Use of BIM at higher learning institutions: Evaluating the level of implementation and development of BIM at built environment schools in South Africa.

Nischolan Pillay[1], Innocent Musonda[2] and Choeu Makabate[3]

[1]Faculty of Engineering and the Built Environment, University of Johannesburg, Doornfontein, 2094, Gauteng, SOUTH AFRICA
[2] Faculty of Engineering and the Built Environment, University of Johannesburg, Doornfontein, 2094, Gauteng, SOUTH AFRICA
[3] Faculty of Engineering and the Built Environment, University of Johannesburg, Doornfontein, 2094, Gauteng, SOUTH AFRICA

E-mails: npillay@uj.ac.za; imusonda@uj.ac.za; makabate4@gmail.com

Abstract:
The introduction of Building Information Modelling (BIM) into the Architecture, Engineering and Construction industry (AEC) has completely revolutionized how we design and construct buildings. BIM shows significant positive changes for the consulting industry in terms of reducing errors, understanding buildings, realistic visualization, clash detection amongst other remarkable features. However, BIM is an ongoing course of complex processes and it is important that users are kept in the loop of new concepts, processes and workflows. Universities, the world over are making concerted efforts to introduce and implement BIM education for their built environment courses as it has become a component of a professionals practical training. However, it is necessary to determine at what level BIM education is being implemented at educational institutions. This research explores how South African built environment schools have implemented BIM in their teaching syllabus and level of implementation. Data was collected using questionnaires from representatives at built environment schools or departments in the public universities. Findings reveal that there is some usage of 2D and 3D CAD in design modules at some universities. However results suggest very little implementation of BIM methods and processes in many universities. This research will be useful for the AEC industry in terms of judging the level of education in the BIM spectrum and can assist with future training of professionals, regarding BIM.

Keywords:
BIM, AEC, Education, Implementation, South Africa

1 Introduction

In the past decade, Building Information Modelling (BIM) has become a key driver in the design and execution of constructing buildings across the globe. Now, more than ever, BIM is revolutionizing how architects, engineers, project managers, quantity surveyors and other built environment professionals conceptualize, design, document and execute the construction of buildings. BIM is no longer a catch phrase for impressive software but rather a complex system of design and documentation that allows for reduction in error, complexity in design, visualization, virtual building and other cost and time saving benefits. As BIM leaves its infancy behind, the training of specialist consultants in the arena of BIM is becoming imminent. Globally, BIM has "caught on" in the Architecture, Engineering and Construction (AEC) industry and consulting firms expect a high level of skill from candidates entering the work force. An expectation of a candidate new to the built environment job market hinges heavily on abilities that are inclusive of a BIM skill set, however the industry believes the acquisition of these specialist skills remains the responsibility of academic institutions. It is in this sentiment that this research explores how universities are implementing BIM into their courses.

Academic Institutions are focusing resources into the development of BIM education for their students in a fast-paced approach. New laboratories are being set up at universities across the world, implementing high-end hardware, the latest BIM software and highly trained staff to bridge the gap in the skills set upon graduation of a candidate. It is evident from enquiry, that universities require a basic understanding and ability of use in BIM, however the question remains pending, at what level in the BIM spectrum is the training implemented and how are schools relating it to the Level of Development (LOD) in the BIM field?

This research makes use of a mixed method approach of primary quantitative data gathering techniques and qualitative interview based, focused questionnaires and a secondary source of literature to explore the usage of BIM implementation and the Level of Development (LOD) at higher learning institutions in South Africa.

2 Literature Review

2.1 The evolution and concept of Building information Modelling (BIM)

As the world moves towards a fourth industrial revolution, technology is proceeding at a rapid pace in all continuums. The Architecture, Engineering and Construction (AEC) disciplines are similarly not excluded from this occurrence. The digital age has changed how buildings are being designed, documented and executed, smarter than ever, through the use of Building Information Modelling (BIM). BIM had its first introduction in 1957, through the use of Computer Aided Machining (CAM) software from which it developed further into Computer Aided Design/Drafting (CAD) in the early 60’s of which was the initial stepping stones of BIM (Goubau, 2012).

Although CAD had developed and was being adopted, it was fundamentally flawed in the sense that traditional CAD represented lines and arc’s similar to that of a drawing board, the benefits were seemingly not significant to consultants, contractors and clients (Kensek and Noble, 2014; p.xxiii). Similarly, Ibrahim (2006, p.265) reinstates that CAD was a replacement of the drawing board and meant that the only challenge was the training for use of the application, Ibrahim further re-establishes that unlike CAD, BIM is thinking of the building process and not about the process of drafting (Ibrahim, 2006). From the author’s opinions on the differentiation of CAD and BIM, it is clear BIM is more than just a tool for drawing but includes depth of information that can be useful for all stake holders on a project.

By the 1980’s a major commotion occurred in the AEC industry by means of 3D CAD. BIM became a disruptor in the CAD industry as it brought along with it a new way of thinking about product and building design (Quirk and Bergin, 2017). Consultants had to now think more intensely about the building in terms of size, geometry, information of materials, implementation etc. According to Gordon *et al* (2006, p.38) the biggest goal BIM sought to achieve was an intelligent information database that was common to all that worked on the project which allowed for unified and progressive approach that was ultimately handed over to the building owners and facilities managers. Azhar (2011,p.242) similarly elucidates that BIM can be understood to include all disciplines, aspects and systems of a building into a single virtual model which allows all stake holders to collaborate more efficiently than traditional methods. It is imperative to understand that BIM is a process of collaboration for a common goal and requires depth of information that is synthesized in one central file, it is this central source that ultimately defines the power of the BIM concept.

In the present day, BIM is taking over the AEC industry and consulting companies, contractors, clients and facilities managers are seeing the benefits of a central database for their buildings (Azhar, 2011, p.243; Eastman *et al.*, 2011, p.1). The demand for BIM is becoming more evident in recent years and governments and multi-national companies becoming the forerunners for implementation of BIM on their projects (HM Government, 2012). As the demand for BIM grows, the question of competent users come to surface, how are universities preparing their students for the working world and the complexities of BIM systems? In the next section, the authors examine literature that has explored the implementation of BIM into curricular and how effective this implementation has been to prepare graduates for the challenges of BIM.

2.2 The implementation of BIM in University Curricula

As BIM becomes more popular amongst stakeholders in a building project, an immense amount of focus is set on training on BIM platforms. It is important to note that BIM took an upward curve from around 2007 with respects to a conversion from CAD to BIM at universities (Mandhar et al, 2013, p.4). Similarly, Abdirad and Dossick (2016, p.255) tracks the progress of implementation of BIM in curricula from 2007 to 2015 and elucidates a chronologic development of BIM in curricula. According to Abdirad and Dossick (2016, p.255) from 2007, universities focused on moving from CAD to BIM, then focused on the integration of BIM into syllabi thereafter developing into integration of BIM across construction related courses and at present pedagogical strategies to improve the educational outcomes of BIM. Although BIM has had an intriguingly sharp incline of adoption and implementation into construction education, a few outstanding problems persist in teaching and learning of BIM. The literature suggests three issues that are inherently troubling and the authors of this particular research feel it is a worthy mention.

Through integration of BIM into the syllabi, both positive and negative effects are observed by various authors. According to Boeykens *et al* (2013) the issue of mind-set in architectural design studios where 2D drawings is favoured over BIM practices and studio masters of architectural design see it as a hindrance to creativity. Sacks and Barak (2010,p.30) observe a similar occurrence in Civil Engineering and Architecture education and state that the training is still based on traditional 2D drafting and not on modelling, the authors view this as a major issue in the adoption of BIM. Shelbourn *et al.* (2017, p.294) however observes that educators themselves view BIM as just another CAD software which students are expected to learn in their own time and reinforces the fact that it affects creativity. It is evident from the author's views on BIM adoption in curricula, there exists a major mind-set issue in the use, training and adoption of BIM.
Although mind-set in the adoption of BIM is a critical issue, the competency of teaching staff is another major issue observed in built environment schools. Mandhar and Mandhar (2013) states that a critical issue in the training of graduates in BIM is the lack of competent teaching staff. Similarly, Berwald, (2008) elucidates the current nature of teaching staff; *"Currently, professors are more comfortable critiquing physical models and two dimensional drawings such as plans, sections and elevations than a 3-dimensional digital model. While this is understandable given the tools that existed at the time of their training, it can be problematic."* It is from the various authors opinions we are able to paint a picture of the issue of staff that are not 100% trained in BIM. However, what strategies are universities implementing to include BIM into the curriculum so that it becomes a holistic exercise for both students and the teaching faculty?

BIM implementation in university syllabi is fast becoming a reality and universities are making it a priority to produce graduates that are competent and ready for industry. Current literature suggests that there is a high implementation rate in most countries but they are still experiencing issues of integration with other courses. According to Barison and Santos (2010) there exists three approaches for the integration of BIM into curricula namely; *Single Course:* Where institutions are implementing BIM, but only in one course e.g. Architecture, *Interdisciplinary:* Where institutions are implementing BIM with collaboration of other disciplines but at the same institution and *Distance Collaboration:* Where institutions are implementing BIM with two or more other Institutions and creating a collaboration over distance. From Barison and Santos, the three major methods of integration are made clear, however various studies suggest that standalone BIM courses are not as powerful as integrated BIM course and does not promote long-term learning, furthermore due to students only implementing the process for that specific course they do not retain the skill set and feel it difficult to reapply it to other courses (Ghosh et al., 2013, Gier, 2008, Clevenger et al., 2010 as cited in Abdirad and Dossick, 2016, p.258). There issues of collaboration that exist are mainly related to the cross disciplinary aspects of working at a university setting. Although as difficult as the setting may be, many countries and institutions are determined to make it work and learn from the issues that exist or may arise.

According to Mandhar and Mandhar (2013) BIM implementation in curricula in the United Kingdom is driven by the Royal Institute of British Architects, The Government and Architectural Practices to fully prepare graduates for the working world. Similarly, USA, Australia, the Scandinavian Region, Singapore, China, South Korea and Brazil are pushing the same agenda through the various stakeholders (Kolarić *et al.*, 2017). It is clear that with support from all stakeholders, universities will be able to implement BIM faster and better than without the necessary support. Through the review of various literature, it is becoming evident that BIM implementation in university curricular of AEC courses is becoming top priority. The evident problems of mind-set, knowledgeable staff and integration of BIM across courses can be seen as early teething problems and can be resolved through proper approaches. It is evident that the first world countries have been increasing the gap in BIM implementation, however what strategies are being implemented in the BRICS countries to implement BIM in the processes? The next section of this review investigates the implementation of BIM in the BRICS countries to form a background to the level of implementation of BIM in educational institutions.

2.3 The implementation of BIM in BRICS Countries University Curricula

The BRICS countries consist of Brazil, Russia, India, China and South Africa and is an association of the five major developing economies. The BRICS countries show much promise in terms of development and an investigation into the level of adoption of BIM is critically important for this study. This section gives a brief overview of the level each of the BRICS currently implements. Brazil is currently in its infancy with respect to BIM, it still currently has no national frameworks that promote the use of BIM or guidelines for the implementation of BIM in educational institutions (Kassem, 2016). However, The Brazilian Government has sought the services of Mohamad Kassem to assist with the framework and implementation of BIM in Brazil (Cousins, 2014). *R*ussia has learnt from the UK's strategy of BIM implementation from which it used a few projects to gain its footing in the BIM industry, furthermore the Russian Government has implemented frameworks to instil the use of BIM for construction projects (Mills, 2016). In India, The AEC industry is the second largest industry after the Agriculture industry (Amarnath, 2017). BIM is being highly implemented in India, however it is still in its "experimentation" stage and India unfortunately does not have a Framework set up by government for BIM implementation (Ahuja *et al.*, 2016). A well-known fact about China is their front-running in digital technology, consequently the uptake of BIM implementation has been fast paced and software giant Autodesk has set up many programmes in China for the development and implementation of BIM (LITENG and Jun Kim, 2010, p.412). The Chinese government has also implemented BIM for use on big projects, which also reveals the they are moving in the right direction with regards to BIM implementation (O'Neil, 2017). BIM is also being heavily implemented into AEC education in China and new strategies and pedagogies are being applied (Zhang *et al*, 2016). According to Harris (2016) the uptake and implementation of BIM in the AEC industry of South Africa has been very slow. Although many institutions exist and promote BIM, the industry has not taken to the concept as quickly as other countries.

2.4 BIM maturity and Level of Development

To fully understand the BIM process, one must interact with two major concepts in the BIM spectrum, namely: BIM Maturity and Level of Development (LOD). In this section, the concepts are explained to create a knowledge base to be implemented in the empirical study.

BIM Maturity

The BIM Maturity level model was developed by Bew and Richards in 2008 and has become the UK's main component for an implementation strategy (Succar,2015 as cited in Dakhil and Underwood, 2015, p.236). The BIM maturity model has four levels in which maturity is illustrated and judged upon, the following figure graphically represents the maturity levels:

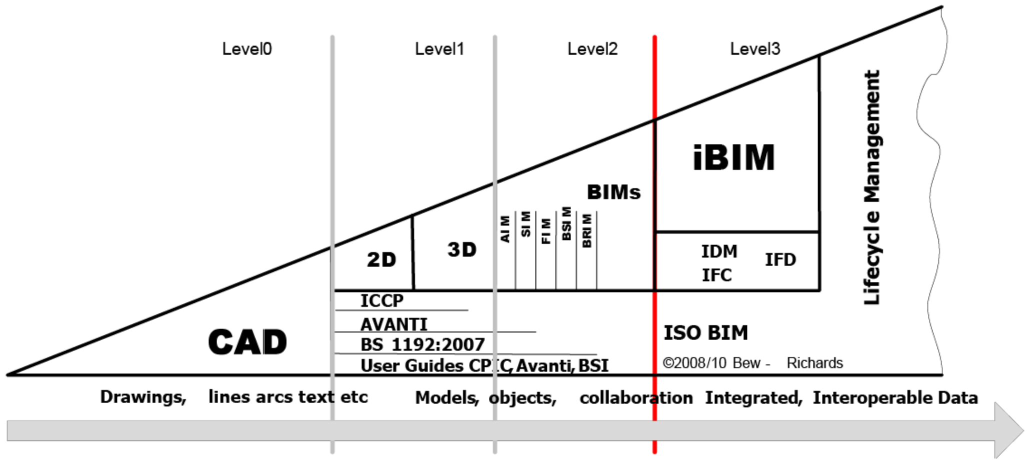

Figure 1: BIM Maturity level model by Bew & Richards (2008) (Source: Succar, 2015)

According to Dakhil and Underwoord (2015, p.236) and Balu (2017) the following is an explanation of the maturity levels:
BIM Level 0: Is termed as an unmanaged CAD system which represents lines and text but not depth of information. It is also termed the digital drawing board.

BIM Level 1: Is termed as a managed 2D and 3D CAD system with standardized formats and structures, furthermore BIM level 1 is considered the "Lonely BIM" as the model is not shared with other team members, the purpose of it is mostly for conceptual work.

BIM Level 2: Is termed as a managed 3D model with other parametric data, but each discipline creates a separate model which will be consolidated into one model but will not lose their integrity or identity.

BIM Level 3: Is termed as a highly managed collaborative project model which is referred to as an integrated model. The model is handled through a collaborative server for use by all team members in real time. BIM level 3 is still in development and has still not attained the goals it has set out.

It is clear from the literature that the BIM maturity levels are an important step for the BIM industry, the BIM maturity level model aims to unify the work processes and describe to its users the stage that they currently fall into and what they would need to accomplish to rise to the next level.

Level of Development (LOD)
Although the BIM Maturity model has a broad perspective of the use of BIM, it also incorporates model based development which is an important concept, to this we refer to Level of Development (LOD). According to Adams (2017) the LOD is the level at which a part of the model, or the model itself has been developed with regards to the information it carries. Adams (2017) defines the LOD below:

LOD 100: The basic Form.
LOD 200: Generic Form, Approximate size, shape and location.
LOD 300: Specific shape, size and location.
LOD 350: Actual model of product including its shape, size and location.
LOD 400: Similar to LOD 350 but including fixing, assembly details and information.

The level of development however does not flow from stage to stage, at times a model will contain other models which are at different LOD's (Alderton, 2017). It is of great importance to understand the LOD concept, especially for students at tertiary institutions using BIM. The critical development of a building that LOD provides actually assists designers to make decisions in a step by step process. This research will further investigate the LOD at built environment schools in South Africa to judge the level at which BIM is being implemented.

3 Research Methodology

This research made use of a mixed method approach of qualitative and quantitative data collection methods from which rich data was extrapolated to reveal significant findings. South Africa has 13 Universities which offer some type of Built Environment course, however the primary data was collected from 9 universities in South Africa due to time constraints. The study focused on the departments that most used the BIM philosophy in their teaching strategies, these departments were the Architecture, Civil Engineering and Construction Project Management programmes.

The study made use of a questionnaire which was both quantitative to gather statistical data and qualitative to determine what the issues were with the implementation of BIM. The questionnaire thus, was structured in its first part as a formal questionnaire to gather statistics and in its second part included open ended questions focused on the department's philosophy on BIM implementation which yielded significant findings.

The questionnaire was sent out to the 13 Universities which offered Built environment courses, the task was significant in the sense that it included research based on the entire countries approach to BIM implementation. From the total of 13 Universities, an envisaged 27 responses were expected, however only 9 Universities responded with a total of 14 responses. As the expected 27 responses were not received, the 14 that were received created significant data for interpretation for the research. It must be noted that the research only focused on faculty staff and not students for the research.

Since statistical significance was not a requirement for this study, output from the analysis of the data was more qualitative with the quantitative output being frequencies of occurrence or presence of evidence of implementation of BIM.

4 Findings and Discussion

The findings for this research will begin with the statistical data collected to frame the context in which the South African Schools of the built environment implement BIM. The questions were grouped and a bar chart implemented for interpretation. The discussion will then lead onto the qualitative questionnaires which will explain the issues surrounding implementation of BIM at South African built environment schools. The following sections give an insight into the various findings of the research.

4.1 Academic Institutions and Departments included in the study

The first approach to the research was to quantify the data sets according to the Academic Institution and Department the research was conducted in. The following bar graph gives insight to this statistical data:

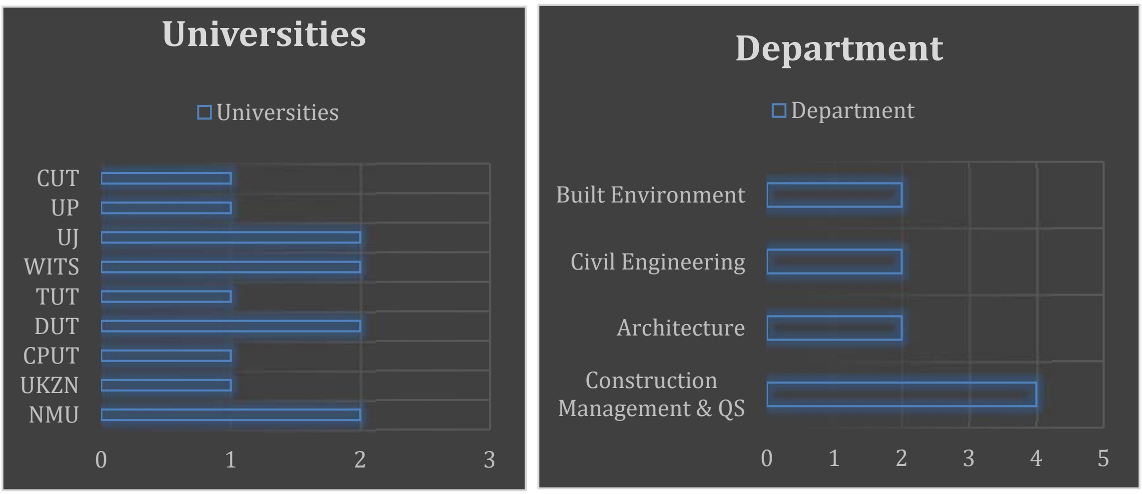

Figure 2: Number of Universities included in the study and Departments

From the data presented, 9 Universities participated in the study, from the 9 Universities four major departments namely the Built Environment, Civil Engineering, Architecture and Construction Management & Quantity surveying faculties responded to the questionnaire. The next data set gives an indication of how BIM is implemented into the syllabus.

4.2 BIM Implementation

The second part of the study directed questions towards the actual implementation of BIM within the departments or courses, furthermore questions were asked about the department's intentions to introduce BIM, the specialist staff that were employed to teach BIM and the current undertaking of BIM research within the department. The following graph gives insight into the levels of implementation of the various questions that were put forward to faculty staff:

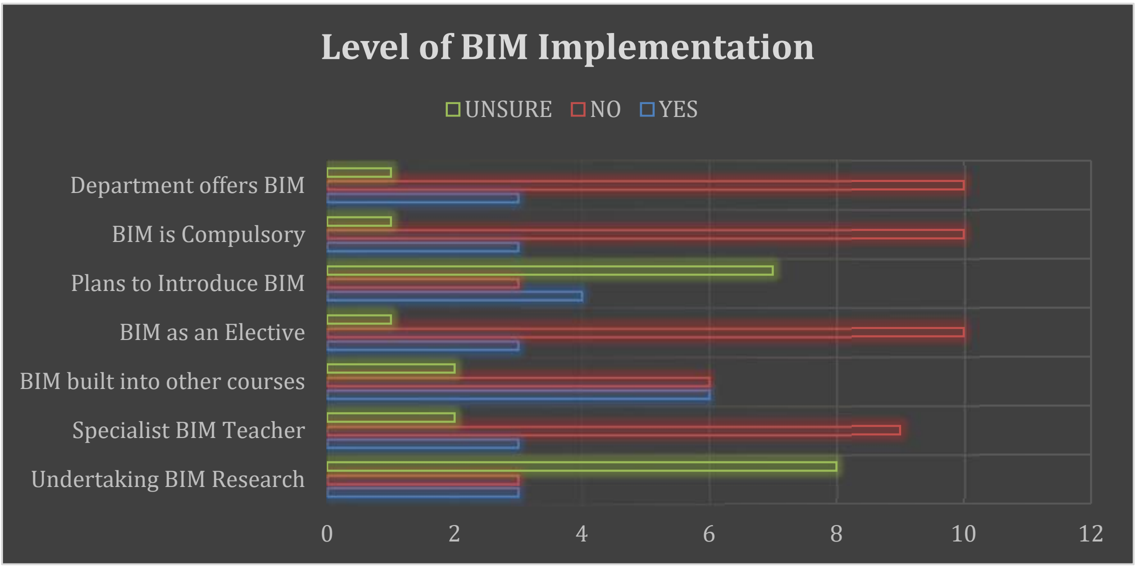

Figure 3: Statistical Data representing the implementation of BIM at Universities in South Africa.

From the data presented in figure 3, the researchers started the discussion of BIM offering in the department and if it was a compulsory requirement. According to the data presented, 10 respondents noted that departments they teach at, don't offer a BIM course per se, however 3 respondents noted that the department does offer some sort of BIM course and 1 respondent noted that they were unsure if the department indeed offered a BIM course. Similarly, respondents answered to the question of BIM being compulsory in the exact same fashion. At this point, the researchers noted that the faculties of the Built environment were not necessarily implementing BIM as a philosophy to strengthen their exit outcome, however it is noted also a small amount of implementation is taking place formally. When asked about the department's plans to introduce BIM into their courses, 3 respondents noted that they have not discussed strategies to implement BIM, 4 respondents noted that they have had discussions for BIM implementation and 7 respondents were unsure if BIM was to be implemented in future. The results of this specific question are worrying in the sense of an implementation strategy. If the current approach continues, South Africa will remain behind both in the BRICS consortium and the world at large with regards to the BIM philosophy.

The researchers further went on to specifically question the courses which included BIM and those that had a blended BIM implementation. It was discovered that 10 of the respondents answered with a "NO" to BIM being an elective course, 3 as "YES" to BIM being an elective and 1 respondent was unsure if a specific BIM module existed. When asked about blended BIM into courses, 6 respondents replied to having implemented BIM with a blended approach, 6 respondents noted that there was no blended learning and 2 respondents replied as unsure. The data presented here again is a cause for concern as it directly indicates the lack of implementation of a BIM course or blended learning. As compare to the other BRICS countries, South Africa is still lagging behind the pack in terms of BIM implementation at higher learning institutions.

As a closing on implementation of BIM at the faculties, the researchers posed two very important questions to the respondents, firstly the respondents were asked if a trained BIM expert was indeed teaching the BIM philosophy to students. A total of 9 respondents indicated that a BIM expert was not presently teaching at the department, 3 of the respondents noted that they did have a BIM expert teaching their BIM course and 2 respondents were unsure if there was a BIM expert presently teaching the BIM philosophy to students. The response to these questions brings forward critical data forward in terms of implementation. From the respondents we can clearly observe a lack of skills that are available for the teaching of BIM. In the critical years of a Built Environment Professional, it is critical that these skills be developed and passed on by a knowledgeable educator.

To close the discussion on BIM implementation, the researchers felt it necessary to question the current faculty's research into the academic arena of BIM. From the results 3 respondents noted that they are currently involved in BIM research, 3 respondents replied to not be actively researching in the BIM body of Knowledge and 8 respondents were unsure if they themselves were interested in BIM research or the other members of the departments were actively researching on BIM related topics. This part of the research question is worrying to the academic world in South Africa in terms of BIM research. It is clear that BIM is not being actively studied as compared to other topics in the various fields. At present, even with literature, little to no research is being conducted academically within the BIM spectrum in South Africa.

From the data gathered, significant deductions can be gathered about the state of BIM implementation at Higher Learning Institutions in South Africa, these conclusions will be further discussed at the conclusion section of this research. In the next section the researchers aimed at investigating which year of study BIM is being implemented and at what level of development (LOD) is being implemented.

4.3 Year level of BIM implementation

The researchers decided that it would be beneficial to the research if they knew the year levels in which BIM was implemented to complete the holistic picture of discovering what the implementation levels of BIM were in the higher learning institutions in South Africa. The following graph illustrates the years in which BIM is introduced and the level of competency students have and the end of the course.

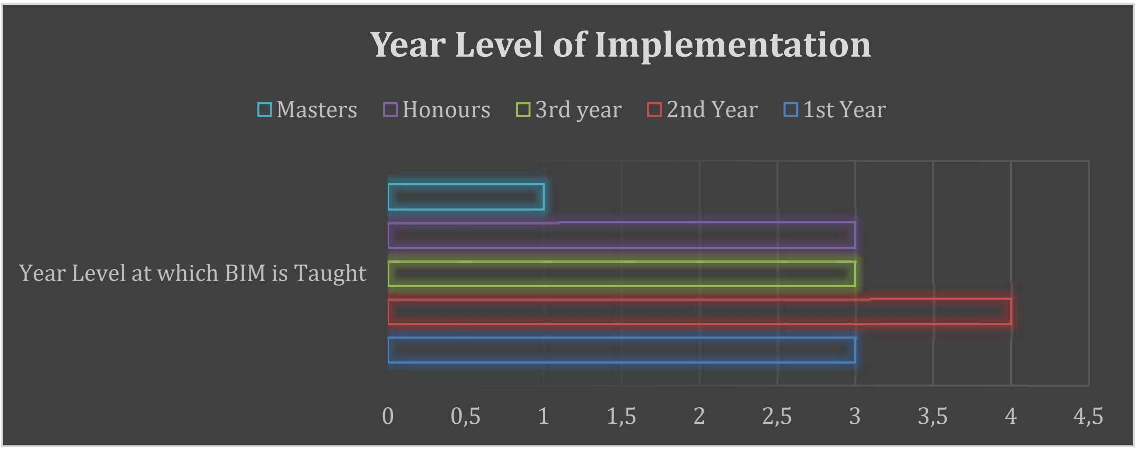

Figure 4: Year Level of Implementation of BIM at Built Environment Schools in South Africa

The data presented in figure 4 is representative of the different years in which BIM is implemented. It must be noted that there are overlaps in faculties that implement the courses many times over the course of study. However, the research points towards the second year of study being the crucial year in which BIM is being implemented. This data is significant as it now paints a picture of exactly when in a student will get to grips with the BIM philosophy. The respondents also noted that in the first year of study, fundamentals are taught to students to prepare them for the second year of advancing their studies in BIM. The third and fourth years were noted to be an advancement of the skill learnt in second year and the masters year of study, was only being implemented at one institution, that being the architecture course at the Tshwane University of Technology (TUT). It must be further noted that not all institutions offer advance BIM techniques due to the lack of supporting staff and the workload of the actual core course takes precedent.

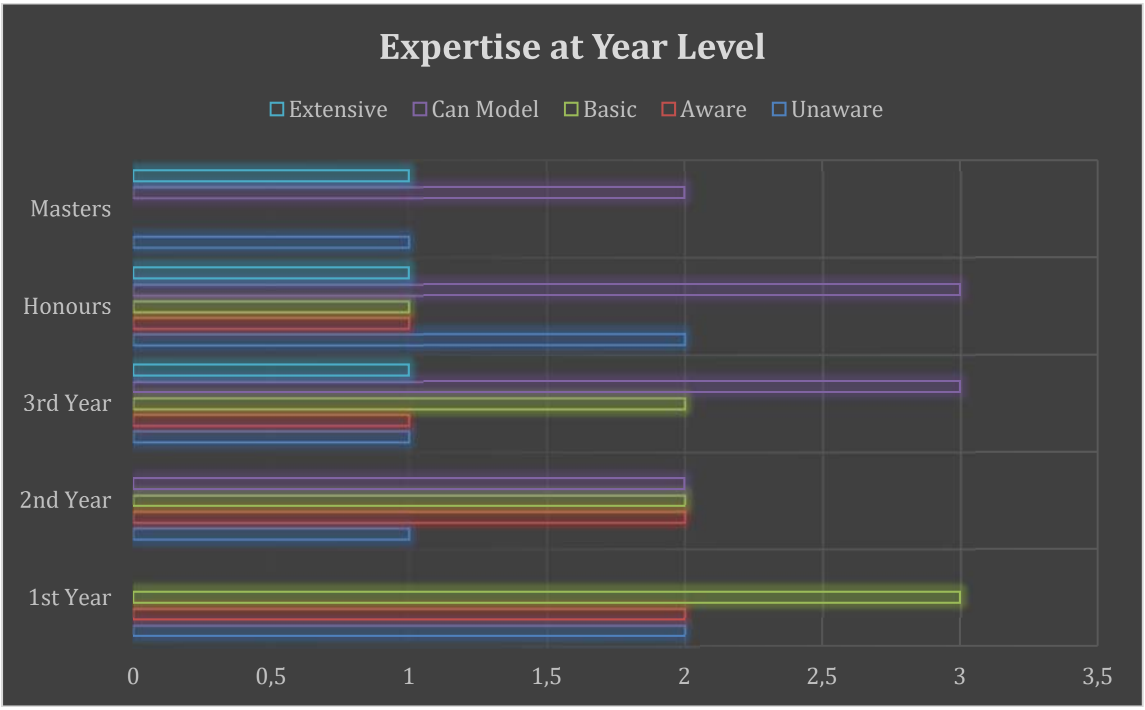

Figure 5: Expertise in use of BIM at the difference year levels

One other factor that is important to note is the expertise level of students that are introduced to and taught BIM at Higher Learning Institutions. It is noted that on average, students have a basic understanding of BIM in their first year, although not a large number, but a significant number to deduce such. Through the survey, it has been discovered that student's skills and abilities in 3D modelling pick up pace at the second year of study and their skills become extensive as they move up to higher years.

4.4 Level of Development

The Level of Development (LOD) is an important part of the BIM Philosophy and it vital that it is implemented at Schools of the Built Environment so that the idea of staging becomes apparent to students early of in their development of both BIM and Projects skills. The researchers implemented a small survey to identify if faculties were indeed teaching with the LOD's. The graph below illustrates the findings of this study:

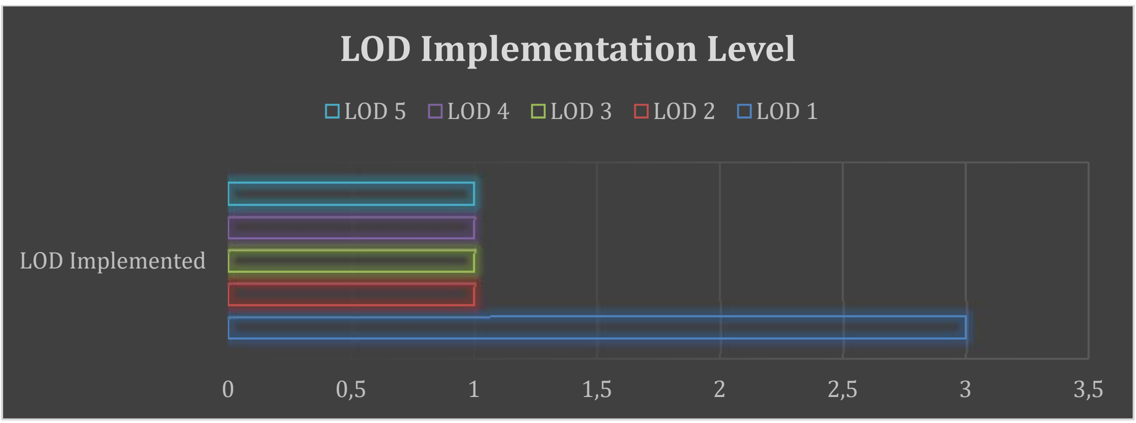

Figure 6: Implementation of LOD's

With reference to the above graph, it is evident that Higher Learning Institutions are heavily implementing the LOD 1 system. It is a good sign that some effort is made to implement LOD's however working only in a basic LOD is worrying at an exit level. Only one institution, TUT, has implemented the LOD system all through to LOD 5. The response from most institutions were none, partly because the lecturers did not understand the LOD system or felt that it was not important to implement it. Due to the lack of results from this particular survey, a holistic view cannot be truly formed on the implementation of the LOD system and could be researched further at Built Environment Faculties in South Africa.

4.5 Philosophy relating to the implementation of BIM

The final question posed to the respondents was an open-ended question. Respondents were asked what was the Departments Philosophy on BIM implementation? The responses made for an interesting set of data. 20% of all the academics interviewed responded in the negative, giving an account of them being unaware of any philosophy being put forward for the implementation of BIM. Furthermore, one respondent stated: "*In academic circles in South Africa, BIM is a very new concept. The BIM implementation has not been thoroughly discussed in our department. The university body might have discussed it but I am not aware of that. Furthermore, I have not read any philosophy in relation to BIM either in the university, faculty or department"*. It is necessary to unwrap this particular response as it doesn't come as something new, not only at South African Universities, but internationally as well. BIM in academia is fairly new, thus the issue surrounding its implementation is also challenging.

The second major discussion point, which was also noted in the statistical research, is the ability of the lecturers and their expertise to teach with a BIM Philosophy. The issue of BIM skills has become contentious amongst academics in the Built Environment schools, partly because they were trained to be an architect, a civil engineer or a project manager, not a BIM expert. One response was: *"We are geared to the implementation of BIM. However, fellow lecturers need training themselves in order to understand the full potential of BIM"*. It is evident that lecturers are embracing the new, however, the issue of being trained is a big one.

All the respondents interviewed, responded positively to why a BIM Philosophy should be implemented. It is noted in many instances, that the respondents believed that BIM technology is time saving and cost effective and should be implemented, however many respondents subjugated BIM as a "TOOL" and not the main focus of the course. One respondent shared his account: "*BIM skills are necessary for the employability of or graduates. We do not find much pedagogical value in teaching BIM but consider it a necessary component of their education"*. It is understandable why the academics believe strongly as BIM being a tool and not the core focus of the course of study.

The fourth major discussion points amongst all respondents was the issue of employability. All the academics interviewed were confident that students with a high level of skill in BIM, were more employable. The issue of employability is also a contentious one, students are somewhat prepared as they leave universities as graduates however is the skills sufficient to "hit the road, running"? According to the quantitative data collected for this research, it is evident that students are not fully prepared in terms of being BIM proficient.

5 Conclusion and Further Research

The study set out to establish at what level BIM was being implemented at Higher Institutions of learning in South Africa. Further, the study set out to determine the level of development that universities are able to reach in BIM teaching. It is crucial to understand that through this research it was discovered that the implementation of BIM at the institutions are incredibly low, most of the time a lack of knowledge of basic BIM concepts was not understood by the participants. It is also noted that a BIM philosophy was not discussed in detail at the various universities, partially because BIM has not been implemented at a governmental level as yet.

The implementation of the Level of Development (LOD) framework is also a major concern, through the research it has been discovered that a very large percentage of built environment faculties only apply the LOD Framework at level 1. By the application of BIM at such a basic level, students are not as well prepared for the working world as it has been imagined. The researchers find it incumbent that the government start with a BIM strategy for the country which must trickle down into the university syllabi. Although BIM is not implemented at a national level, the universities could make concerted efforts to uplift BIM skills of their graduates.

The most important takeaway problem from this research is the skills training for existing lecturers, time and time again research points back to lack of training of staff. It is recommended that faculties of the built environment professions cross pollinate ideas amongst themselves in order to form a BIM implementation strategy to produce graduates that posses a high level of skill in BIM.

Further research must delve into the detailed issues and challenges of BIM implementation and the causation of such slow progress. One of the other burning issues with the BIM philosophy is the integration with the core subjects of the course, further research into the challenges facing integration is vital to understand the complex nature of BIM incorporation into the syllabi.

6 Acknowledgement

Chioma Okoro for capturing the data and analysis.
All participants of this study.

7 References

Abdirad, H. and Dossick, C. S. (2016a) ‘BIM curriculum design in architecture, engineering, and construction education: A systematic review’, *Journal of Information Technology in Construction*, 21.

Abdirad, H. and Dossick, C. S. (2016b) ‘BIM curriculum design in architecture, engineering, and construction education: A systematic review’, *Journal of Information Technology in Construction*.

Adams, B. (2017) *LOD (Levels of Develompent) Explained*, *Redstack*. Available at: https://redstack.com.au/support/blog_posts/lod--levels-of-develompent--explained (Accessed: 13 June 2018).

Ahuja, R. *et al.* (2016) ‘Adoption of BIM by architectural firms in India: technology–organization–environment perspective’, *Architectural Engineering and Design Management*, 12(4). doi: 10.1080/17452007.2016.1186589.

Alderton, M. (2017) *How Level of Development Brings a New Standard of Excellence to AEC*, *Redshift by Autodesk*. Available at: https://www.autodesk.com/redshift/level-of-development/ (Accessed: 13 June 2018).

Amarnath, C. (2017) *BIM implementation in India*, *BIMCommunity*. Available at: https://www.bimcommunity.com/news/load/467/bim-implementation-in-india (Accessed: 10 June 2018).

Azhar, S. (2011) ‘Modeling (BIM): Trends, Benefits, Risks, and Challenges for the AEC Industry’, *Leadership and Management in Engineering*, 11(3), pp. 241–252.

Balu, V. (2017) *BIM Maturity Level*, *The BIM Hub*. Available at: https://thebimhub.com/2017/07/14/bim-maturity-level/#.WyDtw6czaUk (Accessed: 13 June 2018).

Barison, M. B. and Santos, E. T. (2010) ‘BIM teaching strategies: an overview of the current approaches’, in *Proceedings of the International Conference on Computing in Civil and Building Engineering (ICCCBE) 2010*.

Berwald, S. (2008) ‘From CAD to BIM: The Experience of Architectural Education with Building Information Modeling’, in *AEI 2008: Building Integration Solutions*. doi: 10.1061/41002(328)8.

Boeykens, S. *et al.* (2013) 'Experiencing BIM Collaboration in Education', in *Computation and Performance – Proceedings of the 31st eCAADe Conference (Vol. 2)*.
Chegu Badrinath, A., Chang, Y. T. and Hsieh, S. H. (2016) 'A review of tertiary BIM education for advanced engineering communication with visualization', *Visualization in Engineering*, 4(9). doi: 10.1186/s40327-016-0038-6.
Cousins, S. (2014) *Brazil turns to Teesside University academic to draft BIM policy | BIM+, Website of the Chartered Institute of Building*. Available at: http://www.bimplus.co.uk/news/brazil-turns-uk-academic-draft-bim-policy/ (Accessed: 10 June 2018).
Dakhil, A. and Underwoord, J. (2015) 'BIM Client Maturity: Literature Review', in *12th International Postgraduate Conference 2015*.
Eastman, C. *et al.* (2011) *BIM Handbook A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers, and Contractors*. 2nd edn. Hoboken, New Jersey: John Wiley and Sons.
Gordon, V. . and Holness, P. . (2006) 'Building Information Modeling', *ASHRAE Journal*, 48(8), pp. 20–24. doi: 10.1002/9780470432846.
Goubau, T. (2012) *A History of BIM - APROPLAN*, *A History of BIM*. Available at: https://www.aproplan.com/blog/construction-collaboration/a-history-of-bim (Accessed: 5 June 2018).
Harris, V. (2016) *South African BIM Survey Report*. Cape Town.
HM Government (2012) 'Building Information Modelling', *Industrial Strategy: Governement and Idustry in partnership*, Vol.1, pp. 1–22. doi: 10.1016/j.aei.2007.03.001.
Ibrahim, M. (2006) 'To BIM or not to BIM, This is NOT the Question: How to Implement BIM Solutions in Large Design Firm Environments', in *eCAADe 2006*. Volos, Greece: University of Thessaly.
Kassem, M. (2016) *Strategy for the diffusion of BIM in Brazil*. New Castle.
Kensek, K. and Noble, D. (2014) *Building Information Modelling- BIM in current and future practice.* 1st edn. Hoboken, New Jersey: John Wiley and Sons.
Kolarić, S. *et al.* (2017) 'Assesing Educational approaches to Building Information Modeling (BIM) at Construction Management Master studies in Croatia.', *Tehnički vjesnik*, 24(4).
LITENG and Jun Kim, J. (2010) 'BIM IN CHINA', in *International Conference on Sustainable Building Asia*.
Mandhar, M. M. and Mandhar, M. M. (2013) 'BIMing the Architectural Curricula – Integrating Building Information Modelling (BIM) in Architectural Education', *International Journal of Architecture*. doi: 10.1017/CBO9781107415324.004.
Mills, F. (2016) *BIM in Russia*, *theb1m*. Available at: https://www.theb1m.com/video/bim-in-russia (Accessed: 10 June 2018).
O'Neil, D. (2017) *BIM Around The World Series: Paul Doherty on BIM in China | BIMIreland.ie | Ireland's Only Dedicated BIM Exclusive Resource*, *BIMIreland.ie*. Available at: http://www.bimireland.ie/2017/05/16/bim-around-the-world-series-paul-doherty-on-bim-in-china/ (Accessed: 11 June 2018).
Quirk, V. and Bergin, M. (2017) *A Brief History of BIM*. ArchDaily. Available at: https://www.archdaily.com/302490/a-brief-history-of-bim (Accessed: 7 June 2018).
Sacks, R. and Barak, R. (2010) 'Teaching Building Information Modeling as an Integral Part of Freshman Year Civil Engineering Education', *Journal of Professional Issues in Engineering Education and Practice*, 136(1). doi: 10.1061/(ASCE)EI.1943-5541.0000003.
Shelbourn, M. *et al.* (2017) 'Students' perceptions of BIM education in the higher education sector: A UK and US perspective', *Industry and Higher Education*, 31(5).
Succar, B. (2015) *BIM ThinkSpace: BIM Maturity*, *BIM Think Space*. Available at: http://www.bimthinkspace.com/bim-maturity/ (Accessed: 13 June 2018).
WorldBuild365 (2016) *BIM in Russia: young, but promising*, *WorldBuild365*. Available at: https://www.worldbuild365.com/news/umsqrufac/building-architecture/bim-in-russia-young-but-promising (Accessed: 10 June 2018).
Zhang, J., Schmidt, K. and Li, H. (2016) 'BIM and sustainability education: Incorporating instructional needs into curriculum planning in CEM programs accredited by ACCE', *Sustainability (Switzerland)*, 525(8). doi: 10.3390/su8060525.