THE USAGE OF BUILDING INFORMATION MODELLING (BIM) IN MALAYSIA'S ARCHITECTURE INDUSTRY

[1] M.F.I Mohd-Nor, [1] Tahir M.M., [1] I.M.S. Usman, [2] Abdul Halim Ismail

[1] Jabatan Seni Bina dan Alam Bina (SErAMBI),
Fakulti Kejuruteraan dan Alam Bina,
[2] Pusat Citra Universiti,

Universiti Kebangsaan Malaysia,
43600 Bangi, Selangor, Malaysia.

ABSTRACT

Over the last few decades, the architecture field have seen tremendous developments in skills level, work processes and professional culture with the adoption of computer software technologies. Investment in technology has always been to increase effectiveness and overall performance in the design and construction process that results in a return of investment. Today, more and more digital technologies have been developed and created to accommodate the high demands of the market over the years, including Building Information Modelling (BIM). This research paper aims to look into the insight of how architect firms in Malaysia are coping up with the adoption of BIM in the country. This research was originally conducted in 2013-14 and has seen its preliminary findings published over the years. However, this paper uncovers the sequential parts of the research that has yet to be published. The main data collecting instrument used was a nationwide survey that was conducted on all the architectural firms in Malaysia and the findings was used as a foundation for subsequent research phases on the subject matter. From the findings, it is revealed that BIM-based practice is still at an infancy level and that the industry and government bodies need to put on greater effort and produce better strategies to make BIM an industry standard technology.

Keywords: *Building Information Modelling (BIM), Architecture, CAD, Technology.*

INTRODUCTION

Computer software technologies have been changing how architects work and live for the last few decades. In the early 2000s, research and development carried out by the industry and academia have led to the creation of an even more sophisticated technology that not only alters the conventional design process but also the standard practices of the profession. That technology is today called Building Information Modelling (BIM). Today, BIM is centre-stage within the Architecture, Engineering and Construction (AEC) sector the world-over. It is seen as a means to overcome those age-old difficulties in communications and information management that have plagued the architecture industry for decades. Reports and research from around the globe shows that BIM has now gained strong grounds and its adoption rate continue to grow from year to year (Contsruction, 2012).

The 2012 SmartMarket Report by McGraw Hill shows that the adoption rate of BIM in the United States has reached 72% (Contsruction, 2012). Reports by the same publisher for the same year also states that the adoption rates in Korea is at 58% while the Middle East stands close to 25% (Contsruction, 2012). According to a 2010 report, BIM usage in Western Europe has reached 38% (Contsruction, 2010). The National Building Specification (NBS), a body owned by the Royal Institute of British Architects (RIBA), reported that the BIM adoption rate in the UK for 2012 stands at 31% (Contsruction, 2010). On the Southern Hemisphere, a 2012 national report by Masterspec states that New Zealand has 34% users of BIM while Australia's adoption rate is at 19% (NBS, 2012).

Due to the benefits of BIM and its huge potential of improving the Architecture, Engineering and Construction (AEC) industry, governments of developed and developing countries around the world have also started to mandate the usage of BIM in their respective countries. In the United States, the General Services Administration (GSA) began requiring the use of BIM in all new projects in 2007 (Masterspec, 2012). BIM has been compulsory in Finland since 2007 when it comes to the state enterprise Senate Properties that provides property services primarily to government customers (Masterspec, 2012). Whereas in Norway, the civil state client *Statsbygg* decided to use BIM for the whole lifecycle of their buildings from 2005 onwards (Fortner et al., 2008). In 2007, Danish state clients such as the *Palaces & Properties Agency*, the *Danish University Property Agency* and the *Defence Construction Service* require BIM to be used for their projects (Baxter, 2013). The Dutch Ministry of Interior on the other hand, requires BIM to be used for large building maintenance projects in the Netherlands from 2012 onwards (Fortner et al., 2008). In Asia, where BIM was initially seen as slow to adopt BIM has now taken steps to catching up with the rest by mandating BIM use for public works. The Hong Kong Housing Authority will require BIM for all new projects from 2014 while the Public Procurement Service of Singapore made BIM compulsory for all projects over S$50 million and for all public sector projects by 2016 (Kubba, 2012).

However, whilst BIM have shown promise elsewhere, it has not been the same in Malaysia. As to date, no government agencies or body has mandated the usage of BIM. Research in BIM is also at a low where none of the academic institutions have set up a unit or department that looks into BIM matters. While national scale reports or surveys on BIM usage has been conducted in many developed countries, it has not been the case with Malaysia.

ISSUE

When CAD was introduced to the architecture world about a quarter century ago, the architecture industry in Malaysia took its own time to adopt the new technology. This was probably due to the fact that the medium for the technology, the computer, was also a new technology altogether and a luxury to own such machine. Nevertheless, CAD technology is now used to the fullest by the majority of firms if not all. According to a survey done on Malaysian architecture firms in 2009, AutoCAD by Autodesk is a household item and used by all the respondents in the survey. It also revealed that high end 3D solid and surface modelers were used extensively by the industry (BuildingSmart, 2011).

However, BIM and BPS is a different game altogether compared to CAD, CAAD and CAM. It is not a tool that replaces pens and pencils. BIM is much more of a change for the industry than CAD/CAM/CAAD: it reorganizes the sequence, timing, and duration of the design process, ushers in a new model of constant, detailed communication, puts a geometrically larger amount of information into one place, and might even change the fundamental roles of each participating company (Mohd-Nor et al., 2009). A huge amount of investment is required to adopt this new system. Without data, guides and assist, few people can justify their adoption of BIM and those at the forefront of BIM technology may be moving in a direction that does not necessarily lead to success (Sive, 2007).

METHODOLOGY

Looking to the above matter, it is crucial that a report on the adoption and usage of BIM is produced at a national level as a first step towards developing the future roadmap towards full BIM implementation in the country. For this, a quantitative survey was done on all the architectural firms in Malaysia amounting to 535 firms. All of these firms are registered to the Malaysian Institute of Architects or *Pertubuhan Arkitek Malaysia* (PAM), the professional body for architects in Malaysia. The survey, which was distributed electronically through emails, was carried out from 18 March 2013 to 17 June 2013, a total period of three (3) months. From the survey, 140 firms responded, which gives a responds rate of 26%. From a demographic aspect, 61% of the responds came from Kuala Lumpur, Malaysia's capital and biggest city.

There are two (2) main objectives as to why the survey was carried out. The first objective was to find out the current use of digital technologies in practice. This includes the types of computer application used in offices and categorizing it into primary and secondary usage. The survey also gives insights into the impacts that these technologies are having on design strategies, associated management structures and cultures within the industry. The second objective of this survey was to explore the usage of BIM within the industry. This will also provide an insight into the impacts that BIM are having on design strategies, associated management structures and cultures among the firms.

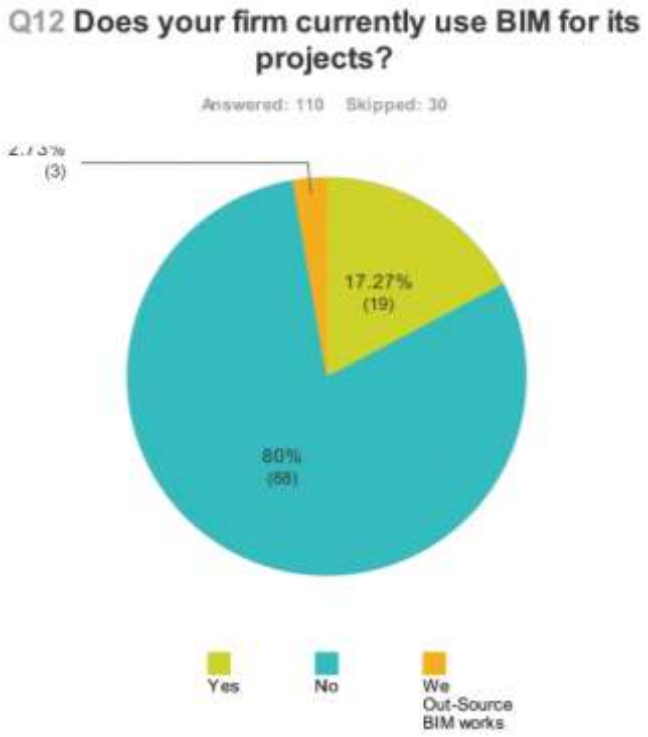
This self-completion survey questionnaire had a total of 20 close-ended questions that were allotted into five segments. Segment 1 inquires demographics information; Segment 2 investigates the current usage of digital technologies; Segment 3 explores the awareness and experience of BIM in practice; Segment 4 inquires the respondents' general view towards BIM; and Segment 5 scrutinizes the industry's perception towards the role of academia. This paper focuses on findings from Segment 3 and 4 from the survey questionnaire. The results obtained from this survey have provided *Lembaga Arkitek Malaysia* (LAM) and *Pertubuhan Akitek Malaysia* (PAM) an insight which would help enable them to take further actions in promoting the adoption of BIM within the architecture industry in the country.

FINDINGS AND ANALYSIS

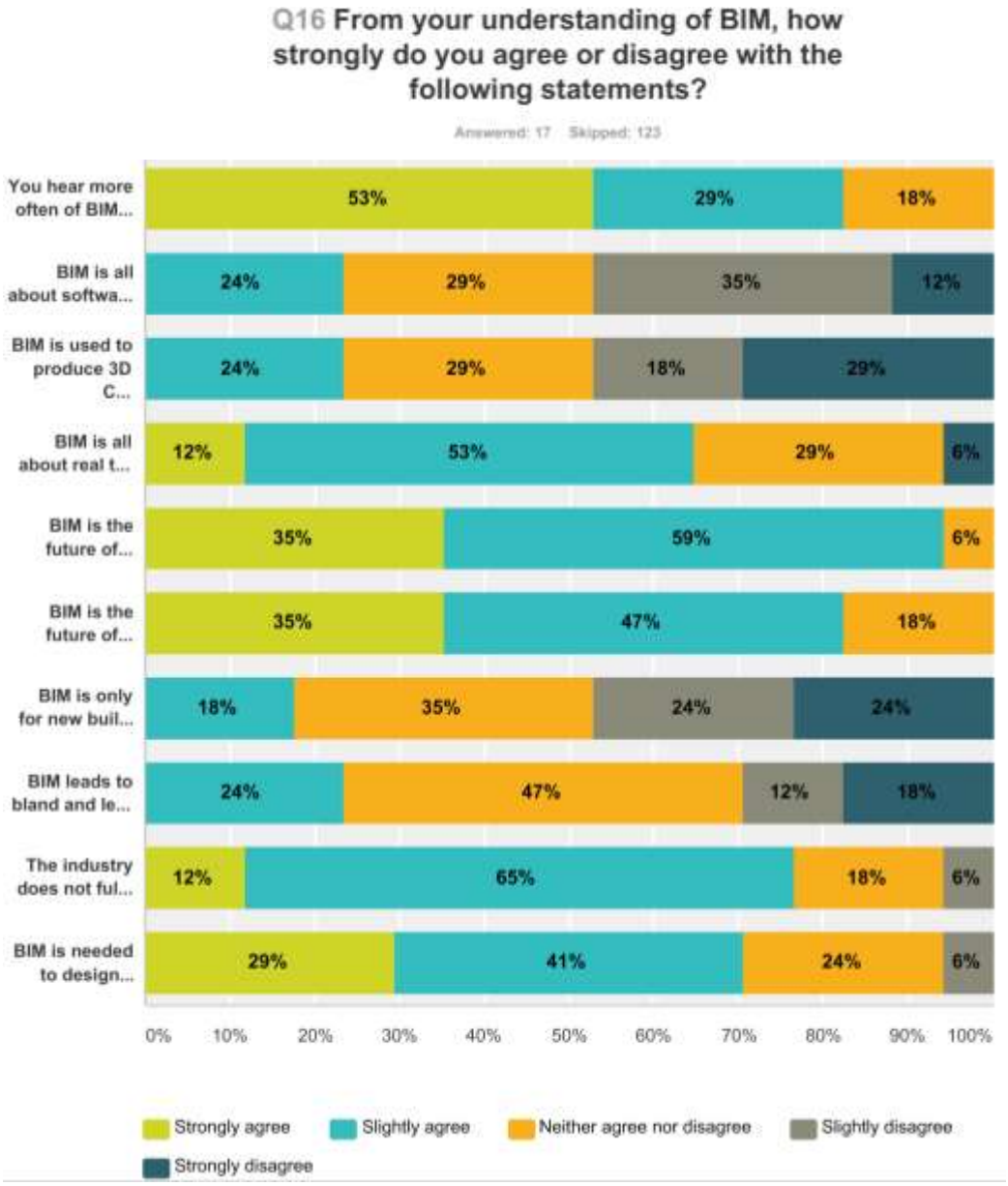
Kenzo Tange merupakan seorang arkitek Jepun yang dilahirkan pada tahun 1913 di Osaka, Jepun. Beliau mendapat pendidikan di Imbart high School, Ehime. Menyambung pelajaran dalam bidang senibina di University of Tokyo pada tahun 1938. Mendalami bidang perancangan bandar pada tahun 1942 dan mendapat pengiktirafan doktor falsafah dalam bidang Spatial Structure pada tahun 1959. Beliau pernah bertugas di

bawah firma Kunio Maekawa pada tahun 1938 sehingga 1941. Menjadi profesor dalam bidang Kejuteraan Bandar di Tokyo pada tahun 1960-1974. Juga pernah menjadi profesor di *Massachusetts Institue Of Technology* (MIT) Kenzo Tange membuka firmanya sendiri selepas memenangi pertandingan untuk Hiroshima Peace Centre dan juga merupakan pengasas kepada Urtec iaitu sebuah konsultan arkitek dan urbanisasi.

SEGMENT 3 – BIM IN PRACTICE



This question, which has been published earlier by the author in *The Journal of Transactions on Environment and Development* by WSEAS in 2014 is shown herewith to serve as a basic understanding before proceeding with the subsequent findings from the survey. Based on the above figure, in spite of 83% of the sample reported of being aware of BIM, only 20% are actually adopting it in their project deliverables (Mohd Nor, 2014). Needless to say that 14% from those who use BIM opted to out-source BIM works rather than adopting the technology in-house. This figure is a concern if one would compare it to some other parts of the world where the US and Europe has nearly 70% and 34% of their architects respectively using BIM. It is also obscure as to why so many people choose not to use it while concurrently acknowledging the technology and its qualities (Mohd Nor, 2014).


Q16 From your understanding of BIM, how strongly do you agree or disagree with the following statements?
Answered: 17 Skipped: 123
You hear more often of BIM...
53%
29%
18%
BIM is all about softwa...
24%
29%
35%
12%
BIM is used to produce 3D C...
24%
29%
18%
29%
BIM is all about real t...
12%
53%
29%
6%
BIM is the future of...
35%
59%
6%
BIM is the future of...
35%
47%
18%
BIM is only for new buil...
18%
35%
24%
24%
BIM leads to bland and le...
24%
47%
12%
18%
The industry does not ful...
12%
65%
18%
6%
BIM is needed to design...
29%
41%
24%
6%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Strongly agree
Slightly agree
Neither agree nor disagree
Slightly disagree
Strongly disagree

	Strongly agree (1)	Slightly agree (2)	Neither agree nor disagree (3)	Slightly disagree (4)	Strongly disagree (5)	Total	Weighted Average
You hear more often of BIM these days	53% 9	29% 5	18% 3	0% 0	0% 0	17	4.35
BIM is all about software and nothing more	0% 0	24% 4	29% 5	35% 6	12% 2	17	2.65
BIM is used to produce 3D CAD drawings only	0% 0	24% 4	29% 5	18% 3	29% 5	17	2.47
BIM is all about real time collaboration	12% 2	53% 9	29% 5	0% 0	6% 1	17	3.65
BIM is the future of project information	35% 6	59% 10	6% 1	0% 0	0% 0	17	4.29
BIM is the future of project management	35% 6	47% 8	18% 3	0% 0	0% 0	17	4.18
BIM is only for new build, not refurbishment or alteration	0% 0	18% 3	35% 6	24% 4	24% 4	17	2.47
BIM leads to bland and less creative design	0% 0	24% 4	47% 8	12% 2	18% 3	17	2.76
The industry does not fully understand what BIM is yet	12% 2	65% 11	18% 3	6% 1	0% 0	17	3.82
BIM is needed to design sustainable buildings	29% 5	41% 7	24% 4	6% 1	0% 0	17	3.94

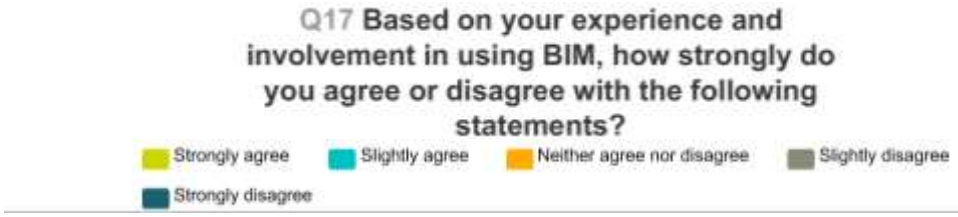
Views on BIM (Q16). Even though only 20% from the sample have actually implemented BIM, their experiences are vital in order to ensure that the direction for future strategy would bear fruit and afterwards fulfil the industry's requisites. The first point of this question conforms to Q11, where BIM is becoming a household term nowadays. However, whether this would translate into a fully adopted technology by profession in the near future is yet to be known. Looking at the responses, the users seem to understand what BIM is all about and how it is meant to be utilised. Only a few perceived BIM as just another typical drawing software used for producing 3D images, which is definitely not the case.

The majority agreed that BIM is about real-time collaboration, even though the average rating for this item is just 3.65 out of 5, which is arguably not very strong. This could have happened due to the fact that many users are still beginners and they may have yet to fully utilize BIM on a full-scale collaboration with other team players. The majority also conceded that BIM is the future of project information and project management, where both of these items received a high rating of 4.29 and 4.18 respectively.

Some respondents have expressed that they are unaware of BIM's capability to work on refurbishing or alteration of a building. Since adopting BIM requires a substantial one-time investment, it may not be within an architecture firm's immediate decision to do so for primarily refurbishing and alteration works, as these types of labour in Malaysia are usually low-cost and do not generate as much income as a new build. However, nearly half of the sample disagreed that BIM is only for new builds, not refurbishment or alteration.

One detail that seems to be interesting is the sample's perception that BIM leads to bland and less creative design. While many scholars and industry professionals seem to agree that BIM may lead to bland designs, users in Malaysia have mixed opinions towards this. While nearly half of the users are unresolved with regards to this, there is certainly a degree of balance between those who are for this point as those against it. This would subsequently ascertain the next point where a majority of the users (76%) agreed that the industry has yet to fully comprehend what exactly is BIM. Therefore, it is unsurprising that while the majority of the sample are aware of this new technology, only a small

percentage chose to implement it. This is a principal argument as it shows that the lack of knowledge on BIM technology might be the contributing factor towards the hindrance of its full-scale adoption by the industry.



	Strongly agree (1)	Slightly agree (2)	Neither agree nor disagree (3)	Slightly disagree (4)	Strongly disagree (5)	Total	Weighted Average
BIM has improved visualisation	50% 8	50% 8	0% 0	0% 0	0% 0	16	4.50
BIM has increased coordination of construction documents	38% 6	44% 7	19% 3	0% 0	0% 0	16	4.19
BIM has improved site logistics	19% 3	44% 7	38% 6	0% 0	0% 0	16	3.81
BIM has improved productivity	31% 5	38% 6	31% 5	0% 0	0% 0	16	4.00
BIM has increased speed of delivery	38% 6	38% 6	19% 3	6% 1	0% 0	16	4.06
BIM has brought cost efficiencies	25% 4	63% 10	6% 1	6% 1	0% 0	16	4.06
BIM has increased our profitability & return of investment (ROI)	6% 1	38% 6	50% 8	6% 1	0% 0	16	3.44

BIM Experience (Q17). This question shall answer the third objective of this research, which intends to look into how BIM has affected architecture deliverables in terms of technical, culture, and business attributes of architecture firms. Based on the following figure of responses, it could be said that respondents have in general, described that BIM has so far given them positive impacts. The following describes the above in detail.

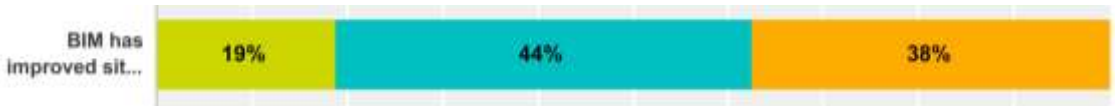
Basic Statistics

	Minimum	Maximum	Median	Mean	Standard Deviation
BIM has improved visualisation	1.00	2.00	1.50	1.50	0.50

First of all, 100% (N= 16) respondents agreed that BIM has improved their work in terms of visualization. This is anticipated as many sources have reported that selected parties have started using BIM for visualisation purposes (Becerik-Gerber et al., 2011b) (Sacks and Barak, 2009) (Gonchar, 2006, Kim, 2011). Even though BIM offers many other innovative features, its quality as a visualization tool is unequivocal and should by all means be utilised to its full advantage.

	Minimum	Maximum	Median	Mean	Standard Deviation
BIM has increased coordination of construction documents	1.00	3.00	2.00	1.81	0.73

Increasingly coordinated construction documents happen to be another quality brought about by BIM, with an approval rate of 4.19 out of 5 by the respondents. This demonstrates that those who used BIM in their project deliverables have actually used it to coordinate construction documents within the consultant teams rather than merely for personal purposes such as visualization or clash detections. With this, it is proven that BIM has become the tool for collaboration between key team players.



	Minimum	Maximum	Median	Mean	Standard Deviation
BIM has improved site logistics	1.00	3.00	2.00	2.19	0.73

This is rather similar to improving site logistics, with 63% (N= 10) admitting to the advantage of using BIM for this purpose. This demonstrates that BIM is not only used during the design phase, but also extends to the construction phase. This also implies that contractors and clients have also started to embrace BIM technology; a rarity in traditional construction practices in Malaysia, as coordination of site logistics with BIM necessitates all parties including clients and contractors to adopt the technology.

	Minimum	Maximum	Median	Mean	Standard Deviation
BIM has improved productivity	1.00	3.00	2.00	2.00	0.79

BIM has proved to be able to increase productivity with a 69% (N= 11) approval rate from BIM users. The rest of the users did not disagree to this but have yet to see any clear evidence of increase in productivity. This approval rate is seemingly crucial, as the main reason to adopt any technology whatsoever is its ability to increase productivity (Al-Jabri and Sohail, 2012) (Eadie et al., 2013b) (Azhar, 2011). It should be noted that when users of a new technology approve of its capacity to realistically increase productivity, it is highly probable that non-users will look into the prospect of adopting this new technology as well.

	Minimum	Maximum	Median	Mean	Standard Deviation
BIM has increased speed of delivery	1.00	4.00	2.00	1.94	0.90

In direct relation to increase of productivity, it is expected that there should be an increase in speed of delivery as well. However, a slight increase of approval can be seen when 76% (N= 12) of the respondents agreed that BIM has increased their speed of job deliverables.

	Minimum	Maximum	Median	Mean	Standard Deviation
BIM has brought cost efficiencies	1.00	4.00	2.00	1.94	0.75

The response towards cost efficiencies in using BIM is quite interesting. While a substantial 88% (N= 14) of the respondents have reported that BIM had increased their cost efficiencies, only 25% (N= 4) 'strongly agree' while the other 63% (N= 10) 'slightly agree' to it. This proves that while it is true that BIM does increase cost efficiencies, it has yet to do so substantially.

	Minimum	Maximum	Median	Mean	Standard Deviation
BIM has increased our profitability & return of investment (ROI)	1.00	4.00	3.00	2.56	0.70

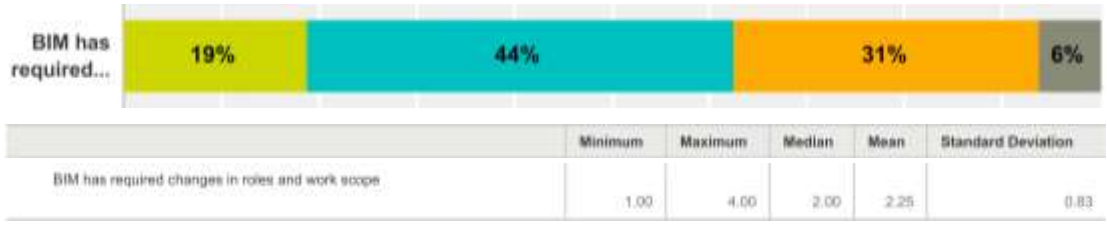
In direct relation to cost efficiencies, not many have experienced appreciable returns of investment (ROI). To clarify, only 6% (N= 1) 'strongly agree' that BIM had increased ROI, 38% (N= 6) 'slightly agree', while a considerable 50% (N=8) neither agree nor disagree to ROI. This suggests that BIM has yet to show any fortifying evidence that it can indeed produce huge ROI to users in Malaysia, contradicting to the claim by Autodesk (2007) that an ROI of 60% could be achieved within just a year of usage. However, even though it may be strange at first when those who claimed BIM to have increased cost efficiencies may not have made the same claim for ROI, it is not entirely unexpected. Using BIM may straight away offer cost efficiency from daily tasks such as reduced prints, sharing of BIM models, simultaneous working by all team players, utilising clash detection and other simulation tools throughout the design process, and so on in comparison to CAD. However, a return of investment (ROI) on the other hand needs more time to realize as BIM is a long-term investment rather than a short one (Pour Rahimian et al., 2014). It is also worth noting that ROI is not easily calculated as approaches to adoption may differ from one to the other, i.e. immediate switch vs phased-in approach; this affects the effectiveness of ROI calculations formula by Autodesk (2007). Also, researchers posit that ROI is better suited to cost-saving projects than for revenue-generating projects (Brien and Dolenc, 2012).

	Minimum	Maximum	Median	Mean	Standard Deviation
BIM has helped us in producing specifications	1.00	4.00	2.00	2.50	0.94

Another feature in BIM is that users can create specifications earlier on and generate it automatically from the drawings along the project timeline (Eastman et al., 2008, Utiome and Drogemuller, 2013, Chapman, 2011). Considering this, BIM users are anticipated to agree to this question. However, only 57% (N= 9) of BIM users agreed that BIM has helped in producing design specifications. What remains a concern is that the other 44% (N= 7) have described the experience adversely. This raised the question as to what extent do these users actually use BIM and whether it is convenient or not to produce

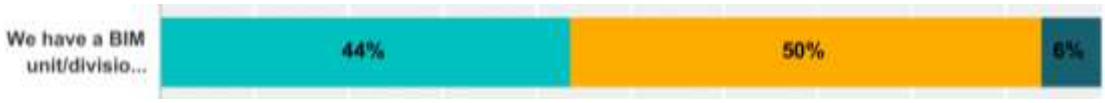
specifications using BIM? What is certain is that only slightly more than half of users use BIM to produce specifications.

It is within BIM's capability to produce accurate calculations on material and costing that is used to produce bills of quantities (B.Q) (Li, 2013, Mahdjoubi et al., 2013, Nadeem et al., 2015). However, it is expected that not all architects from the firms use BIM to produce bills of quantities (B.Q). Only 50% (N= 8) of the firms used BIM in producing bills of quantities (B.Q). This is due to the fact that only quantity surveyors (Q.S) produce B.Q in Malaysia's work environment.



This question is significant in the sense that it affects the traditional practice within the industry. 63% (N= 10) of the firms have claimed that BIM requires changes in roles and work scope. The features of BIM that enables production of drawings, 3D images, simulations of design, bills of quantities, collaboration, and communications have raised the question on whether it is still necessary to have traditional roles such as draftsmen, 3D artists, or traditional project managers as architects can now execute all those tasks by themselves with the BIM platform. Studies by Sebastian (2011), Gu and London (2010), Hannon (2007) and Love et al. (2013) are some of the studies that touched on this issue in general. However, it is notable that even though more than half of the firms have generally agreed that BIM requires changes in roles and work scope, only 19% (N=3) of the firms have 'strongly agreed', indicating that the majority could have probably experienced a change but may not be a significant one.

Corresponding directly to the changes BIM requires for roles and work space, it is expected that BIM will have an effect on existing workflows, practices and procedures as well. With that said, 69% (N=11) of the firms agreed to this notion. This is crucial as changes in roles, workflows, practices and procedures will affect the traditional role of architects and what is required of an architect in the future. Again, the majority responded only 'agree' rather than strongly agree, indicating that they could have probably experienced a change but may not be a significant one.



	Minimum	Maximum	Median	Mean	Standard Deviation
We have a BIM unit/division that handles/supports all BIM matters	2.00	5.00	3.00	2.69	0.77

Another scenario that shows how architect firms are changing as an effect of adopting BIM is that 44% (N= 7) of the architecture firms have established a BIM unit or division to handle and support BIM related matters. However, 50% (N=8) have yet to confirm that they have actually set up a unit or division to oversee matters pertaining to BIM. It is worth noting that starting a new unit or department for new tasks involves more office space, furniture, hardware and software, human resource, and scope of work, resulting in an overall increase in capital. This may not run well with smaller offices with limited resources. Thus, it is possible that 50% (N=8) of the firms did not agree nor disagree because even though they might not have started any BIM unit or division yet, they readily have selected individuals doing it.

	Minimum	Maximum	Median	Mean	Standard Deviation
Clients has increasingly insist on us using BIM	2.00	4.00	3.00	2.75	0.75

Based on the table above, 44% (N= 7) of the architecture firms that have adopted BIM have claimed that their clients have increasingly insisted them to use BIM. The industry should take note of this as nearly half of the clients for these architecture firms have insisted on BIM implementation despite the perceived high investment (Alabdulqader et al., 2013, Takim et al., 2013, Cheng and Wang, 2010, McGraw-Hill, 2012b) they have to make and the fact that the technology is relatively new which may even lack the support and required expertise. Only 19% (N=3) of the firms have not had their clients increasing; insisting on BIM implementation, while the remaining were uncertain as to their clients' preferences. It is unsurprising that quite a significant portion of clients are still unsure of BIM as determined from a very recent survey done by CIOB (2016). The survey in UK also found that more than half of the construction clients in the nation is undecided on BIM as they stated to have yet to see any remarkable evidence of its capabilities.

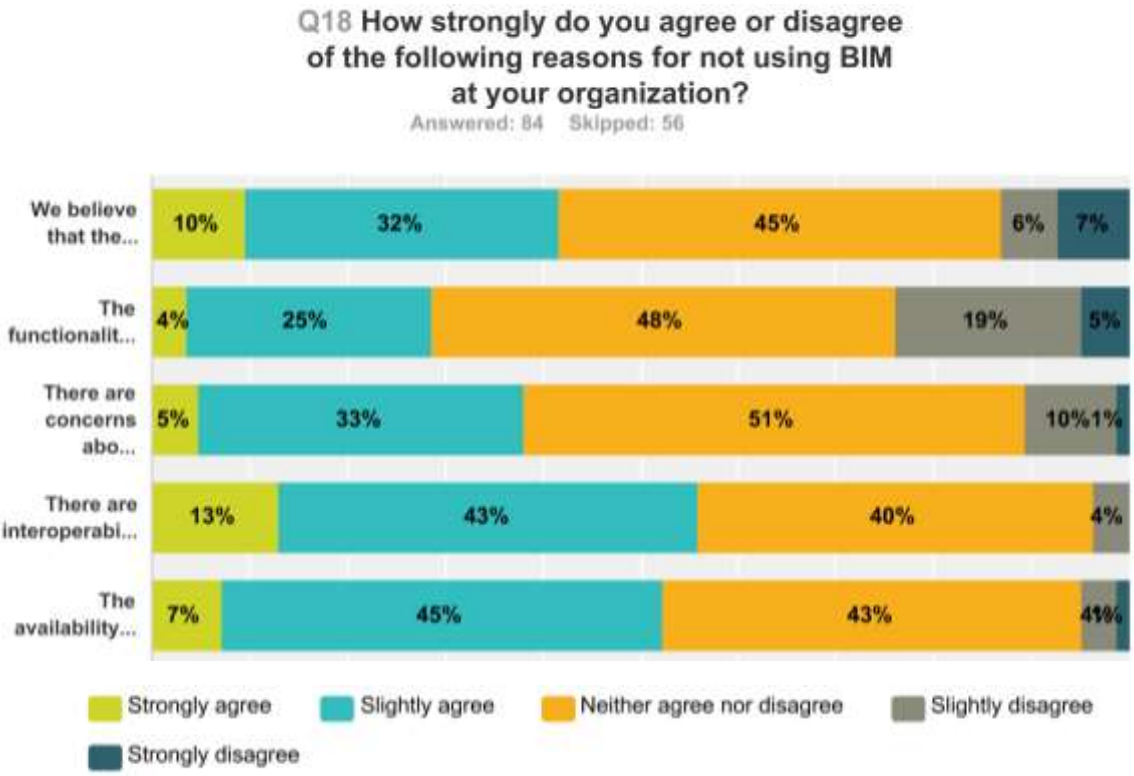
	Minimum	Maximum	Median	Mean	Standard Deviation
We have used BIM successfully	1.00	3.00	2.00	2.25	0.56

It is a positive indication that 69% (N=11) of the architecture firms that have been using BIM were perceived to be using BIM successfully. This trend is in line with the trend in other countries around the world, particularly Canada (60%) (IBC and NBS, 2013), Finland (68%) (Finne et al., 2013), New Zealand (62%) (Masterspec, 2013), and United Kingdom (62%) (NBS, 2014). However, as with the previous question, this notion may not be shared by client-users. Contradictory to CAD, where it does not collaborate or integrate team players on a real-time basis, a collaborative tool like BIM should benefit

all its team players equally or at least share a positive perception by all its users; the recent survey done by CIOB (2016) proved differently.

SEGMENT 4 – GENERAL VIEW TOWARDS BIM

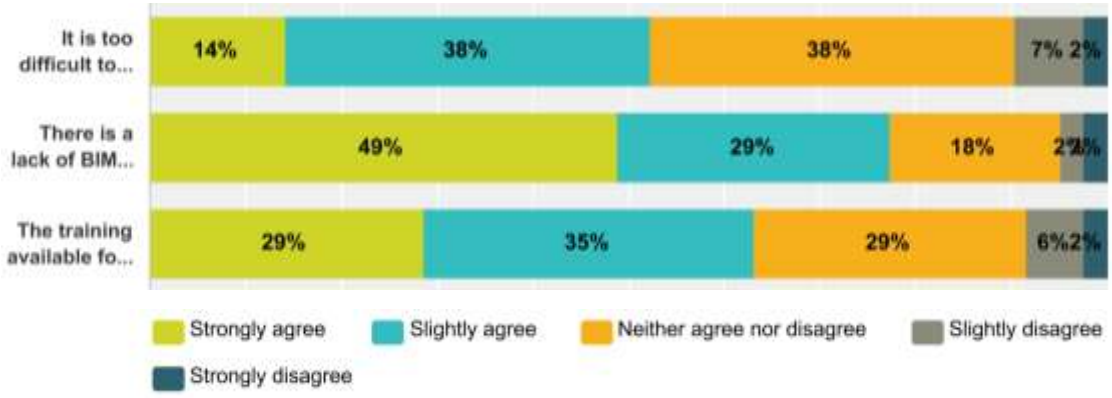
BIM in the future: Drivers and Barriers



	Strongly agree (1)	Slightly agree (2)	Neither agree nor disagree (3)	Slightly disagree (4)	Strongly disagree (5)	Total	Weighted Average
We believe that the approaches/systems we currently use are better	10% 8	32% 27	45% 38	6% 5	7% 6	84	3.31
The functionality of BIM doesn't help much in what we do	4% 3	25% 21	48% 40	19% 16	5% 4	84	3.04
There are concerns about the liability for BIM models	5% 4	33% 28	51% 43	10% 8	1% 1	84	3.31
There are interoperability concerns between BIM and our CAD applications	13% 11	43% 36	40% 34	4% 3	0% 0	84	3.65
The availability of BIM-compatible content/libraries seems to be insufficient	7% 6	45% 38	43% 36	4% 3	1% 1	84	3.54

BIM Barriers (Q18). For non-BIM users, which form the majority of the sample, it is important to know the reasons that may have prevented them from adopting the technology. It is to be noted that by this stage of the survey, only 84 out of the 92 non-BIM users remained with the survey while eight non-BIM users had opted out. There are 16 sub-questions in this question that can be further categorized into five groups, namely non-users' perception to the technological dimension of BIM, BIM in relation to human resources, non-users' perception towards BIM in relation to cost and investment, non-users' perception towards legal matters pertaining to BIM, and lastly a little bit on BIM research.

Among the architecture firms that have not used BIM exclusively, 42% (N=35) believed that BIM is not any better than the system or technology that they are currently using, whereas another 45% (N=38) neither agree nor disagree. Even though 42% of non-users of BIM might have claimed that their current system may be better, only 29% (N=24) stated that it was due to functional aspects, while nearly 50% were undecided. Besides that, the concern towards the liability of BIM models can be quite significant for 38% (N=32) of the architecture firms, while most of them (62%, N=52) are not quite sure of that. However, what seems to be more significant to non-users are matters pertaining to interoperability of files and model library. For these, 59% (N=47) perceived that there could be a possibility of an interoperability issue between BIM and the current software that they are using, possibly due to the fact that BIM and CAD are two totally different systems. In addition to this, the requirement by local councils and authorities for *building plan* e-submission to be in DWG (AutoCAD) format (DBKL, 2013, MPKK, 2015) would encouraged firms to retain CAD rather than move to BIM. Even though there are BIM software that can convert BIM propriety and non-propriety file formats such as RVT, IFC, and COBie into DWG format, there could be issues with object enablers and loss of information when exchanging platforms. Apart from that, about half of the non-BIM users (53%, N=44) in Malaysia were concerned about the availability of sufficient BIM-compatible model libraries. As having a sufficient model-library was generally deemed to be vital especially when working with CAD, it is not surprising that users now would expect the same with BIM.

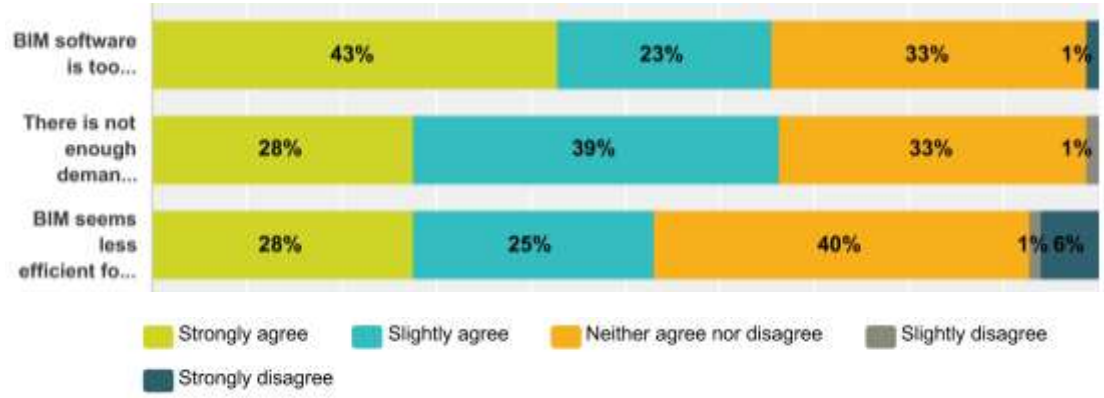


	Strongly agree (1)	Slightly agree (2)	Neither agree nor disagree (3)	Slightly disagree (4)	Strongly disagree (5)	Total	Weighted Average
It is too difficult to use BIM software	14% 12	38% 32	38% 32	7% 6	2% 2	84	3.55
There is a lack of BIM skilled staff	49% 41	29% 24	18% 15	2% 2	2% 2	84	4.19
The training available for BIM is inefficient	29% 24	35% 29	29% 24	6% 5	2% 2	84	3.61

The above sub-questions 6-8 explore BIM in relation to users' skills and training. According to BIM researchers, one of the barriers of adopting BIM is that many users find it difficult to operate BIM as it requires a steep learning curve, particularly at the beginning (Woo, 2007, Tse et al., 2005, Hetherington et al., 2010, Eastman et al., 2008, Sharag-Eldin and Nawari, 2010, Kaner et al., 2008, Weber and Hedges, 2008, Aly, 2014, Cunningham et al., 2015). This is reflected in this survey when 52% (N=44) of non-user architect firms perceived that it was difficult to use BIM. However, there is some light to this as from those who *agree*, only 14% (N=12) claimed to *strongly agree* to this notion, indicating that the majority could have perceived that it may be 'slightly difficult' to use BIM rather than 'significantly difficult'.

The responses to the next sub-question is very important as it received the highest percentage of 'agree'. A whopping 78% (N=65) of the architecture firms perceived that there is a lack of BIM skilled staff or expertise to actually run BIM in the office. And from the 78%, 49% 'strongly agreed' to this, signifying that it could be the main reason as to why these firms have not been adopting BIM. What is remarkable is that this was the main obstacle to adopting BIM in other parts of the world as well, which includes New Zealand (Masterspec, 2013), United Kingdom (NBS, 2014) (Eadie et al., 2013a), Ireland (Cunningham et al., 2015), Qatar (Ahmed et al., 2014), Hong Kong (Chan, 2014), India (Kumar and Mukherjee, 2009), Singapore (Teo et al., 2015), as well as among the contractors in the United States (Ku and Taiebat, 2011). A survey done by Liu et al. (2015a) on the AEC industry in Australia and China also revealed that the shortages of skilled personnel is also one of the top barriers to BIM adoption in both countries. The answers for this question as provided by the architecture firms in Malaysia are paramount such that it responds directly to one of the hypothesis of this research and the justification to this notion will be further elaborated later on in this thesis.

Apart from the lack of expertise or skilled staff, the limited availability of training is also a serious impediment to BIM adoption, as claimed by 64% (N=53) of the non-BIM user in architecture firms in Malaysia. In comparison, the lack of comprehensive training on BIM is actually also a hindrance for BIM adoption in countries such as South Korea (McGraw-Hill, 2012b) and China (Consulting, 2014, (SZEDA), 2013). In fact, there have been many studies around the world that also concurred to the lack of available BIM training as being one of the biggest barriers if not the biggest itself in BIM adoption (Eadie et al., 2014, Enegbuma and Ali, 2011, Enshassi et al., 2016, Becerik-Gerber et al., 2011a, Liu et al., 2015a, Mahdjoubi et al., 2015, Kozlovská et al., 2013, Hosseini et al., Chan, 2014). It is noteworthy that a report by Times (2007a) have also shown that many Malaysian firms in general do not prioritize digital technology skills development. Both sub-questions 7-8 can be related to each other and the responses to both questions are equally crucial, as now we know that not only is there a real shortage of BIM skilled staff, but there also aren't many resources that can provide adequate training for them to attend, thus aggravating the shortage of skilled BIM staff. The correlation between these two sub-questions brings us back to the research hypothesis which will be further elaborated in the following chapters.



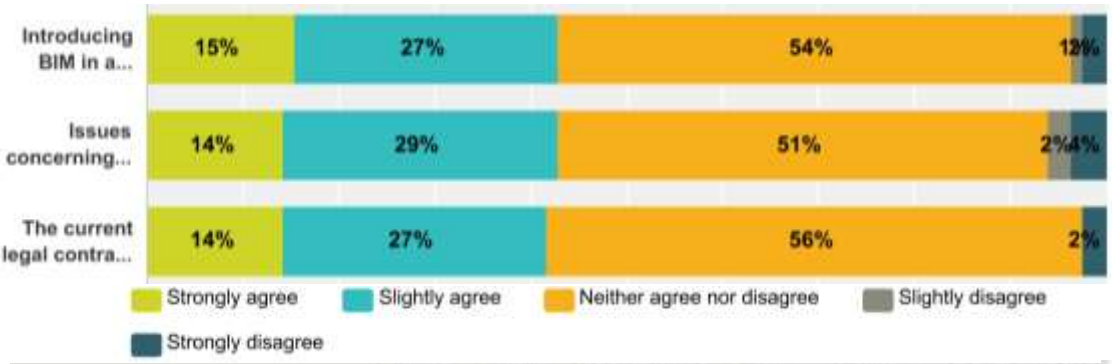
	Strongly agree (1)	Slightly agree (2)	Neither agree nor disagree (3)	Slightly disagree (4)	Strongly disagree (5)	Total	Weighted Average
BIM software is too expensive	43% 36	23% 19	33% 28	0% 0	1% 1	84	4.06
There is not enough demand from clients and/or other project members	28% 23	39% 32	33% 27	1% 1	0% 0	83	3.93
BIM seems less efficient for smaller projects	28% 23	25% 21	40% 33	1% 1	6% 5	83	3.67

Subsequently, sub-questions 9-11 validate that cost is a huge concern to users. Despite the efforts by many bodies around the world, both non-government and government organizations, to promote BIM based on their benefits and positive ROIs, the industry has yet to be convinced of it. This seems to be the case in Malaysia where the second biggest hindrance to BIM adoption is the cost of adopting the system. For this, 43% (N=36) of the non-BIM users in architecture firms strongly agreed, while another 23% (N=19) agreed that BIM is too expensive for them. The situation is the same in many other countries for example, it is also perceived as the second biggest impediment to BIM adoption in North America (McGraw-Hill, 2012a), Korea (McGraw-Hill, 2012b), and Germany (Both, 2012); it is actually the biggest barrier to contractors in the United Kingdom (Gledson et al., 2012). Accordingly, many literatures have acknowledged the high cost of BIM software as the major barrier for its adoption, both for start-up and also subsequent costs such as training, and software and hardware updates (Hetherington et al., 2010, Liu et al., 2010, Crotty, 2013, Liu et al., 2015a, Cunningham et al., 2015, Kim et al., 2016). In addition to this, the relatively weak currency of a developing country like Malaysia as opposed to developed countries, where most of BIM software originates, makes the situation even worse. However, what may have influenced such response from the architecture firms in Malaysia is actually the way the industries in Malaysia generally react to any newly introduced technology. According to Sulaiman Mahbob (2015), the chairman of the Malaysian Institute of Economic Research, the industries in Malaysia have often been very reluctant to quickly invest in new technologies. Studies by Mahalingam (2010), who examined into the application of green technology in Malaysia, and Jakobsen (2014), who wrote on the entrepreneurship development in Malaysia, both concluded that the industries' stakeholders in Malaysia are generally very reluctant to invest on new technologies that is deemed to be costly and may have yet to show explicit evidence on ROI.

The lack of demand from clients and other project teams for BIM implementation in their projects is the third major reason for not adopting BIM. With this, 28% (N=23) strongly agree while 39% (N=32) agree, which amounts to 67% (N=55) of the non-BIM user architecture firms in Malaysia to perceive as mentioned above. This correlated to the

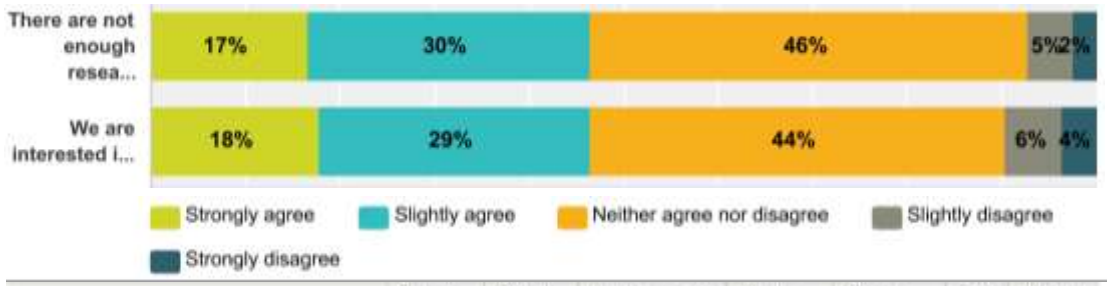
cost of implementing BIM as previously stated where clients in Malaysia tend to be very reluctant and extra careful in taking up new technologies, including BIM. BIM is a system that needs participation from every individual from every layer in the project including the clients themselves; it also requires large investment for start-up and maintenance, as well as operation. Everyone is waiting for everyone else to implement it first to somewhat give solid evidence of the clear benefits and ROIs; they will remain sceptical towards the technology until someone reveals those evidences. It would not be a good idea if only one party were to invest heavily towards BIM and later discover that not every other team member would follow suit leading to BIM not functioning as it should, resulting in a waste of money, time, and energy. This unfortunately has happened in Hong Kong, as reported by Chan (2014) through her survey such that more than 80% of the design firms had adopted BIM, but only 10% of their current projects were delivered with the use of BIM. This can be correlated to a previous survey done in Hong Kong by Tse et al. (2005) that revealed the main obstacle to BIM adoption was the lack of demand from clients. This experience in Hong Kong should be made an example by other countries that are pursuing for BIM adoption in their AEC industry, including Malaysia.

The response to the next sub-question is as anticipated when slightly more than half, 53% (N=44) agreed that BIM seems less efficient for smaller projects as compared to bigger ones. This outcome is shared by some studies including those of Penttilä (2007), Eastman et al. (2008), Liu et al. (2010), Hetherington et al. (2010), Kassem et al. (2012), Arayici et al. (2012b), Leeuwis (2012), Miller et al. (2013), Monozam et al. (2016), and Dainty et al. (2017). According to the studies, there are several reasons behind this. Firstly, small projects in general such as a house or a school block, are often looked at as having less complexity, with straightforward structures and detailing, and do not involve many parties. These projects may be too simple to see the benefits of BIM. Secondly, smaller projects would often mean smaller project costs which then reflect upon the consultation fees paid to the team members, thus results in lower profit margin. It is not surprising if these firms would not have the financial means or be willing to invest heavily on a relatively new yet expensive technology that may not even be used to its full potential, let alone guarantee any ROI. Thirdly, it is mostly the smaller firms that usually take up on small projects, which are consistent with their capabilities, both financially and labour. The reality of having limited man power would mean that it would not be very easy for them to allow their staff to attend training on a new technology. The fact that BIM has a steep learning curve could only mean that training would require longer full-time sessions, hence taking the staff away from his or her duty at work for long periods of time.



	Strongly agree (1)	Slightly agree (2)	Neither agree nor disagree (3)	Slightly disagree	Strongly disagree (5)	Total	Weighted Average
Introducing BIM in a project will result in unclear roles/change in roles of participants	15% 13	27% 23	54% 45	1% 1	2% 2	84	3.52
Issues concerning ownership and maintenance of the BIM model are still unresolved	14% 12	29% 24	51% 43	2% 2	4% 3	84	3.48
The current legal contracts do not adequately address BIM issues	14% 12	27% 23	56% 47	0% 0	2% 2	84	3.51

The next sub-questions 12-14 asked non-BIM users in architecture firms on BIM pertaining to roles, ownership, and legal matters. The response to all three (3) sub-questions are not much different, where slightly less than 50% agree to the questions while slightly more than 50% does not know the answers, hence giving neutral feedbacks. However, a small amount, less than 3% disagreed to any of the statements in all of the above sub-questions. This includes the following perceptions: 1) introduction of BIM in a project will result in unclear change of roles of participants, 2) there are unresolved issues concerning ownership and maintenance of BIM models, 3) current legal contracts do not adequately address BIM issues. What is interesting here is that although 83% (N= 91) of the whole survey sample reported as being fully aware of BIM and what it is about, only slightly half of them are acknowledging the above problems, while more than half are still keeping an open mind towards these issues, neither agreeing nor disagreeing. It is a positive sign that although all of the three perceived issues stated above are relatively established, not everyone is agreeing to it. This is contrary in the UK, Canada, Finland and New Zealand, where more than 80% of users and non-users of BIM claimed that BIM necessitates changes in their roles, workflow, practices, and procedures (NBS et al., 2014).



	Strongly agree (1)	Slightly agree (2)	Neither agree nor disagree (3)	Slightly disagree (4)	Strongly disagree (5)	Total	Weighted Average
There are not enough research on BIM to support its usage	17% 14	30% 25	46% 39	5% 4	2% 2	84	3.54
We are interested in using BIM, but we don't know where to start	18% 15	29% 24	44% 37	6% 5	4% 3	84	3.51

Sub-questions 15-16 received similar responses as sub-questions 12-14. Nearly half of the non-BIM user architecture firms agreed that there is a lack in BIM research while nearly another half chose to remain neutral. This concurs with lots of literature around the world that acknowledged the lack of research in BIM (Becerik-Gerber and Kensek, 2009, Gu and London, 2010, Wong and Yang, 2010, Kim, 2011, Aram et al., 2013, Samuelson and Björk, 2013, Antón and Díaz, 2014, Johansson et al., 2014, Dainty et al., 2017). The answer to the last sub-question of Question 18 revealed that nearly half of the non-BIM user firms are interested in adopting BIM but do not know where to start. This is in accordance to the lack of research as potential users in Malaysia may have heard the hype surrounding BIM and be interested in adopting it, but they could not really find further information from established studies that could convince them to invest in the technology and guide them on implementing the technology.

CONCLUSION

It is apparent that BIM usage continues to grow around the world particularly among developed nations. However, despite the fact that more than 80% of the architecture firms in Malaysia are aware of BIM and its benefits, adoption rate is only at 20% as of in 2014. This situation needs to be addressed urgently yet carefully as the findings proves that adopting a new technology despite with its widely known benefits may not necessarily be easy and smooth sailing as anticipated, and may require more than just advertisements and promotions by vendors and commercial literature. It seems to suggest that greater effort needs to be taken by the industry leaders and government to convince the industry to invest in this technology that many other parts of the world has made it an industry standard technology. It is hopeful that the positive findings from this research on current practices taken from current users of BIM is able to act as a strong basis to convince the industry more on not just the mere benefits of the technology, but also the practicality and reliability of its usage within the local context.

REFERENCES

[1] Mohd Nor, M. F. I., & Grant, M. P. (2014). *Building Information Modelling (BIM) in the Malaysian Architecture Industry*. *WSEAS Transactions on Environment and Development*, *10,* 264-273.

[2] Construction, M.H. 2012. *The Business Value Of BIM In North America: Multi-Year Trend Analysis And User Ratings (2007-2012).*Smart Market Report. New York: McGraw-Hill.

[3] Construction, M. H. 2010. *The Business Value Of BIM In Europe: Getting Building Information Modelling To The Bottom Line The United Kingdom, France And Germany*. Smart Market Report. New York: McGraw-Hill.

[4] NBS 2012. *NBS National BIM Report 2012*. London, RIBA Enterprises Ltd.

[5] Masterspec 2012. *New Zealand National BIM Survey 2012*. Auckland: Construction Information Ltd.

[6] Fortner, B., Wilson, S., PE, M., Tsztoo, D., Handford, C., Rossi, K. & Horvath, J. 2008. *Special Report: Are You Ready for BIM?* Civil Engineering-Reston*,* 78**,** 44-57.

[7] Baxter, P. 2013. *BIM Adoption and Developments* One Team Conference. Las Vegas: Autodesk.

[8] Kubba, S. 2012. *Green Building Design and Contruction : LEED, BREEAM and Green Globes,* US, Butterworth-Heinemann.

[9] BuildingSmart, J. D. 2011. *The BIM Issue*. *Build Smart.* Singapore: Building and Construction Authority.

[10] Mohd-Nor, M.F.I, Usman, I. & Mazlan-Tahir, M. 2009. How the professional practice and the architecture education in Malaysia is catching up with the development of CAD. *European Journal of Social Sciences,* 9**,** 677-683.

[11] Sive, T. 2007. BIM (Building Information Modeling) - A Marketing Primer and Call to Action. Society for Marketing Professional Services Foundation.

[12] Becerik-Gerber, B., Jazizadeh, F., Li, N. & Calis, G. 2011b. Application Areas And Data Requirements For BIM-Enabled Facilities Management. *Journal Of Construction Engineering And Management,* 138**,** 431-442.

[13] Sacks, R. & Barak, R. 2009. Teaching Building Information Modeling As An Integral Part Of Freshman Year Civil Engineering Education. *Journal Of Professional Issues In Engineering Education And Practice,* 136**,** 30-38.

[14] Gonchar, J. 2006. Tech Briefs: To Architects, Building Information Modeling Is Still Primarily A Visualization Tool. Architectural Record.

[15] Kim, J.-L. 2011. Use Of Bim For Effective Visualization Teaching Approach In Construction Education. *Journal Of Professional Issues In Engineering Education & Practice,* 138**,** 214-223.

[16] Al-Jabri, I. M. & Sohail, M. S. 2012. Mobile Banking Adoption: Application Of Diffusion Of Innovation Theory. Journal Of Electronic Commerce Research, 13, 379-391.

[17] Eadie, R., Mclernon, T. & Patton, A. 2015. An Investigation Into The Legal Issues Relating to Building Information Modelling (BIM). *Proceedings of RICS COBRA AUBEA 2015*.

[18] Azhar, S. 2011. Building Information Modeling (BIM): Trends, Benefits, Risks, and Challenges for the AEC Industry. *Leadership and Management in Engineering,* 11**,** 241-252.

[19] Autodesk 2007. BIM's Return on Investment *In:* SOLUTIONS, A. B. (ed.) *REVIT® Building Information Modeling* San Rafael, CA: Autodesk Building Solutions.

[20] Brien, G. & Dolenc, M. 2012. BIM Implementation In The Irish Architecture Industry.

[21] Utiome, E. & Drogemuller, R. An approach for extending Building Information Models (BIM) to specifications. Proceedings of the 30th CIB W78 International Conference, 2013. WQBook.

[22] Chapman, I. 2011. What Does Building Information Modelling (BIM) Mean For

Specifications? *Nbs - Kowledge.*

[23] Li, S. W. V. 2013. *Innovative Generation: Bills Of Quantities Production On Architectural Elements Through BIM Environment.* Doctoral Dissertation.

[24] Mahdjoubi, L., Brebbia, C. & Laing, R. 2015. *Building Information Modelling (BIM) in design, construction and operations*, WIT Press.

[25] Nadeem, A., Wong, A. & Wong, F. 2015. Bill of Quantities with 3D Views Using Building Information Modeling. *Arabian Journal for Science & Engineering (Springer Science & Business Media BV),* 40.

[26] Love, P. E., Simpson, I., Hill, A. & Standing, C. 2013. From justification to evaluation: Building Information Modeling for asset owners. *Automation in Construction,* 35**,** 208-216.

[27] NBS 2014. *NBS National BIM Report 2014*. London, RIBA Enterprises Ltd.

[28] Liu, S., Xie, B., Tivendal, L. & Liu, C. 2015a. Critical Barriers To BIM Implementation In The AEC Industry. *International Journal Of Marketing Studies,* 7**,** 162.

[29] Dainty, A., Leiringer, R., Fernie, S. & Harty, C. 2017. BIM and the Small Construction Firm: A Critical Perspective. *Building Research & Information***,** 1-14.