? \*

Choose one of the following answers  
Please choose **only one** of the following:

- Architectural
- Building Design
- Engineering
- Hydraulic Consultant
- Other

### What is your role in your company? \*

Choose one of the following answers  
Please choose **only one** of the following:

- BIM Manager
- Draftsman
- Architect
- Engineer
- Building Designer
- Other

### What is the size of your organisation? \*

Choose one of the following answers

Please choose **only one** of the following:

- 0-5
- 6-20
- 21-50
- 51-100
- 100+

### Do you have additional offices outside of SEQ? \*

Choose one of the following answers

Please choose **only one** of the following:

- Yes
- No

Do you use a BIM enabled software platform such as Revit, ArchiCAD etc.. Please note, by choosing No, you will not participate in the rest of the survey and will be taken to the submit button to finalise the questionnaire. \*

Choose one of the following answers

Please choose **only one** of the following:

- Yes
- No

### Please identify the BIM Platform(s) you are using? \*

Only answer this question if the following conditions are met:

Answer was 'Yes' at question '5 [A5]' (Do you use a BIM enabled software platform such as Revit, ArchiCAD etc.. Please note, by choosing No, you will not participate in the rest of the survey and will be taken to the submit button to finalise the questionnaire. )

Choose one of the following answers

Please choose **only one** of the following:

- ArchiCAD
- Revit
- Microstation
- Tekla

Other

### How long has your company being using the BIM Platform noted in the previous question?

\*

Only answer this question if the following conditions are met:

Answer was 'Yes' at question '5 [A5]' (Do you use a BIM enabled software platform such as Revit, ArchiCAD etc.. Please note, by choosing No, you will not participate in the rest of the survey and will be taken to the submit button to finalise the questionnaire. )

Choose one of the following answers

Please choose **only one** of the following:

- 0-2 Years
- 2-3 Years
- 3-4 Years
- 5-6 Years
- 7+ Years

## BIM Systems and Software Use - General

This section looks at the software processes and systems in use by the company. Such as Level of Design (LOD), Company Standards etc..

Rate the following statements in regards to BIM use/process within your company  
(1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree and 5 = Strongly agree)

\*

Please choose the appropriate response for each item:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
It was not difficult to learn and become proficient in the BIM platform we use when we upgraded from our previous software	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Our transition to a BIM software platform was made easier by the experience of our staff to both learn and advance the new system	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
We generally use BIM and BIM processes on all (building) projects	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
We have internal standards for modelling which are adopted company wide	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Models are reviewed regularly for conformity of these standards, specifically in how the building is modelled	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The advancement of BIM is in the control of the BIM manager only	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The advancement of BIM is a collaborative process undertaken by all employees	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

(1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree and 5 = Strongly agree)

Rate the following statements about BIM model Level of Development (LOD) within your company.

(1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree and 5 = Strongly agree)

\*

Please choose the appropriate response for each item:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I have heard of and understand what a Level of Development (LOD) is in regards to a Building Model object/element	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
A different LOD is used extensively in our project delivery process for Building Models and based on the project specific requirements	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
A higher LOD in a 3D object is generally required to reduce 2D drafting and documentation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
A higher LOD in a 3D object is required to further parametric capabilities to facilitate a BIM environment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
We have created modelling objects to support our model and LOD and not just 2D drafting practices	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The BIM enabled software platform we use makes it easy to enable LOD in the building models we create	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

(1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree and 5 = Strongly agree)

(LOD is based on the American Institutes of Architects (AIA) G202-2013 Building Information Modeling Protocol Form, the concept of which has been further detailed and expanded on by 'BIM FORUM' details of which can be found at the following location <https://bimforum.org/LOD> (<https://bimforum.org/LOD>))

## BIM modelling

This section is aimed at looking at modelling techniques and concepts that enable a 'real world' and BIM specific application to a building model. The terminology and concepts presented may not apply specifically to the software platform you use. I ask that you answer to the best of your ability with the way you use the software in mind.

Rate the following in relation to creating surfaces and acquiring coordinates in a building model.

*(1 = Never, 2 = Rarely, 3 = Sometimes, 4 = Very often and 5 = All the time)*

\*

Please choose the appropriate response for each item:

	Never	Rarely	Sometimes	Very often	All the time
<b>We set up and acquire real-world coordinates in our models to schedule and locate modelling elements (model set up to provide easting/northing if required) i.e. linking coordinates and delivering model in AHD and Geodetic coordinates</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>Where required, real-world coordinates are provided/scheduled for use in construction. i.e. pier set out (easting, northing, level)</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>We create topographic surfaces in models when a survey has been provided</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>We modify topographic surfaces to produce earthworks models for estimating purposes (i.e. cut and fill quantities), scheduling and for documentation</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>We use topographic 3D surfaces for design and to confirm project levels for modelling elements</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>We commonly use other internal software programs to create surfaces which we insert into our project models i.e. 12D, Civil 3D, AutoCAD</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

*(1 = Never, 2 = Rarely, 3 = Sometimes, 4 = Very often and 5 = All the time)*

Rate the following questions about 3D modelling objects used/created in your company  
(1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree and 5 = Strongly agree)

\*

Please choose the appropriate response for each item:

	<b>Strongly Disagree</b>	<b>Disagree</b>	<b>Neutral</b>	<b>Agree</b>	<b>Strongly Agree</b>
<b>The modelling objects we use are either created or modified from program objects for 2D modelling/drafting requirements</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>We only produce a 3D model for what is required to produce 2D documentation for a project.</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>A 3D model is only produced if a client requests it</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>We use free/paid software add-ins to facilitate efficiencies in CAD processes</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>We use free/paid available software add-ins to facilitate efficiencies in BIM processes</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>Modelling objects sourced from manufacturers are used where possible and are project specified objects</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>Modelling objects sourced from manufactures are used to enhance how the model looks, they don't have to be the specified product/object.</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>We pay and/or subscribe to outside sources to supply or create 3D modelling objects for us when required</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

(1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree and 5 = Strongly agree)

Rate the following questions about how 3D modelling objects used/created in your company are modified to suit project requirements.

(1 = Never, 2 = Rarely, 3 = Sometimes, 4 = Very often and 5 = All the time)

\*

Please choose the appropriate response for each item:

	Never	Rarely	Sometimes	Very often	All the time
Project specific data is added or created in modelling objects to enable scheduling, such as estimating material quantities/cost/time	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Estimating/cost/time scheduling is always provided to our clients as a deliverable	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Estimating/cost/time scheduling is provided as a deliverable outside of your company if requested	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
We make it clear that any information provided in the above manner should be used at the discretion of the client and that all quantities or data should be checked for inaccuracies	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

(1 = Never, 2 = Rarely, 3 = Sometimes, 4 = Very often and 5 = All the time)

We use the inbuilt analysis tools the software we use has for design: such as structural/MEP or Energy Efficiencies, Sun Studys etc.. \*

❗ Choose one of the following answers

Please choose **only one** of the following:

- Never
- Rarely
- Sometimes
- Very often
- All the time

## BIM and Model Collaboration

This section looks at the preference of the user in collaborating or sharing 3D models with other consultants, the preference of users in the exchange of the model i.e. IFC, native format. (native format means you use the same software platform)



### Rate the following statements on general model sharing

(Never = 1, Rarely = 2, Occasionally = 3, Frequently = 4 and Very frequently = 5)

\*

Please choose the appropriate response for each item:

	Never	Rarely	Sometimes	Very often	All the time
If we can, we use a native format model from another company fully for a project to minimise drafting costs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
We have used a shared cloud based multidisciplinary model in projects	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
If we can, we use other consultant's 3D models instead of creating our own, this is usually all we require to undertake the works	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
We will always create our own 3D model, even if we are provide a native format model from another consultant	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sharing models (any format) we find to be the best way to facilitate a BIM environment.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sharing models (any format) we find to be the best way to facilitate a better project outcome for us and the client	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

(Never = 1, Rarely = 2, Occasionally = 3, Frequently = 4 and Very frequently = 5)

Rate the following statements about sharing BIM models with external consultants  
*(unimportant = 1, Of little importance = 2, Moderately important = 3, Important = 4 and Very important = 5)*

\*

Please choose the appropriate response for each item:

	Unimportant	Of little importance	Moderately important	Important	Very important
If consultants use the same software, we try to exchange native data files with these team members	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
We only export IFC models for collaboration and model sharing, not native files	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other consultants' models are imported or linked into our model for clash detection checking and accuracy only	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I find the sharing of BIM models (any format) an integral aspect of working in the Built Environment industry in the current BIM environment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

*(unimportant = 1, Of little importance = 2, Moderately important = 3, Important = 4 and Very important = 5)*

## BIM - Short Answer Qualitative Questions

This section is designed to gauge the overall feeling of the respondent on the BIM software they use and how they believe BIM is being perceived in the industry overall.

Governments such as the UK, USA and Singapore have mandated BIM use to varying degrees in there AEC industries. Do you support Australia to do this?

Do you think it would further BIM development in Australia.

Please also comment if/how you think a mandate would affect your companies use of BIM.

\*

**!** Choose one of the following answers  
 Please choose **only one** of the following:

- Unimportant
- Of little importance
- Moderately important
- Important
- Very Important

Make a comment on your choice here:

Please advise if Industry clients/parteners have expressed interest or requested the use of a building model for facilities management purposes from your company  
i.e. the client requested a 3D model with a Level of Development (LOD) to suit a 6D BIM environment Operations/Facilities Management

Please also comment that you understand what LOD is and if you use a LOD in your projects or project workflows

\*

Please write your answer here:

(LOD is based on the American Institutes of Architects (AIA) *G202-2013 Building Information Modeling Protocol Form*, the concept of which has been further detailed and expanded on by 'BIM FORUM' details of which can be found at the following location <https://bimforum.org/LOD> (<https://bimforum.org/LOD>))

Comment on the max. dimension of BIM you believe you have used in a project? i.e 3D, 4D, 5D, 6D,...nD

Comment if you are looking at developing your BIM processes or are interested in developing the dimension of BIM that you offer?

If you have time, what do you think is required for you to do this? i.e. education, courses, time, money, staff precurement

\*

Please write your answer here:

(3D Shape/Modelling, 4D Scheduling/Time, 5D Estimating/Cost, 6D Operations/Facilities Management, 7D Sustainability/Energy Efficiency and 8D Safety/Emergency plans)

If you had a choice, would your preference be to work with consultants using the same BIM enabled software?

Please provide comments why or the relevance to work with consultants using the same BIM software. Is it relevant?

\*

🗨️ Choose one of the following answers

Please choose **only one** of the following:

- Unimportant
- Of little importance
- Moderately important
- Important
- Very Important

Make a comment on your choice here:

Interoperability between projects, open BIM and sharing IFC models, means we are required to re-model and update models regularly.

If you have time, please comment.

\*

🗨️ Choose one of the following answers

Please choose **only one** of the following:

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Make a comment on your choice here:

*(Do you find you are constantly updating your 3D building models to accommodate changes by other consultants? Are changes just a normal or expected modelling process? Do you change your model in these instances if the design is complete and is not effected even though spatially it is incorrect?)*

Which industry sector do you believe is progressing the BIM environment in SEQ?

In regard to your answer above, please comment why you believe that industry is progressing the use of BIM.

\*

Please write your answer here:

*(Architectural, Engineering ... it is a collaborative change)*

I was confused by the questions provided and/or they were not relevant to my industry. **Please comment briefly.**

If you have time, please comment on improvements that could be made to this questionnaire to make it more relevant to the use of BIMMS software and BIM for the AE industry. This information may be used to assist further studies into BIM and the software use to facilitate a BIM environment.

Please write your answer here:

*(BIMMS = Building Information Model Modelling Software)*

Thank you for taking your time in completing this survey and helping with this research.

03.10.2020 – 22:03

Submit your survey.

Thank you for completing this survey.

## Appendix E: Question Group A

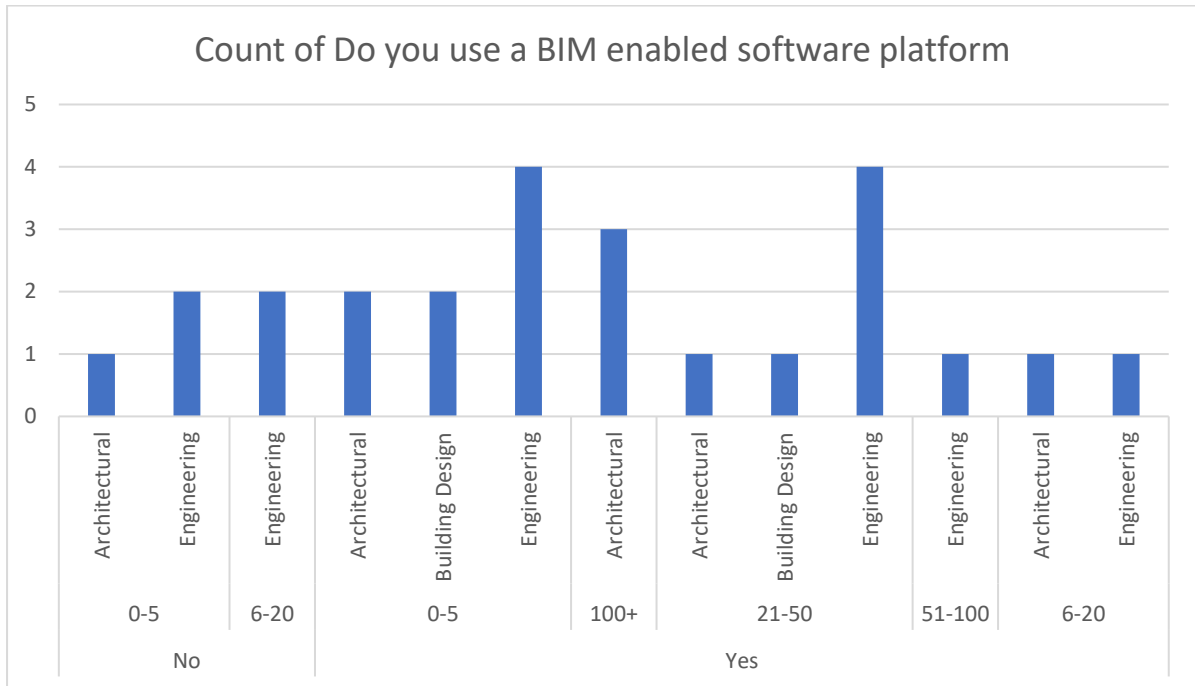


Figure.1. Question A5: Do you use a BIM enabled software platform

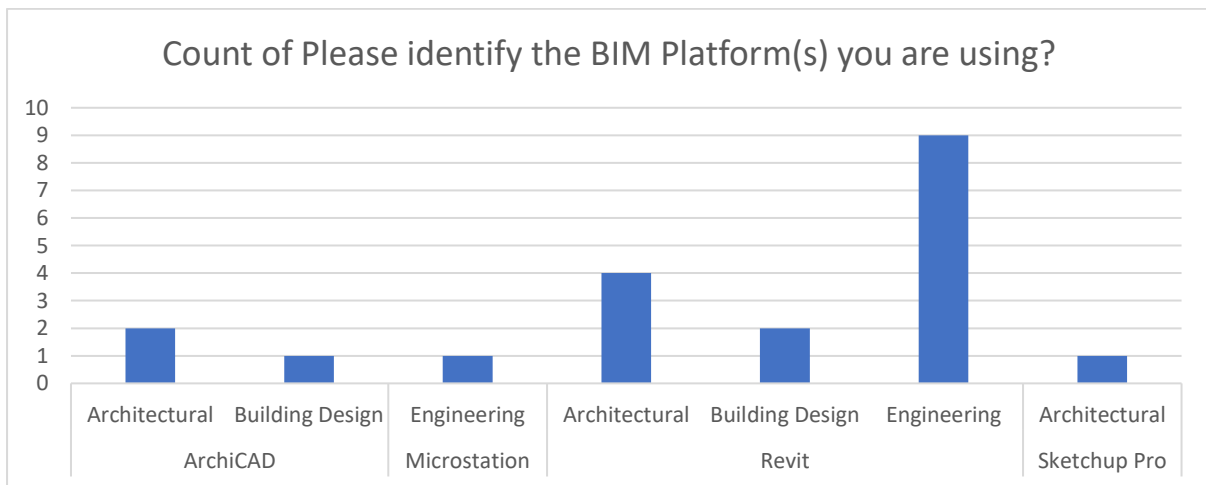
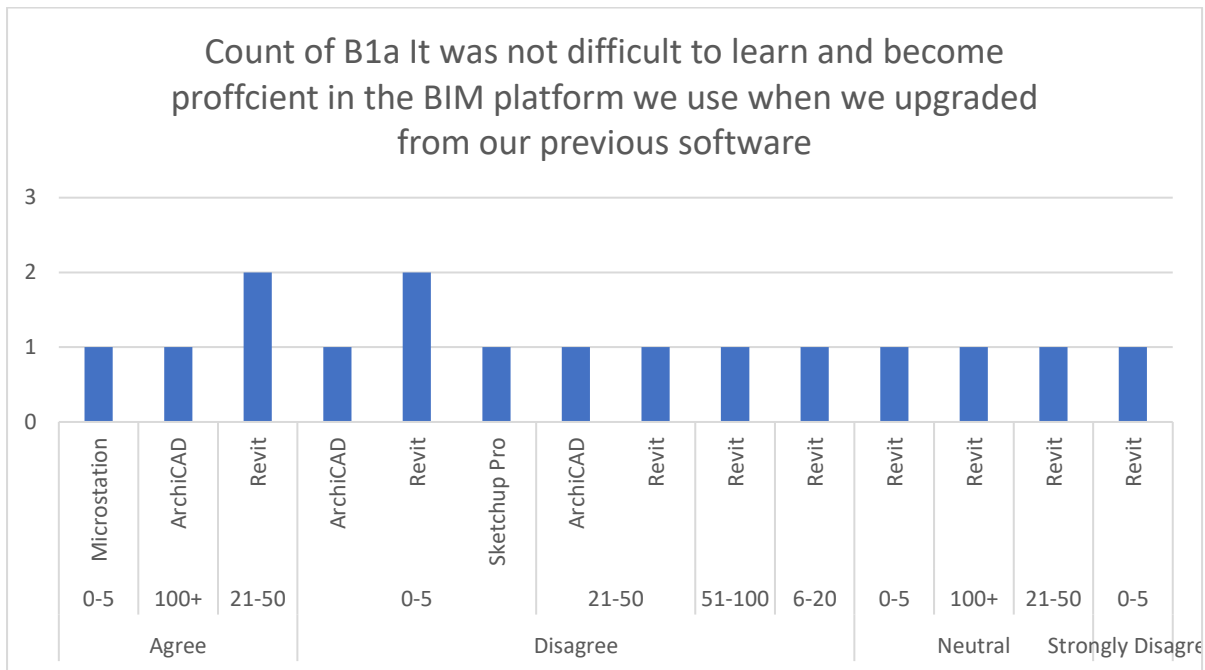
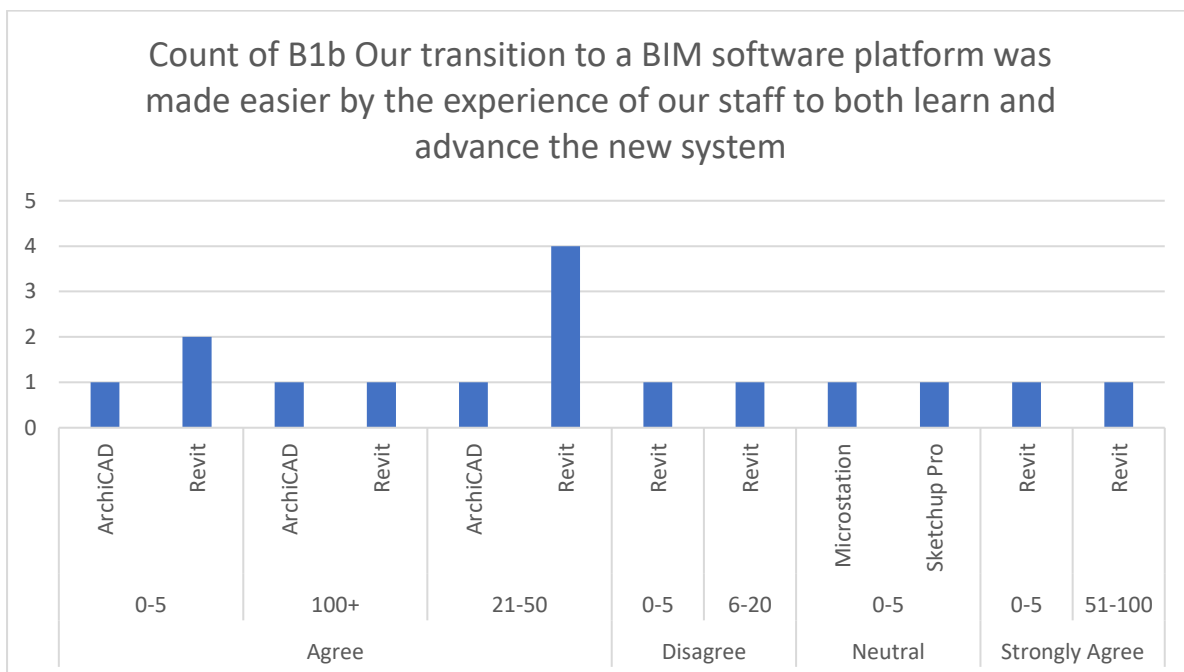


Figure.2. Question A6: Please identify the BIM platform you are using

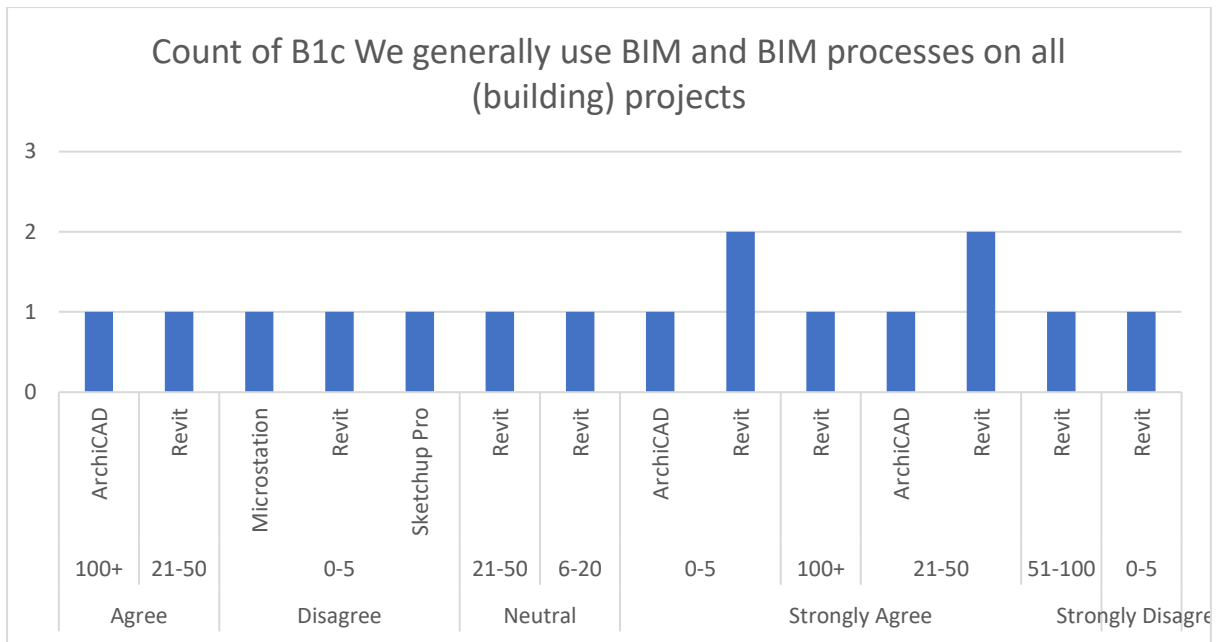
## Appendix F: Question Group B



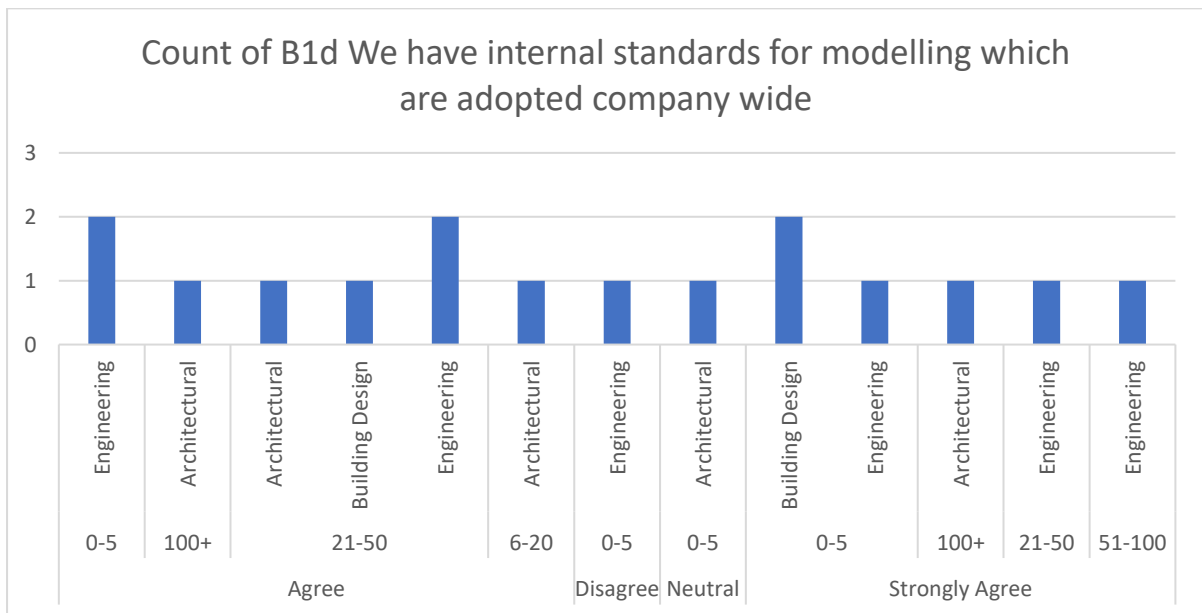
**Figure.3. Question B1a: Difficulty in learning to be proficient when upgrading from 2D to 3D BIMMS**



**Figure.4. Question B1b: Ease of transition to BIM software due to experienced staff**

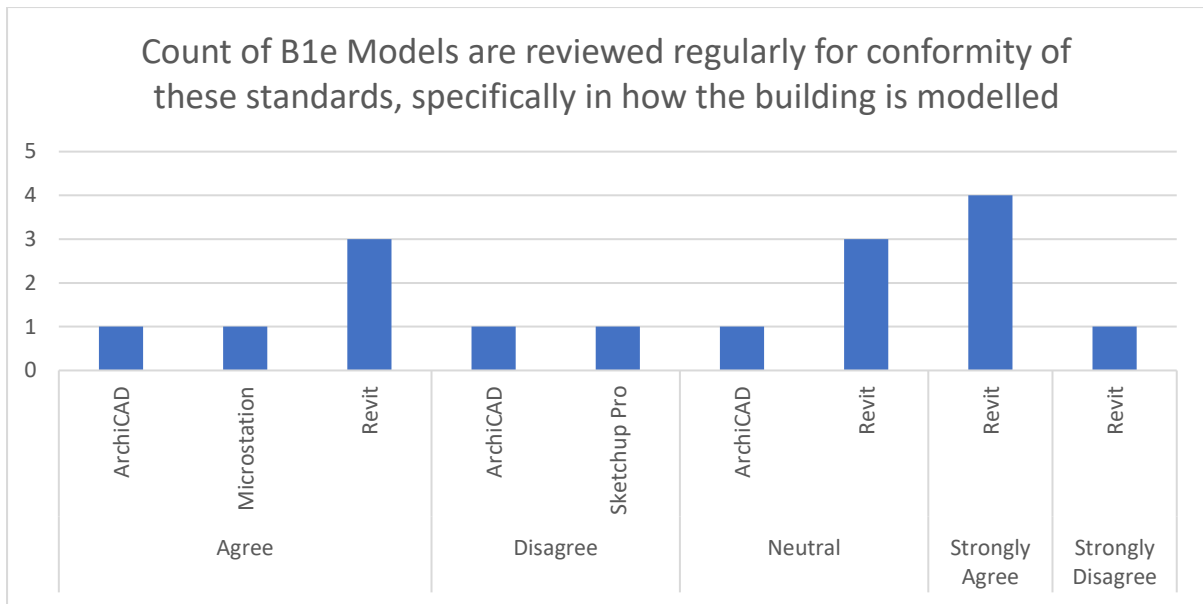


**Figure.5. Question B1c: BIM and BIM processes on Building Projects**

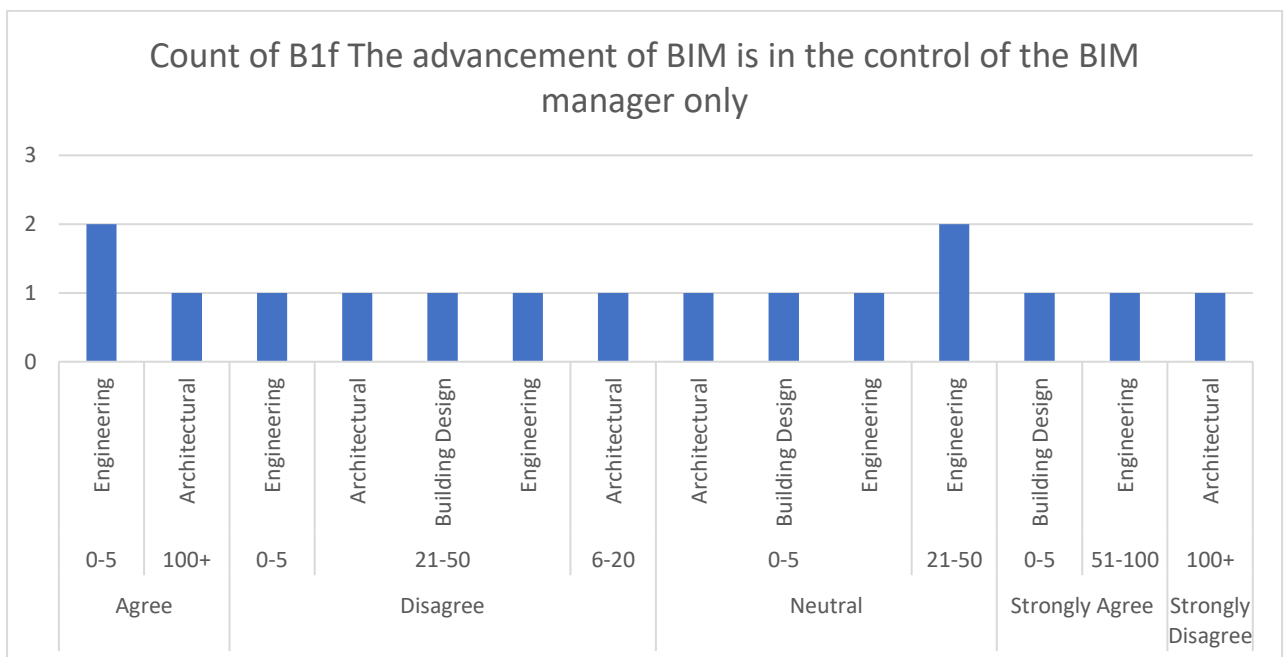


**Figure.6. Question B1d: Internal Standards within the BIMMS platform being used**

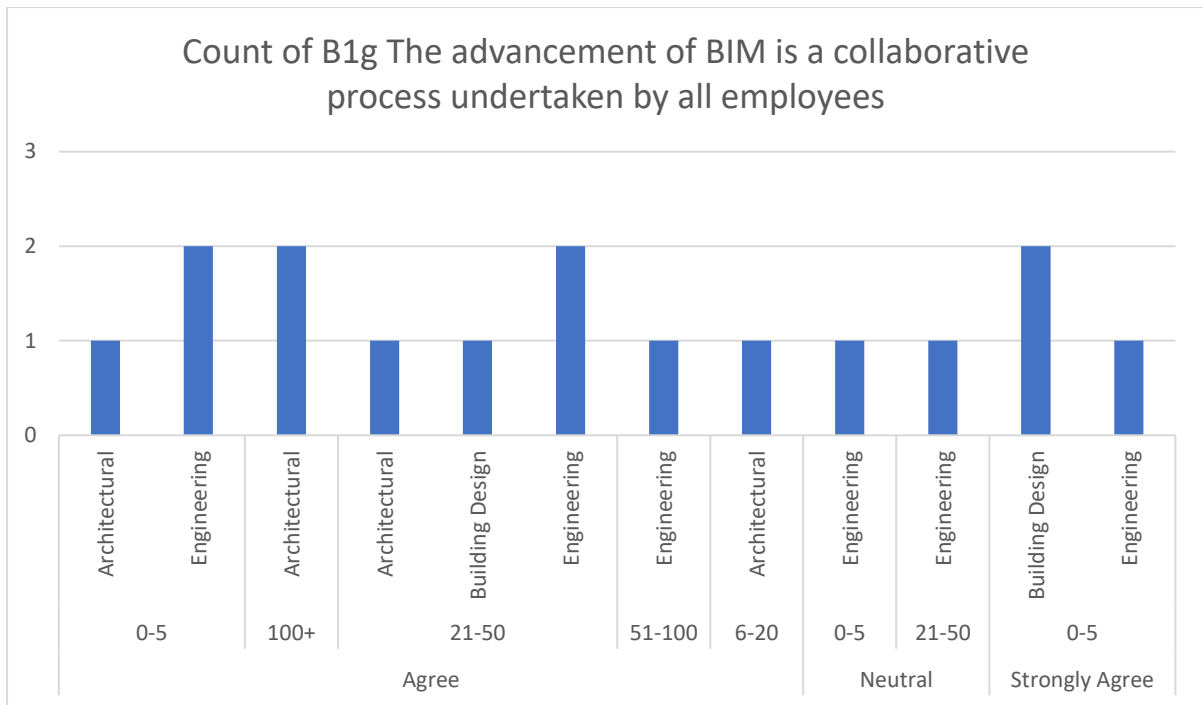




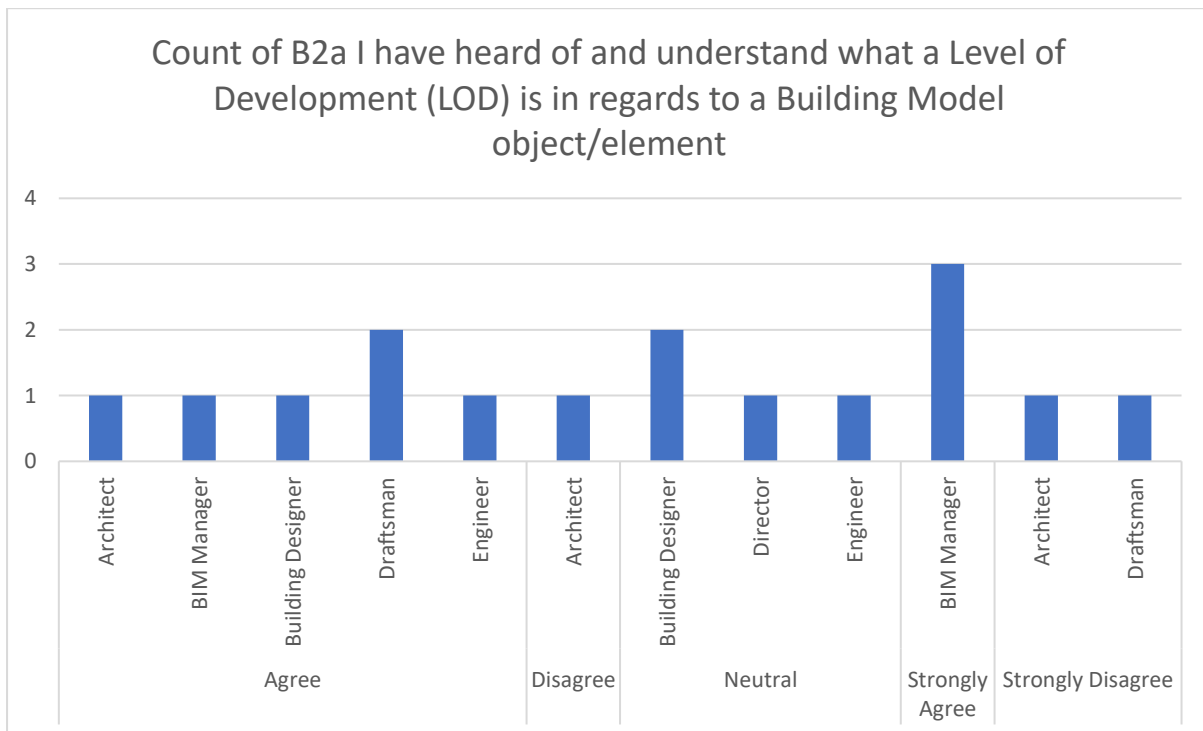
**Figure.7. Question B1e: Review of Building models for conformity to internal standards**



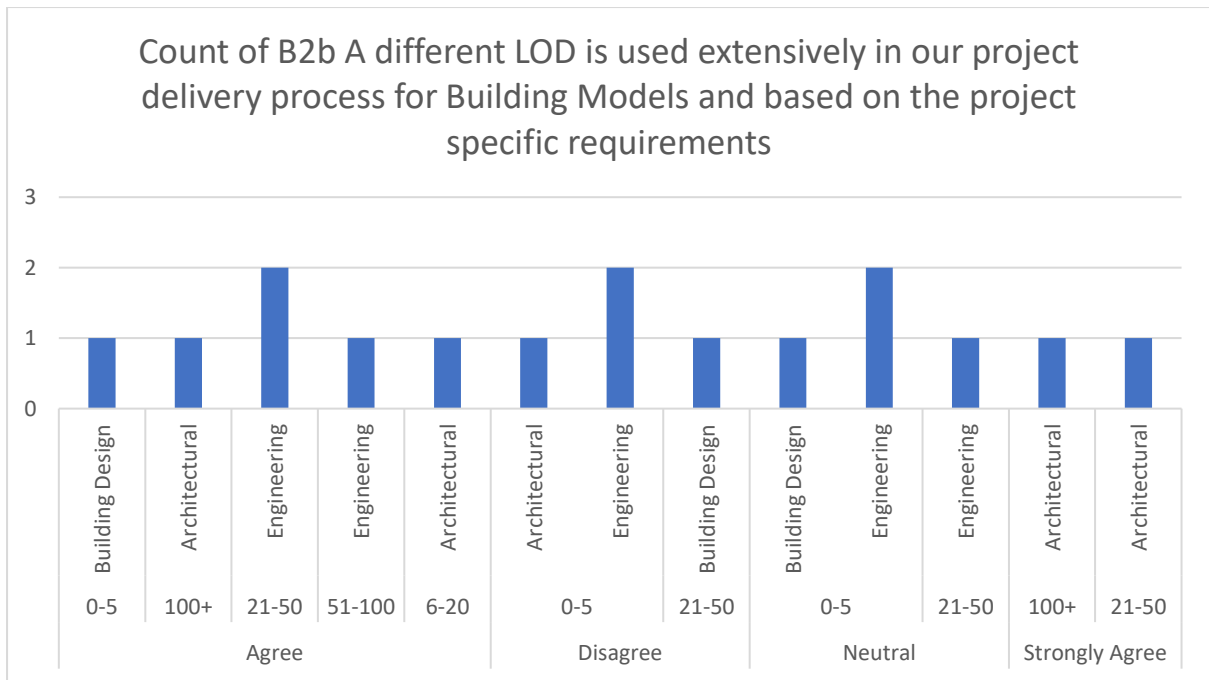
**Figure.8. Question B1f: The advancement of BIM is in the control of the BIM manager only**



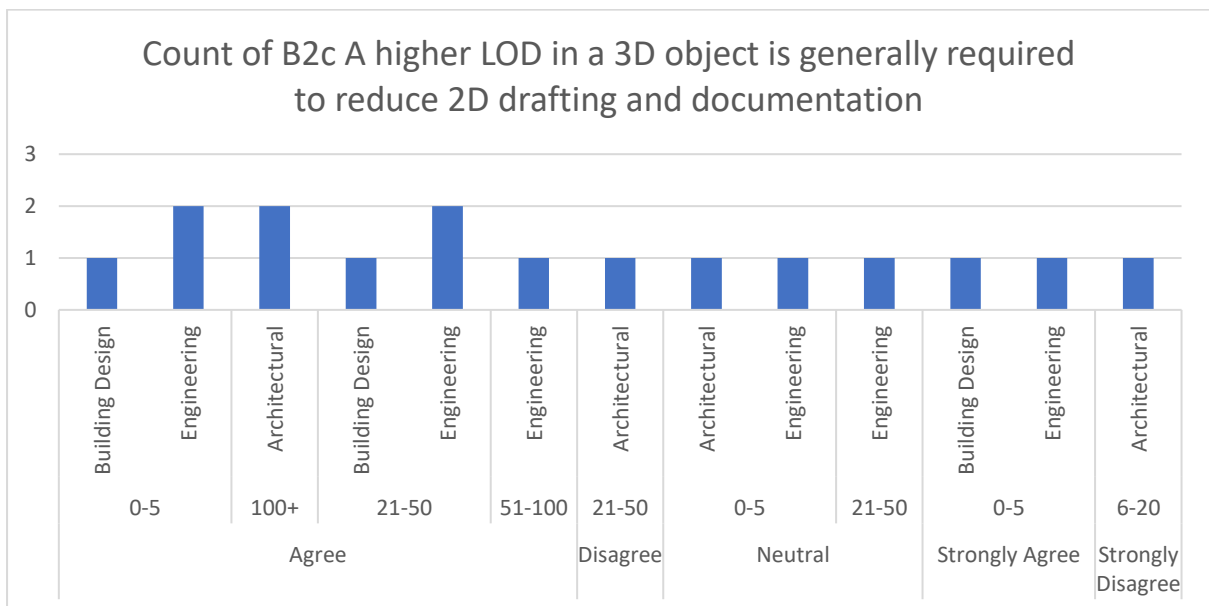
**Figure.9. Question B1g: The advancement of BIM is collaborative process undertaken by all employees**



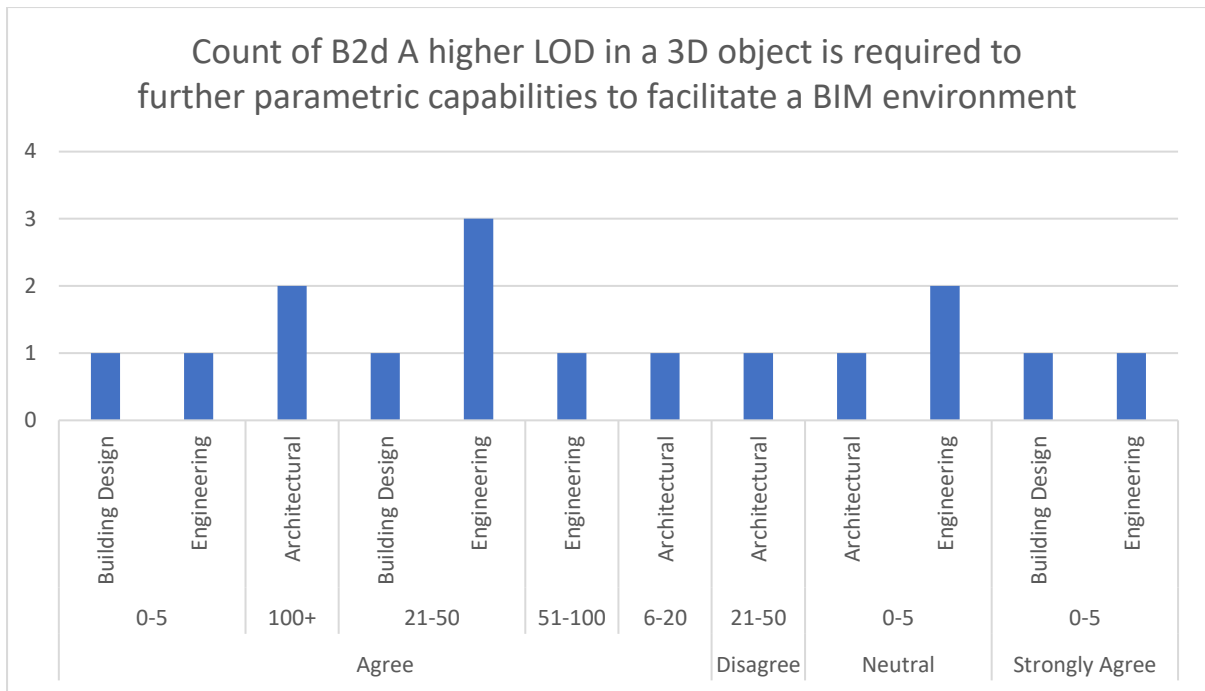
**Figure.10. Question B2a: Understanding of a Level of Development (LOD) in regards to a building model**



**Figure.11. Question B2b: A different LOD is used extensively in our project delivery process for Building Models and based on project specific requirements.**



**Figure.12. Question B2c: A Higher LOD in a 3D object to further 2D drafting capabilities**



**Figure.13. Question B2d: A Higher LOD in a 3D object to further parametric and BIM capabilities**

## Appendix G: Question Group C

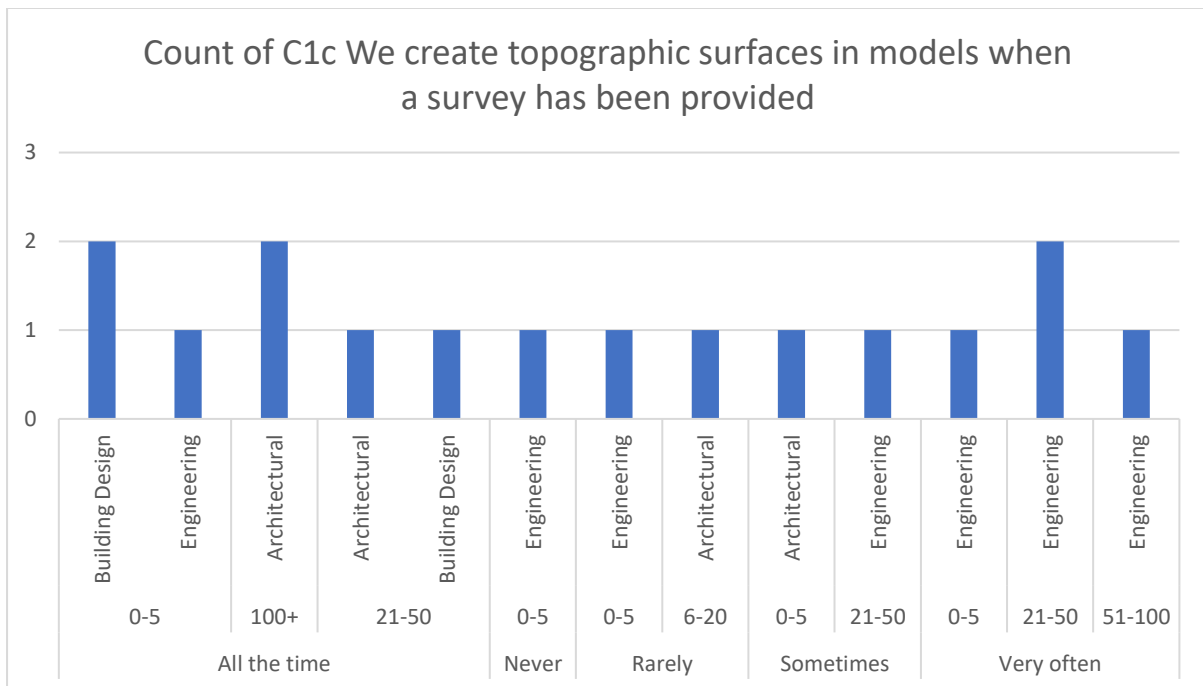


Figure.14. Question C1c: Creation of Topographic Surfaces in Models

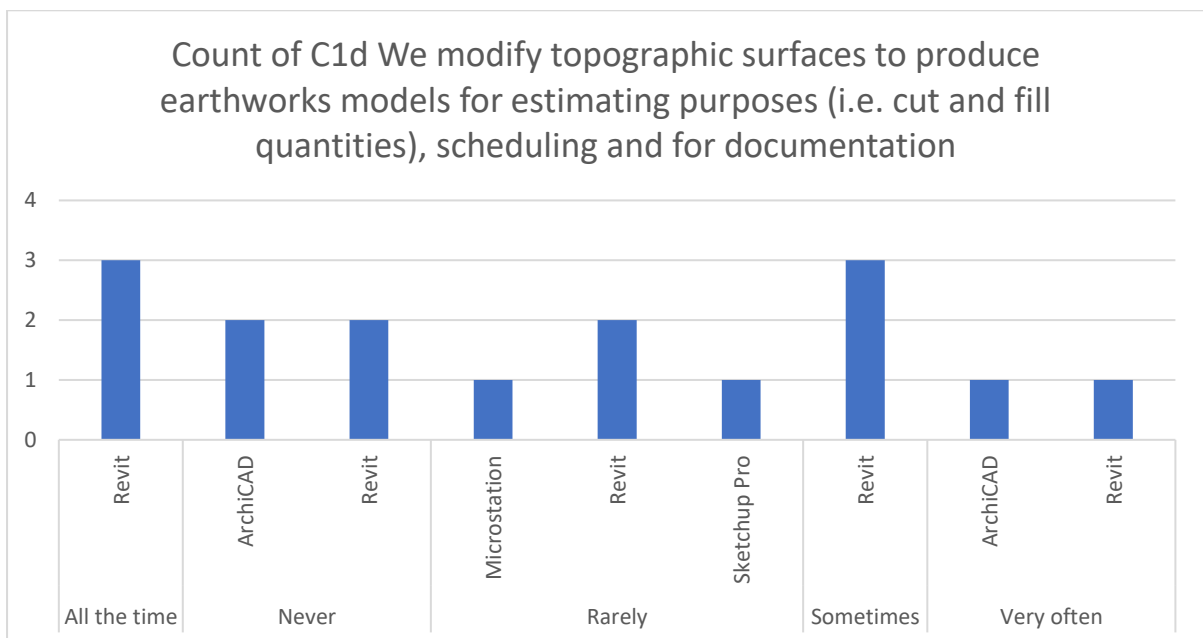
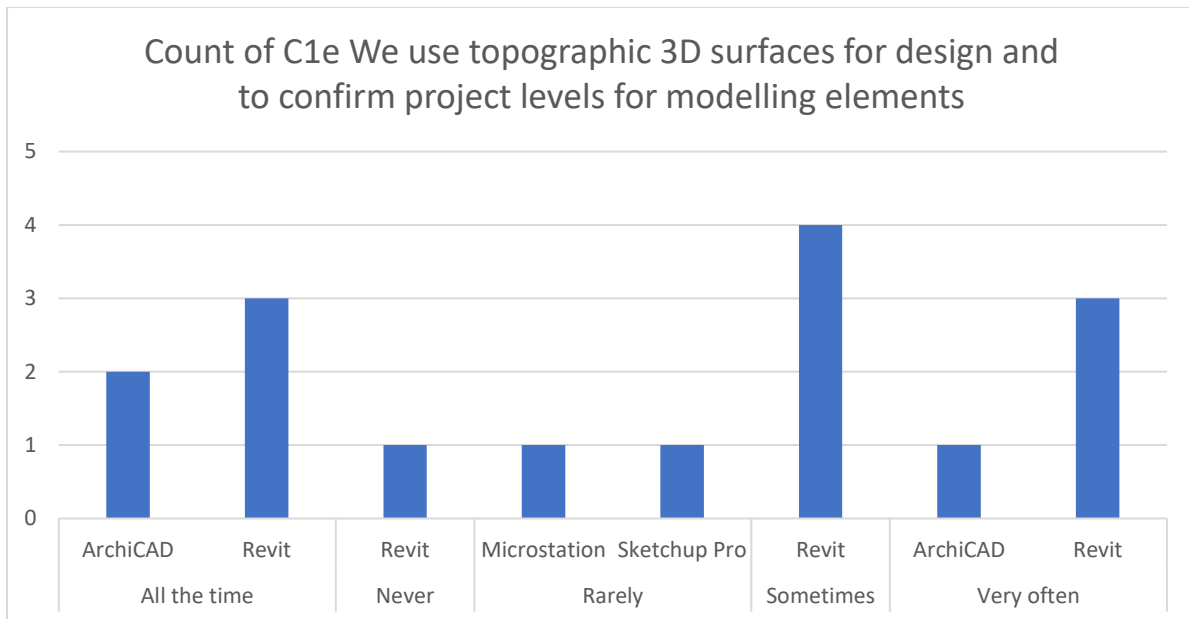
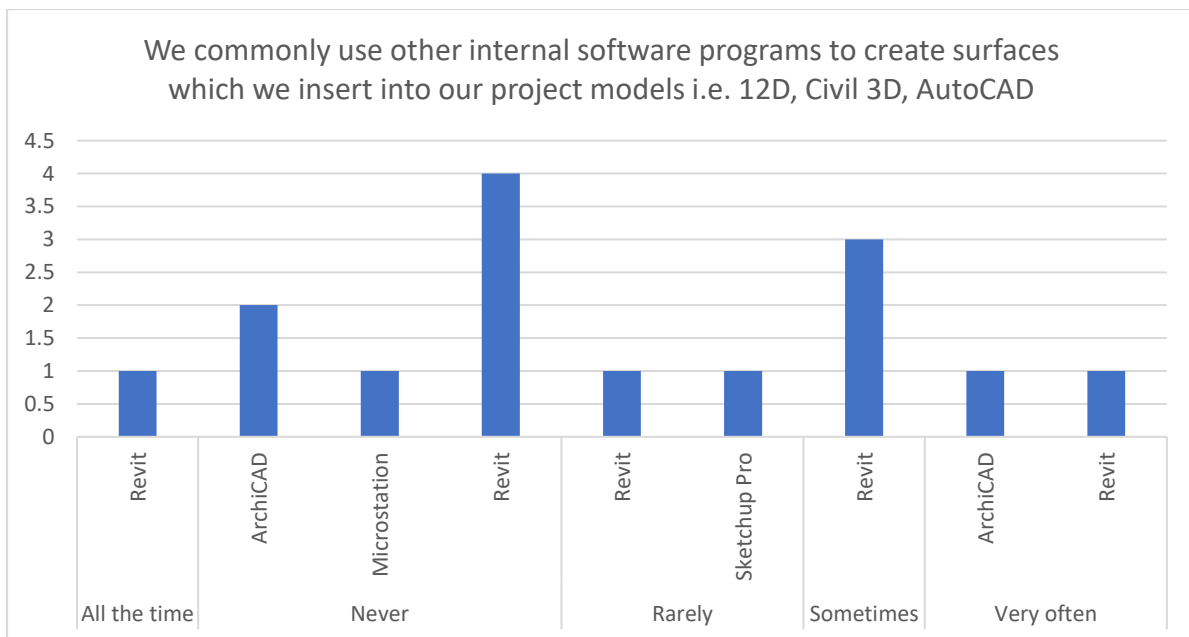


Figure.15. Question C1d: Topographic Surfaces in Models are used for Estimating

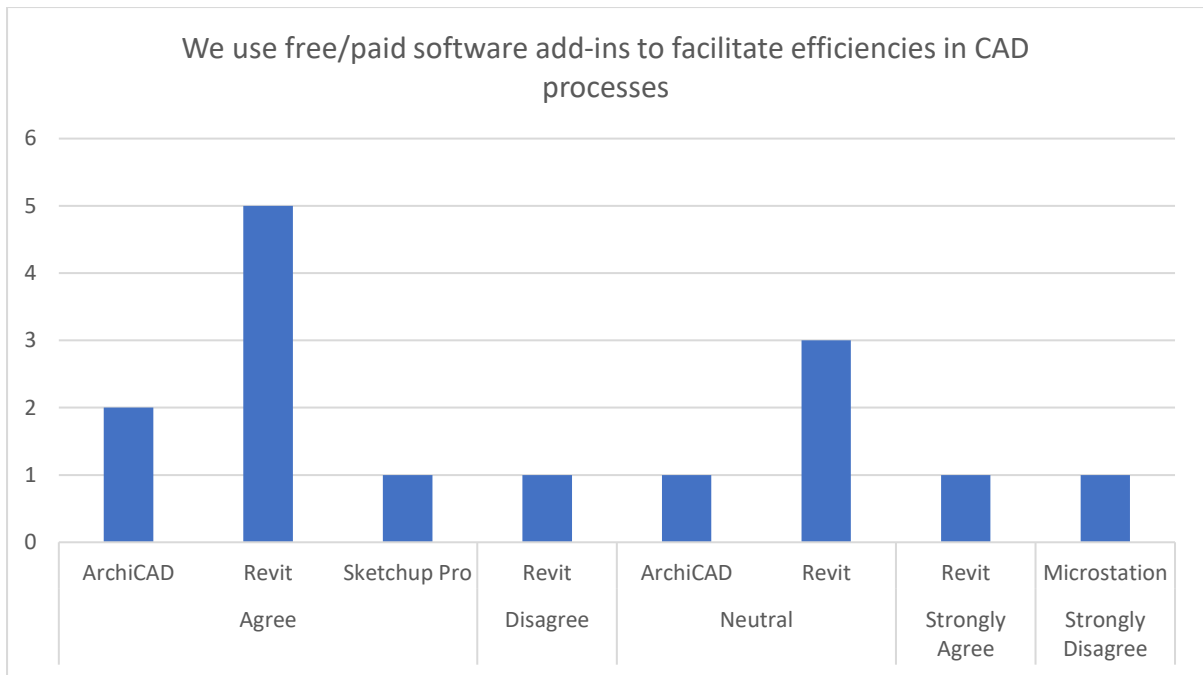


**Figure.16. Question C1e: Topographic 3D Surfaces are Used for Design and Conformation of Project Levels**

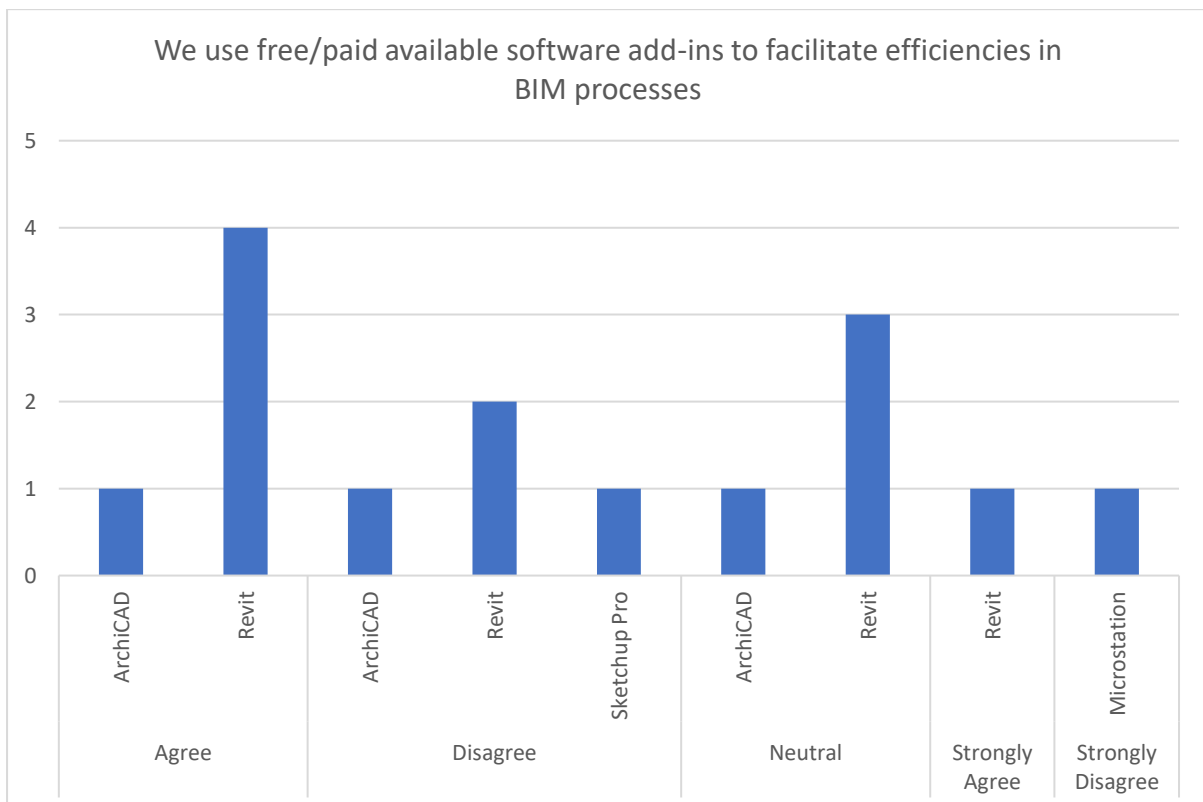


**Figure.17. Question C1f: We use Other Software Programs to Produce Surfaces we use in our Models – by BIMMS**



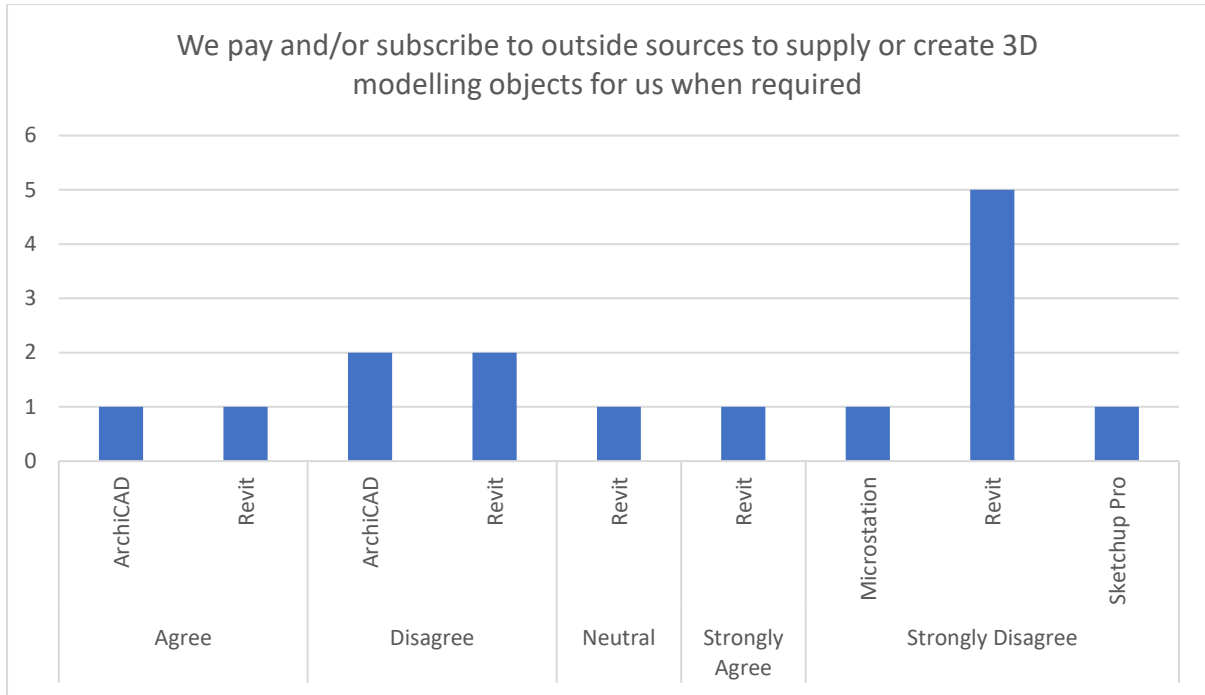


**Figure.20. Question C2d: Free/Paid Software Add-ins are used to Create Efficiencies in CAD Processes**

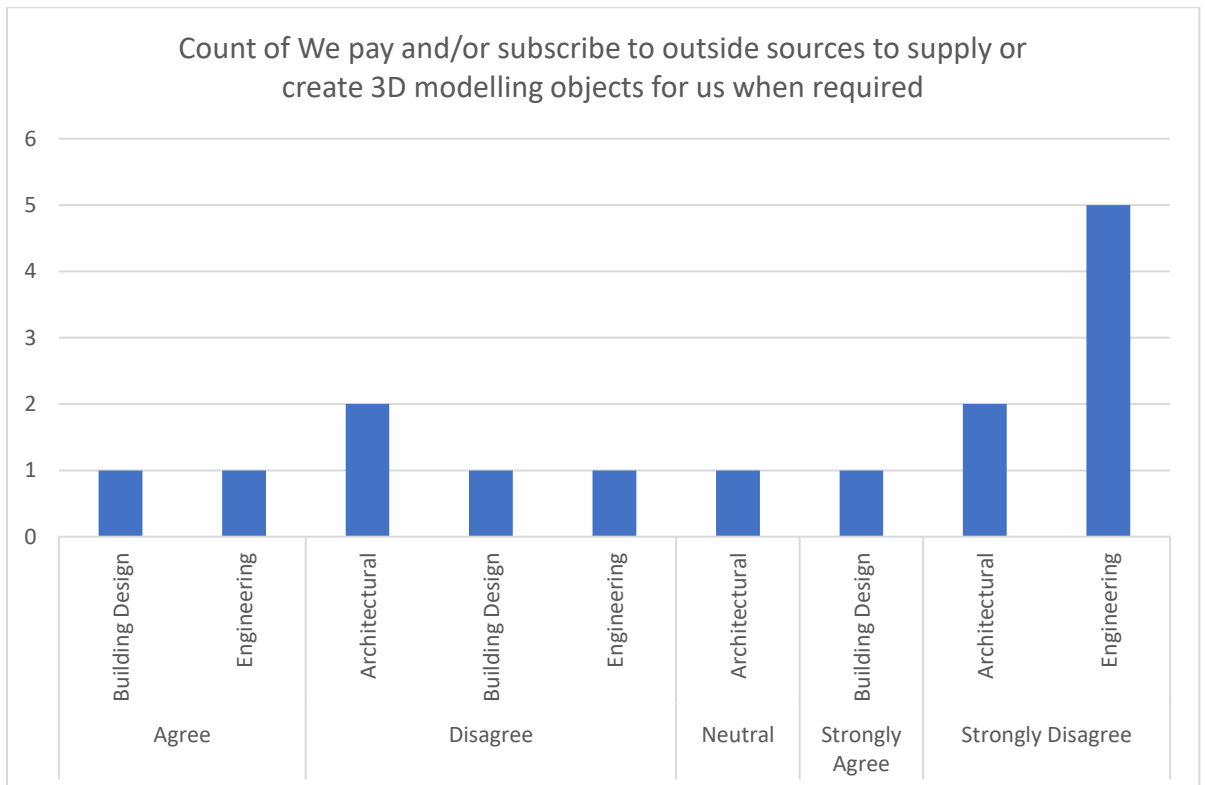


**Figure.21. Question C2e: Free/Paid Software Add-ins are used to Create Efficiencies in BIM Processes**

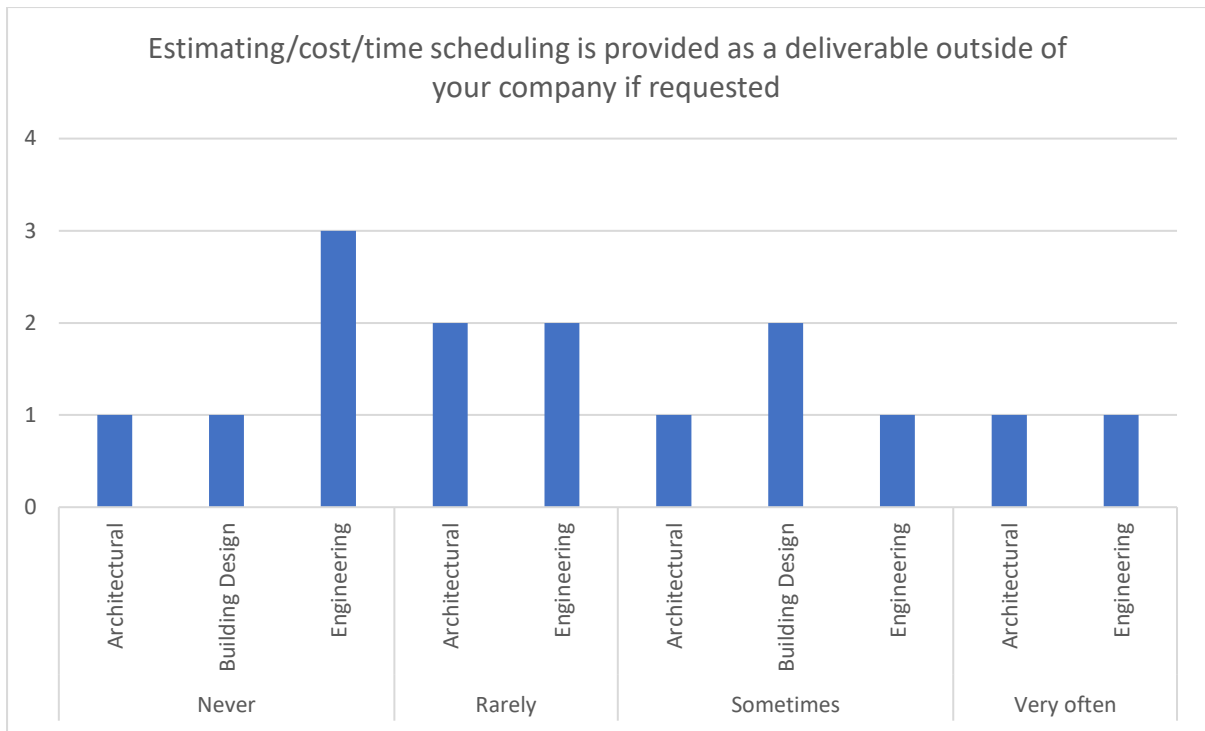




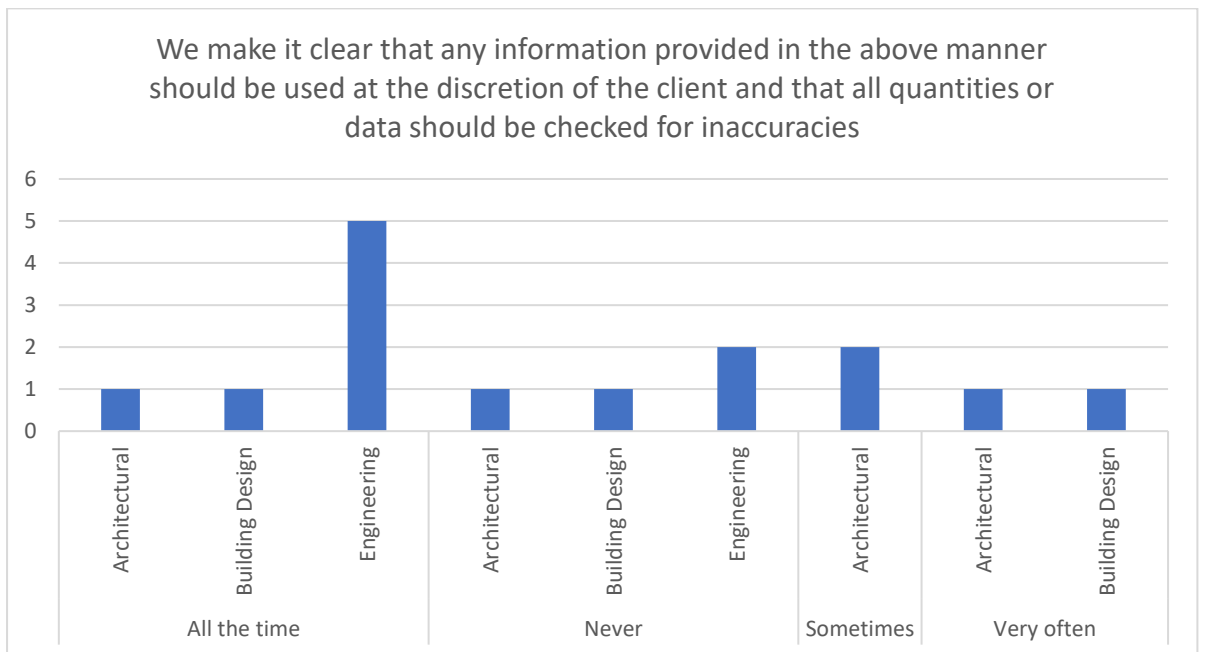
**Figure.22. Question C2h(i): We Pay/Subscribe to Outside Sources to Create or Supply 3D Modelling Objects – by BIMMS**



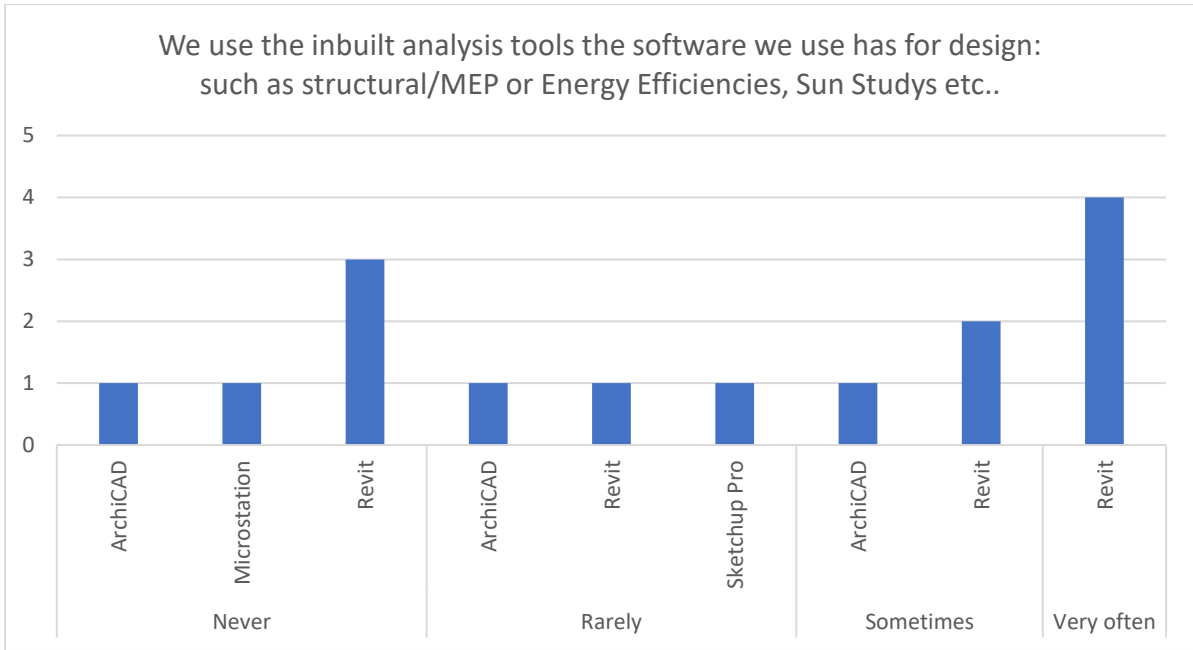
**Figure.23. Question C2h(ii): We Pay/Subscribe to Outside Sources to Create or Supply 3D Modelling Objects – by Industry**



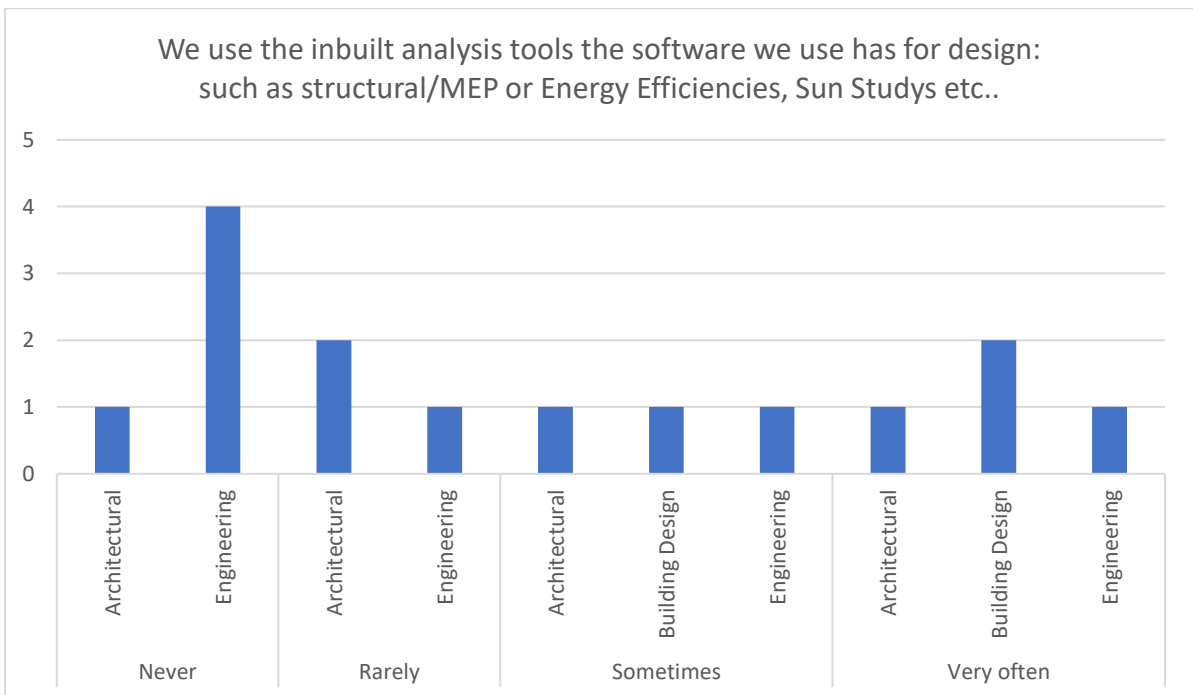
**Figure.24. Question C3c: Scheduling is Only Provided as a Deliverable to our Clients if Requested**



**Figure.25. Question C3d: Information Provided as Schedules is Disclaimed as to be Verified for all Information Contained within.**

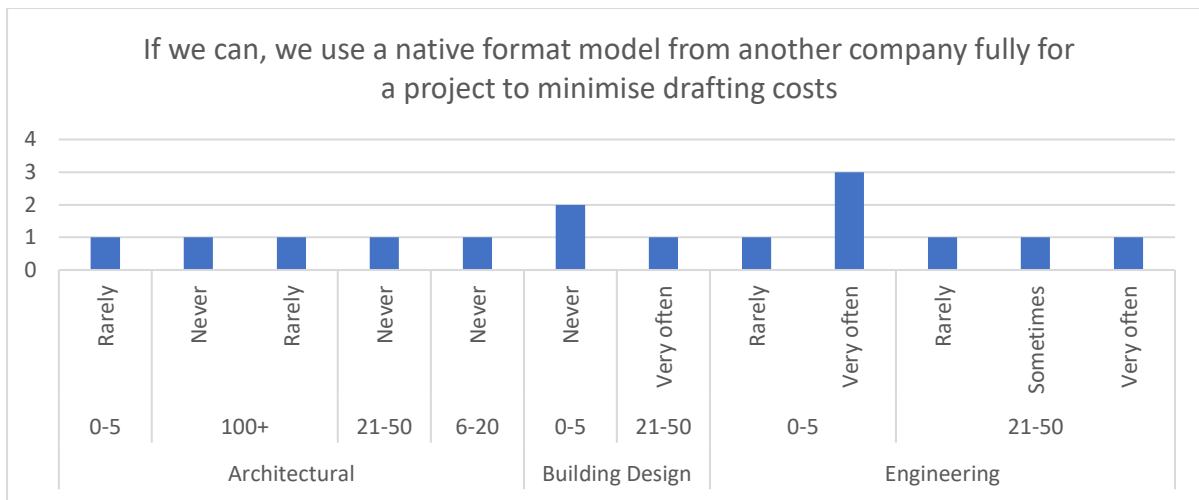


**Figure.26. Question C4(i): Use of BIMMS inbuilt Analysis Tools – By BIMMS**

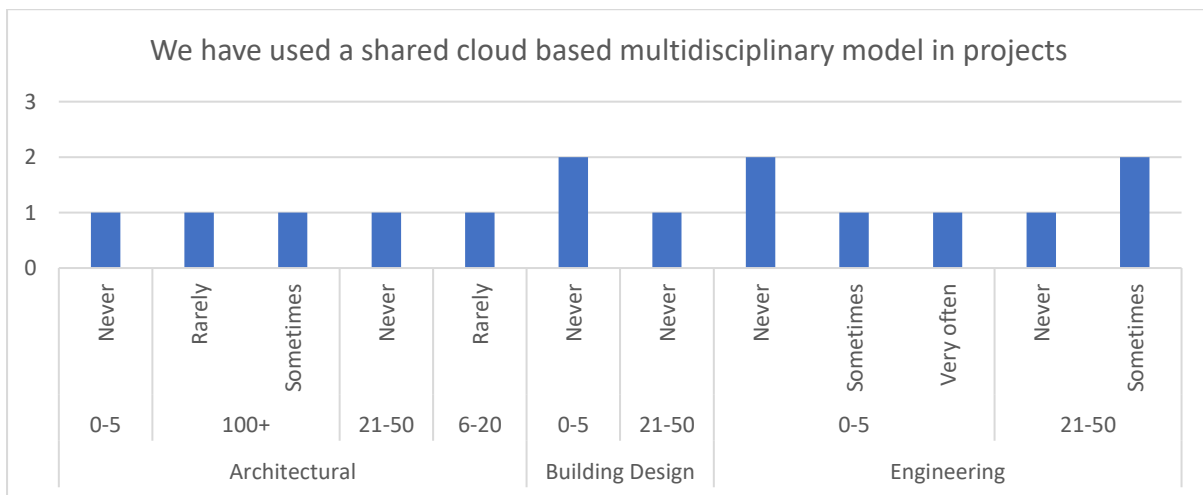


**Figure.27. Question C4(ii): Use of BIMMS inbuilt Analysis Tools – By Industry**

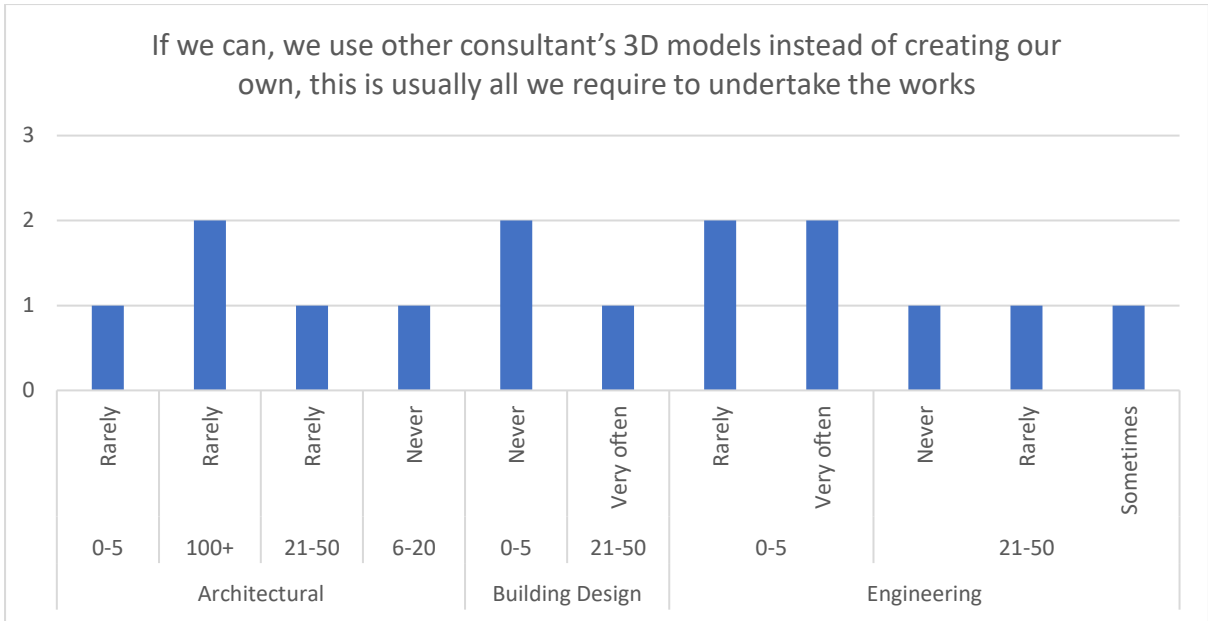
## Appendix H: Question Group D



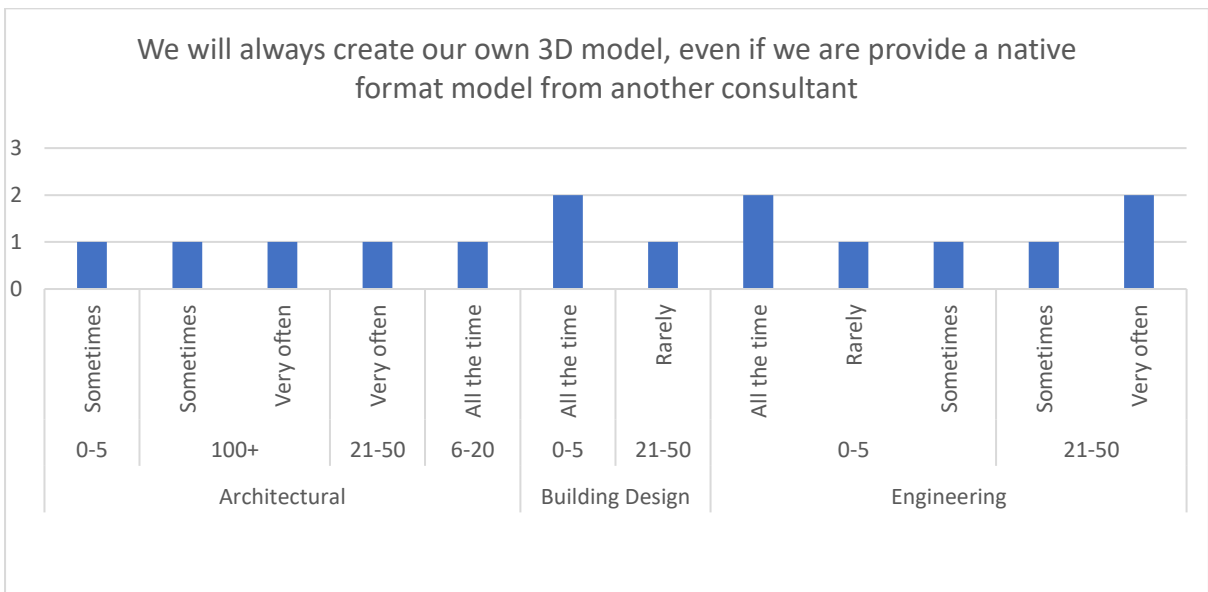
**Figure.28. Question D1a: Use of Other Consultants Native Models for Drafting**



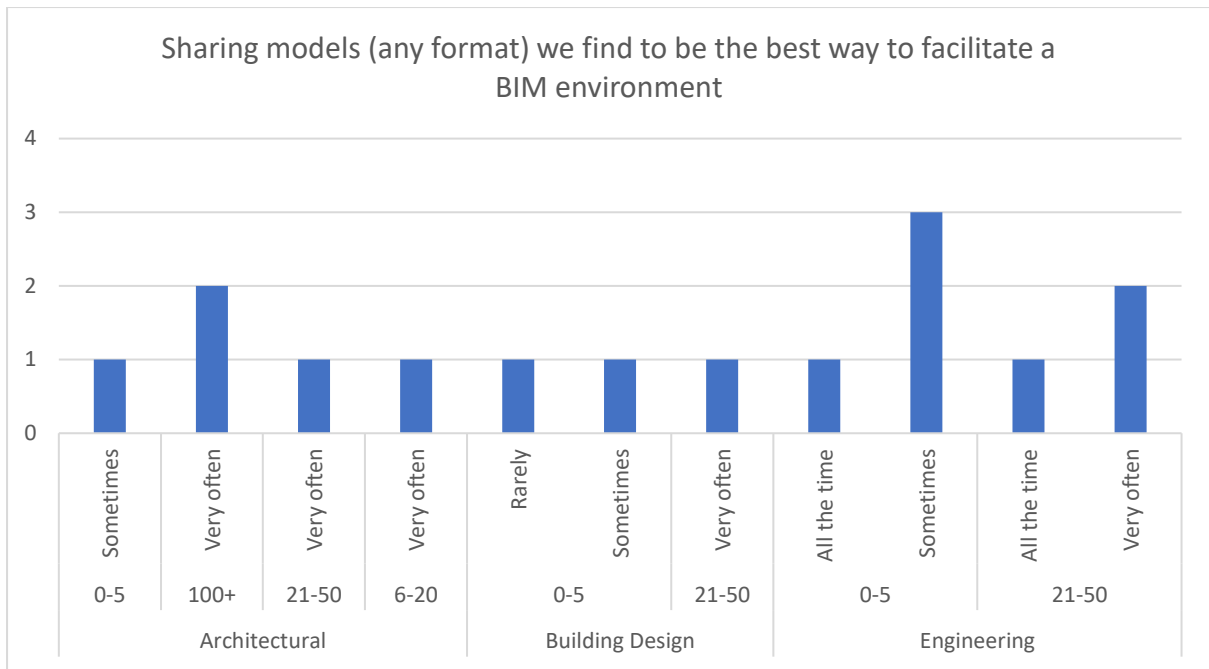
**Figure.29. Question D1b: Use of Cloud Based Multidisciplinary Models**



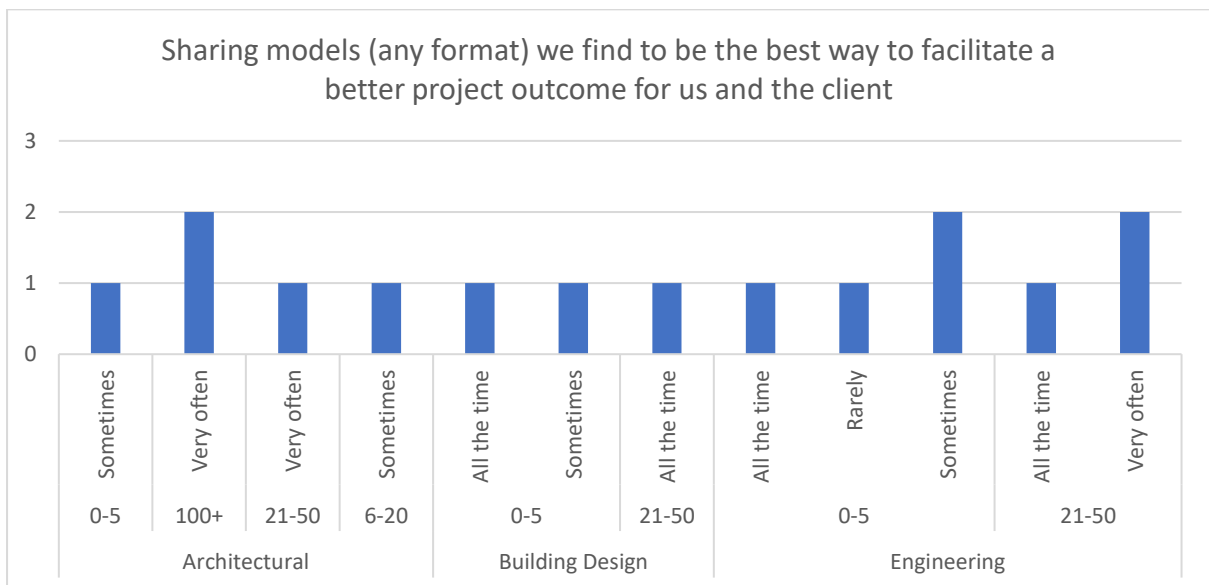
**Figure.30. Question D1c: Use of Other Consultants Models Instead of Creating Own Models**



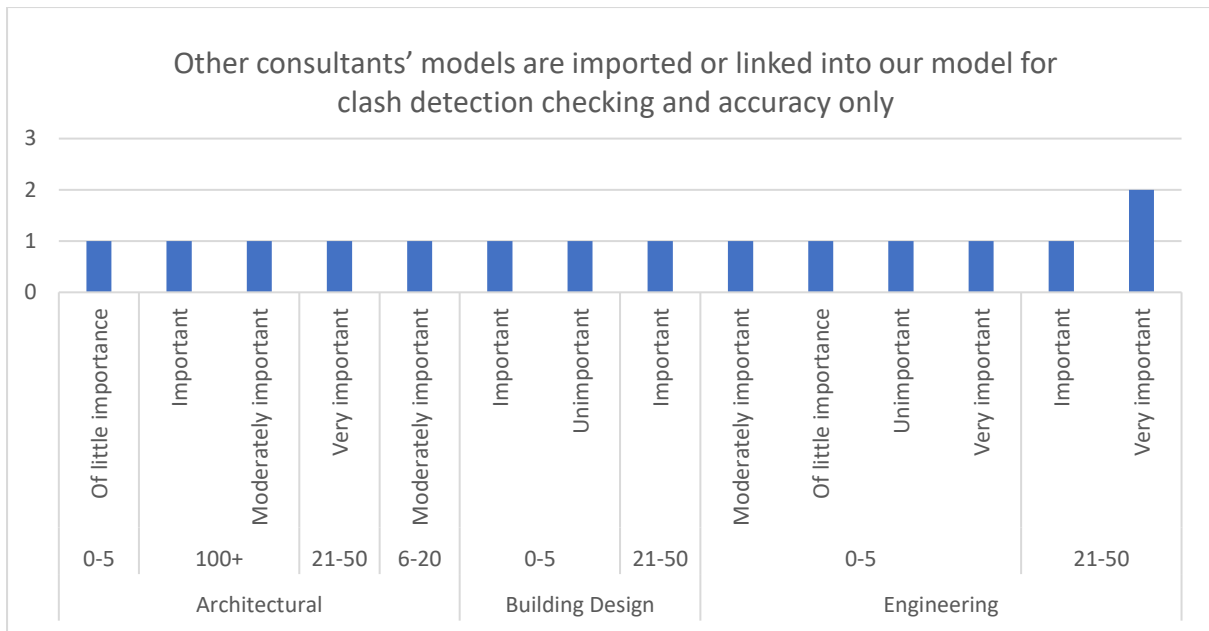
**Figure.31. Question D1d: Creation of 3D Models when Provided Model in Native Format from Another Consultant**



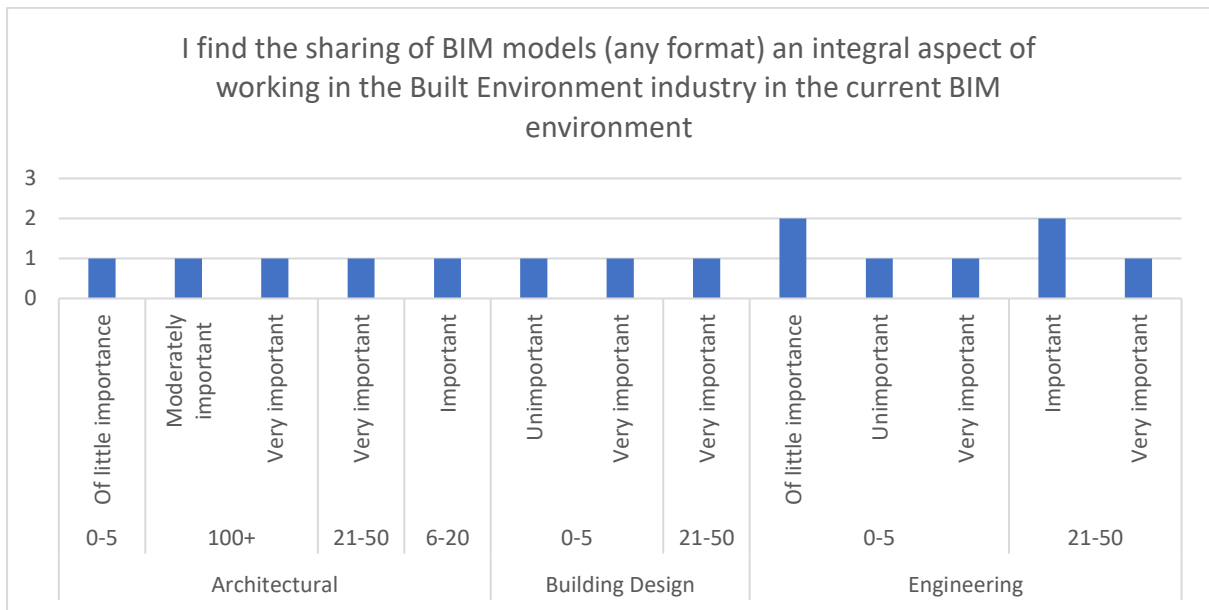
**Figure.32. Question D1e: Sharing Models and the BIM Environment**



**Figure.33. Question D1f: Sharing Models and Project Outcomes**

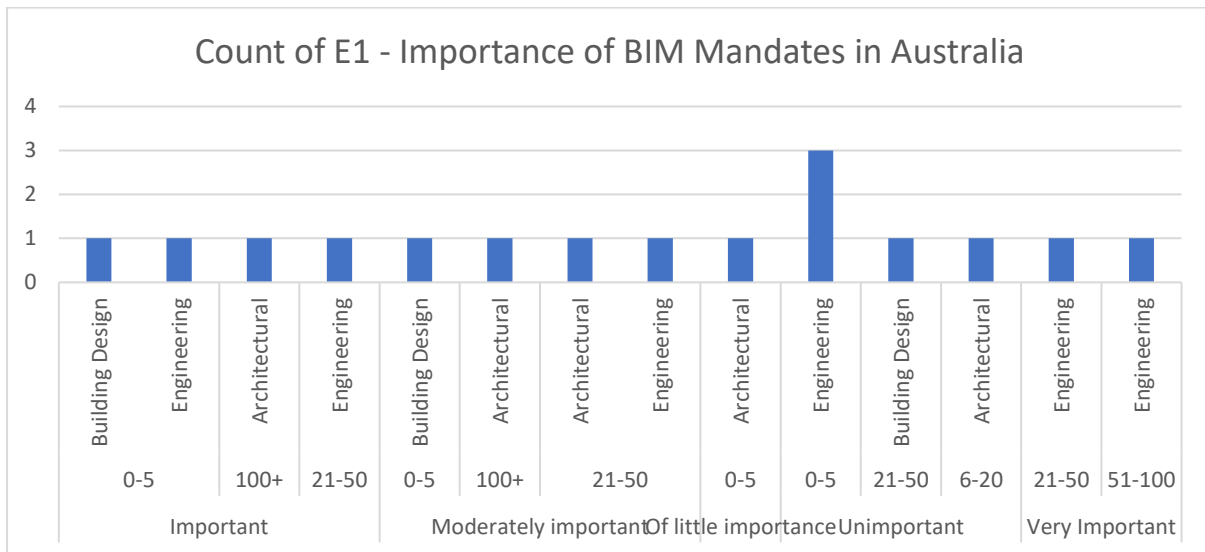


**Figure.34. Question D2c: Importing Consultants Models for Clash Detection and Model Accuracy**

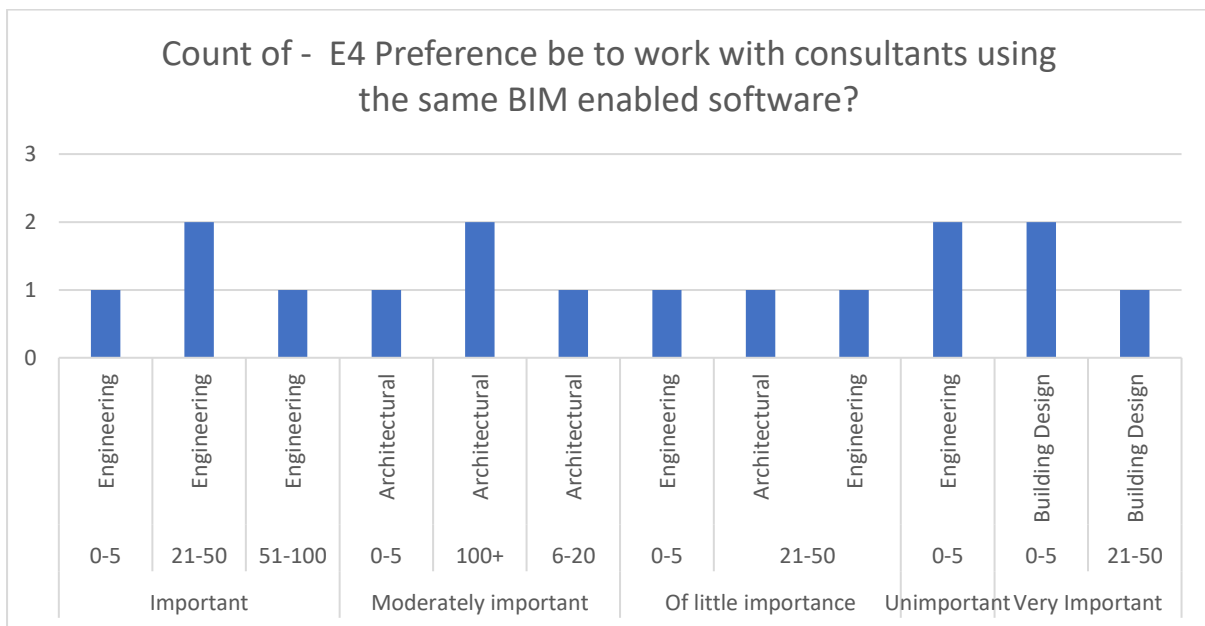


**Figure.35. Question D2d: Sharing of BIM Models is Integral to working in the Built Environment**

## Appendix I: Question Group E



**Figure.36. Question E1: Governments such as the UK, USA and Singapore have mandated BIM use to varying degrees in there AEC industries. Do you support Australia to do this?**



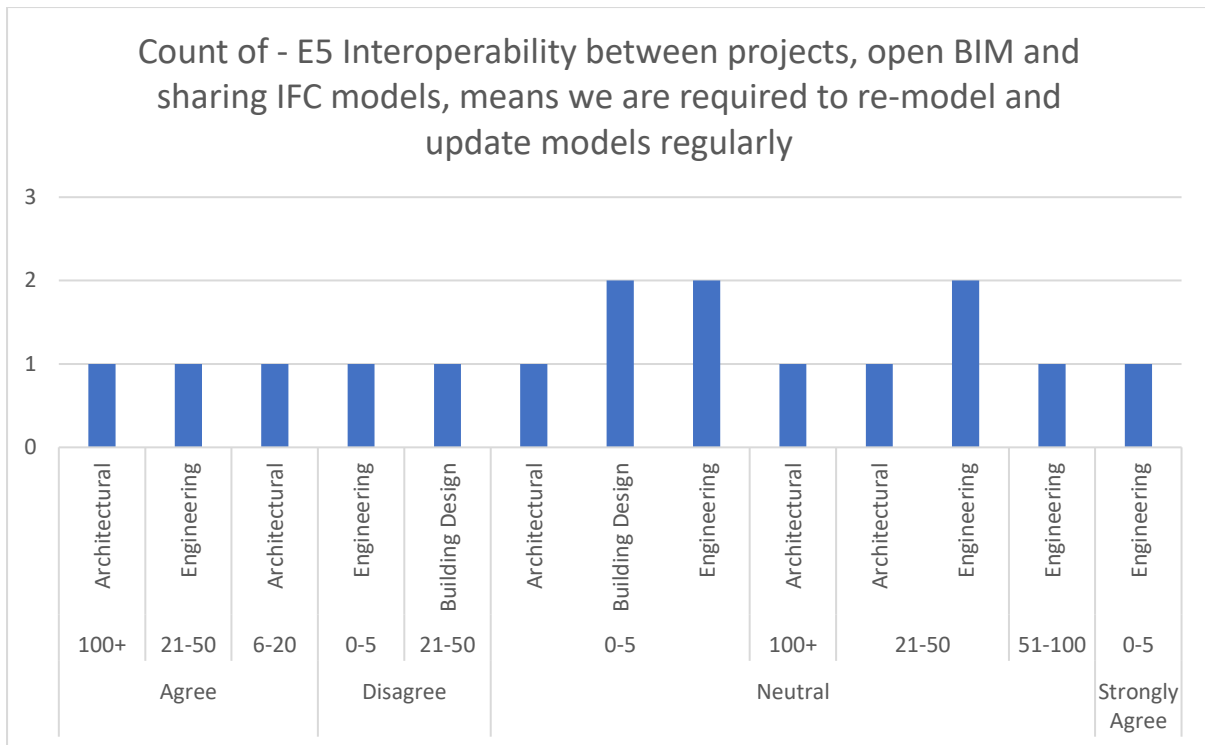
**Figure.37. Question E4: If you had a choice, would your preference be to work with consultants using the same BIM enabled software?**



What AE industry sector do you identify with?	What is the size of your organisation?	How long has your company been using the BIM Platform noted in the previous question?	If you had a choice, would your preference be to work with consultants using the same BIM enabled software? Please provide comments why or the relevance to work with consultants using the same BIM software. Is it relevant? [Comment]
Building Design	0-5	7+ Years	the easier the BIM processes are made the more consultants will take up it's use
Engineering	0-5	7+ Years	99% of IFC or BIM models from other contractors are useless. 3D models from other contractors can vary a lot - some are okay, some just don't work, some are so large they are unusable. There is no common standard. Unlike 2D CAD files - I would say 99% of contractors request 2D CAD files - which they will translate into their own 3D model (as we do) if 3D is needed.
Architectural	0-5	3-4 Years	
Engineering	0-5	7+ Years	While not vital, there is a preference due to others perceptions. It is often perceived by those outside the design field that there is a "go-to" piece of software for a project of a particular type and those outside these are inferior or will be difficult to work with.
Engineering	0-5	2-3 Years	IFC files or similar are usually enough to get the required project outcomes.
Architectural	100+	5-6 Years	It is easier to control graphics, scheduling, tagging, etc..
Building Design	21-50	7+ Years	If it's best for project, then the right thing to do is to share and interface
Building Design	0-5	7+ Years	not enough engineers are on Revit
Engineering	0-5	2-3 Years	BIM does not appear to help and is a waste of time and money unless you are a software developer.
Engineering	21-50	7+ Years	

Architectural	21-50	7+ Years	As long as the data is able to imported / exported in a compatible format, the native program is irrelevant - as is to intent with IFC / openBIM
Architectural	100+	7+ Years	We use Archicad, which is fine and comparable to revit. However it is limiting with a majority of consultants using Revit. We learn to get by with IFC's etc, but I think if the business had their time again they would have chosen the alternative just to make it easy. This tells you that BIM is not really being used, with everyone really just trying to use the same platform to deliver their product/service.
Engineering	21-50	7+ Years	
Architectural	6-20	7+ Years	
Engineering	21-50	3-4 Years	I see the value in Open BIM, but it can make life harder for the design team.
Engineering	51-100	7+ Years	its tends to be easier if everyone has the same software

**Table E4: Tabulated Response to question E4**



**Figure.38. Question E5: Interoperability between projects, open BIM and sharing IFC models, means we are required to re-model and update models regularly.**

What AE industry sector do you identify with?	What is the size of your organisation ?	How long has your company being using the BIM Platform noted in the previous question?	Interoperability between projects, open BIM and sharing IFC models, means we are required to re-model and update models regularly. If you have time, please comment. [Comment]
Building Design	0-5	7+ Years	
Engineering	0-5	7+ Years	Unless two companies agree on a set of CAD and software standards before they start a project, it is almost impossible to share BIM effectively. There are too many variations in how software libraries are setup. Most companies we deal with share 2D files and only provide 3D IFC or revit models for visual purposes.
Architectural	0-5	3-4 Years	
Engineering	0-5	7+ Years	We have to make the changes in our model around the normal coordination and clash detection, however this isn't onerous as we have

			been working with a number of different packages for a long time and are comfortable with the process. We ensure that our model is spatially correct even if it adds extra time to the project.
Engineering	0-5	2-3 Years	Most works are in-house so this is not an issue, if the model needs to change for a design reason or client changes, it gets changed. Not seen as 're-work' more a project outcome.
Architectural	100+	5-6 Years	
Building Design	21-50	7+ Years	Everyone is paid to do a certain amount of modelling. If someone wants interoperability, then they can advance these elements from within the model but there must be levels of modelling to suit budgets or product development.  One of the hardest things is to get a client to understand the value of modelling. If they can to there, then there is some value in interoperability outside a draftsman desk.
Building Design	0-5	7+ Years	
Engineering	0-5	2-3 Years	BIM does not appear to help and is a waste of time and money unless you are a software developer.
Engineering	21-50	7+ Years	I think during preliminary stages of the project it is easier to coordinate through sharing models as we don't have to stop and produce PDF documents.
Architectural	21-50	7+ Years	It means each discipline can stay in control of their own model. They are not 'infected' by other disciplines.
Architectural	100+	7+ Years	
Engineering	21-50	7+ Years	
Architectural	6-20	7+ Years	
Engineering	21-50	3-4 Years	
Engineering	51-100	7+ Years	A lot of smaller changes on site we don't bother modelling unless it is a project requirement.

			Mandated BIM projects do require some re-modelling
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**Table E5: Tabulated Response to question E5**

What industry sector do you identify with?	AE What is the size of your organisation ?	How long has your company been using the BIM Platform noted in the previous question?	E6 Which industry sector do you believe is progressing the BIM environment in SEQ? In regard to your answer above, please comment why you believe that industry is progressing the use of BIM.
Building Design	0-5	7+ Years	Architecture - large scale architecture projects require time consuming consultant co-ordination
Engineering	0-5	7+ Years	I can see that architects benefit greatly from BIM - it shows their clients the end product. Building engineers probably make better use of sharing models with architect, but even most of their documents are done in 2D. Example - the building engineer uses their 3D model to extract 2D slab profiles, then they use these profiles create 2D reinforcing details. The only time I've ever seen concrete reinforcing documents done in 3D is in the precast industry - I've never seen in-situ concrete details produced entirely from 3D - it's would not be time efficient.
Architectural	0-5	3-4 Years	Engineering
Engineering	0-5	7+ Years	Up until this point I think it has been in the 'standard' building and engineering disciplines. These include mainly commercial projects. I think the next big leap will occur when large infrastructure projects are mandated to use BIM and then will follow through with FM.
Engineering	0-5	2-3 Years	The Engineering sector appears to be furthering the modelling techniques to enable smarter BIM and a more complete building model, however, I think there is more movement by the Architectural sector, tying a LOD to an Architectural specification which would also lead to a more complete facilities management

			aspect for a BIM lifecycle makes sense in the long term.
Architectural	100+	5-6 Years	The Architects.
Building Design	21-50	7+ Years	I think all sectors are developing BIM. People are working across different sectors and bringing BIM tools with them across all sectors. Don't forget that people work across different disciplines also which bring other improvements in documentation/modelling
Building Design	0-5	7+ Years	Most Building Designers, some architects
Engineering	0-5	2-3 Years	Architectural Structural
Engineering	21-50	7+ Years	I think it is become collaborative between all industries. We are starting to see more of an engagement from contractors with regards to modelling.
Architectural	21-50	7+ Years	Health, Brisbane Airport Corp
Architectural	100+	7+ Years	Construction
Engineering	21-50	7+ Years	Structural
Architectural	6-20	7+ Years	...
Engineering	21-50	3-4 Years	MEP seems to be going well. The engineer is often the modeller and they use analysis tools and Graphical scripting well
Engineering	51-100	7+ Years	In general engineering firms are ahead of Architectural firms. Services consultants have been slow to pick up BIM but are now starting to get serious

**Table E6: Tabulated Response to question E6**

What AE industry sector do you identify with?	What is the size of your organisation ?	How long has your company been using the BIM Platform noted in the previous question?	E7 I was confused by the questions provided and/or they were not relevant to my industry. Please comment briefly. If you have time, please comment on improvements that could be made to this questionnaire to make it more relevant to the use of BIMMS software and BIM for the AE industry. This information may be used to assist further studies into BIM and the software use to facilitate a BIM environment.
Building Design	0-5	7+ Years	
Engineering	0-5	7+ Years	I think BIM modelling is great for architects. But the more information and details you add to it the more difficult it becomes to use. Engineering is about the details. Architects don't show connection details - eg end plates, bolts, plates etc - once you start adding this level of detail the model becomes extremely difficult to maintain.
Architectural	0-5	3-4 Years	
Engineering	0-5	7+ Years	The mandating of BIM, while a fantastic outcome would need some caveats in my opinion. For commercial project it is a feasible possibility to create the models, however the concern comes as to how the models remain updated in high maintenance environments. For instance in a hospital where there may be 20-30 trade contractors on maintenance, is it the responsibility of the hospital to employ someone to update every change made or is it the responsibility of each contractor to have a copy of the software and update the model and send the changes. If so how do you 'vet' the quality of data being received to ensure no degradation of the data over time. For residential projects, my concern is financial feasibility. The cost of modelling every element is not fiscally responsible and almost impossible to get a 5D or 6D of each building element without blowing out the cost. While I think mandating BIM is a good idea, I think a measured approach is required to ensure it is applicable an of use.

Engineering	0-5	2-3 Years	Some questions were not relevant to my industry or the works we undertake with the BIM software platform we use. We use both 2D and 3D software. Options to choose multiple BIM platforms and disciplines would have been useful.
Architectural	100+	5-6 Years	No confusion, everything was relevant and appropriate.
Building Design	21-50	7+ Years	To improve the BIM industry, further marketing should be targeted at the 5th/6th dimension - ie. end user and having them interact with the model, changing wall colours, furniture etc via mobile app. Further development in this will quickly push investment and the need for BIM and make it standard for the integration of the virtual world with the real world assisting augmented reality.
Building Design	0-5	7+ Years	the questions were occasionally poorly worded.
Engineering	0-5	2-3 Years	This survey appear to be trying to justify BIM and appears bias.
Engineering	21-50	7+ Years	
Architectural	21-50	7+ Years	
Architectural	100+	7+ Years	
Engineering	21-50	7+ Years	
Architectural	6-20	7+ Years	
Engineering	21-50	3-4 Years	No, this is valuable research and a good survey.
Engineering	51-100	7+ Years	

**Table E7: Tabulated Response to question E7**