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Discovering the level of BIM Implementation at South African Architecture Schools: A qualitative study.

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Abstract

It is a well-known fact the architecture industry is at the forefront of implementing and using Building Information Modelling (BIM) to conceptualize, develop, resolve and execute buildings. Although it may seem like a new concept, BIM had its foundations set in the 1980's with the disruption being 3D CAD. BIM has significantly been revolutionized beyond the likes of 3D CAD to become a complex system of information. Currently, BIM is still revolutionizing how architects design buildings by intelligently documenting buildings, realistic visualization, error reduction and 3D resolution of construction detailing. However, when and where is BIM implemented to allow architects to maneuver in the complex web of BIM? In recent times, BIM has become a household phrase amongst architecture schools around the world. BIM is fundamentally important in the architectural design and construction courses as it allows students to explore their designs and resolve problems surrounding the resolution of designs, construction of buildings, materiality etc. BIM is a complex system of information and is an ever-changing philosophy that has changed how buildings are conceptualized and executed. As BIM revolutionizes the architecture industry, it is important to grasp the level of implementation and methods of executing the teaching pedagogies in teaching BIM. From various research conducted, it is evident that the architecture industry is at the forefront of BIM implementation, however is this the case at the various schools of architecture? This research focuses on the levels of implementation of BIM at schools of architecture in South Africa. The research makes use of a mixed method approach of both primary and secondary data. The primary method of data collection was executed using a qualitative interview-based approach to unravel the various opportunities and challenges faced at architecture schools in teaching and disseminating BIM knowledge in South Africa. The interview schedule was based on various questions including the current state of implementation, equipment, lecturer's knowledge and importance of an integrated BIM philosophy in courses. The secondary data for this research was collected through an intense literature review that sought to discover the implementation of BIM throughout the world and the opportunities and challenges experienced by other international schools of architecture. Preliminary findings reveal that there is some usage of 2D, and 3D CAD being implemented, however little implementation of BIM methods, processes and pedagogies have been recorded, which prompted the need for research in this key area. This research will be useful to Universities which are currently implementing BIM, the BIM research community, Industry and other stakeholders which wish to contribute to the body of knowledge of Building Information Modelling.

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1. Introduction

The introduction of Building Information Modelling into the construction industry has completely revolutionized how Architecture, Engineering and Construction (AEC) professionals carry out their daily tasks. BIM has become a key driver allowing consultants to conceptualize, correct errors, document, estimate and execute projects at a faster rate with better accuracy. Globally, BIM has caught on to all the construction courses more especially the Architecture

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fraternity. The reason for this quick uptake is obvious with the likes of a conceptual design being the opening of a project. Although BIM is a relatively new concept, it has been rapidly introduced into the architectural office. Candidates entering the industry are expected to have a high level of skill with BIM protocols, with that in mind it has been noted that Architectural firms are inclined to hire a candidate with excellent BIM skills more than candidates with great design/construction skills. It then becomes obvious that architectural firms want candidates to produce work from day one. With this disruption, it leads to a key question; where are architectural professionals getting their training from and how effective is it?

With the rapid uptake of BIM in the Architectural Industry, Academic institutions have reacted by implementing the dissemination of BIM knowledge to their students by introducing courses and integration of a BIM component within the design syllabus. It has also been noted that Universities have implemented dedicated BIM labs as part of their infrastructural needs and have hired staff to teach BIM courses. An initial glance at the syllabus of most Universities indicated BIM is being taught at an introductory level and not as a gradual advancement through the years, this becomes problematic as students are equipped with basic skills only. Following on from the syllabus integration, an aspect that has troubled many architecture schools is the hindering of creativity in design due to BIM and understanding of construction detailing with use of BIM. These two key areas form a major part of all architectural syllabi's and it is important to understand the approach towards an integrated BIM philosophy in teaching architecture.

This research intends to discover the level of BIM implementation at Schools of Architecture in South Africa by investigating BIM usage from the perspective of the teachers and students. The research further investigates the pros and cons of BIM in both the design and construction detailing studios. Initial literature reveals that this is an under-researched area and the information produced by this research will be critical to not only understand the usage of BIM at Architectural Schools in South Africa but also to determine what issues are pertinent in disseminating BIM knowledge.

2. Literature Review

In this section the authors examine multiple sources of literature to create a framework to understand the world issues of BIM implementation at schools of architecture. The literature review will be synthesized with the findings of this study and cumulate in recommendations going forward.

2.1. What is Building Information Modelling?

Building Information Modelling (BIM) had its infancy based in the early 1960's with the introduction of 2D CAD and the digital drawing board was born [12]. The digital drawing sector was disrupted even further by the introduction of 3D CAD in the early 1980's and became the successor to 2D CAD [19]. BIM became a workflow to capture rich information such as size, information, geometry, materials etc. whereas AutoCAD only had simple line data [13].

BIM culminates information into a complex 3D model or composite model which allows consultants, contractors and fabricators the opportunity to collaborate within a single database with various data sets for mutual benefit [4]. Similarly, Eastman et al [10] states; BIM fosters a re-think of how the construction industry consultants think and execute buildings in many senses, i.e.; Analysis of various concepts early in the design stage, Analysis of the BIM Model in terms of structure, energy, planning, cost implications, Team collaboration both within the discipline and cross discipline, construction detailing and execution on site, fabrication of various building components and facility management. Sabongi [18] goes on further to elucidate that due to an information- rich data base which is parametric in nature, all aspects of a building can be characterized, analyzed and executed. Azhar [6] states that even though a BIM model is rich in data, it must be accurately constructed digitally for it to hold important information for physical construction. It is of vital importance to understand that BIM is not only a modelling software for visualization but a model that holds deep information of an entire project across disciplines, however are architects implementing the strategies of a BIM system to its full potential on their projects? If so, how are they doing it? In the next section the authors investigate using literature to understand how architects are implementing BIM at their practices.

2.2. *BIM education in Architecture Schools*

In this section the authors investigate various topics including but not limited to; BIM adoption into curricular, Barriers in BIM education. The idea of researching other authors work globally forms a powerful form of analysis as to the approaches used in South Africa.

2.2.1 *BIM adoption into curricular:*

Over the past decade, BIM has been significantly implemented into schools of Architecture and Construction [6]. Focusing on earlier research, academics dwelled on the transition from 2D CAD to BIM [e.g 7,9,16]. However, recent studies dwell more on the actual use of BIM within the classroom at schools of architecture and construction [e.g. 2,5,14]. It is vital to understand how BIM is being implemented in curricular worldwide to determine the trend and methods of implementation. Pillay et al [17] conducted a study in South Africa on BIM use at South African construction schools and determined that very low levels BIM of implementation in the curriculum occurred, furthermore, lack of understanding of concepts became popular on the agenda. Similarly, Ahn et al [5] reports that students in Asia are more inclined to CAD use and most of the students have not experienced BIM technology.

Although various pedagogical approaches have surfaced in the implementation of BIM in university curricular, which methods are most sustainable? Ghosh et al [11] proposed a vertical systematic approach to implementation of BIM, through various years of study from basic to advance. Clevenger *et al* [8] suggests three methods; a stand-alone module, integrated BIM modules into current courses to develop BIM thinking and a combination of the two methods. The authors agree that all methods are noteworthy and can be implemented, however it is important to understand the barriers in BIM implementation.

2.2.2 *Barriers in BIM education:*

Like all pedagogical endeavors, BIM is subject to barriers that prohibit information dissemination. In this section the authors study the various sources of literature to determine some of the barriers facing BIM adoption and implementation at educational institutions. Some of the most common barriers facing BIM adoption into the curricular are Mindset in the process, Lecturers knowledge and training, complexity of software, equipment, time, lack of support from faculty etc. [8,11,1,3,17]. The issues facing BIM adoption in curricular are glaring and strategies to overcome them must be put into place. From various literature, a common thread is seen in implementation. Although various pedagogical issues arise, universities through the help of practice must ensure a smooth transition into acceptance and execution.

3. **Research Methods**

This research aims to discover the use of BIM at South African Schools of Architecture, in order to realize the research, question the authors propose the following method:

3.1 *Task 1: Review of Literature*

In this task, the authors conduct an extensive and critical review of literature of; BIM definition and BIM education in architecture schools.

3.2 *Task 2: Research Methods*

In this task, the authors opted for both a quantitative questionnaire and an interview-based approach of gathering data and understanding the current implementation of BIM. The research consisted of two groups of interviewees, namely students and lecturers.

The initial study sort to investigate responses from the 10 schools of architecture in South Africa, however due to time constraints not all schools participated in the study. Only 5 schools participated in the study. The schools that participated in the study yielded significant results to understand the BIM use climate in South Africa. The schools

that participated in this study included: University of the Witwatersrand, University of Johannesburg, University of Pretoria, University of Kwa-Zulu Natal, and Nelson Mandela University. These schools offer a comprehensive program in architecture and are well suited for this research.

3.2 Task 2: Analysis of Data and Reliability

Data was collected from 5 schools of architecture over a period of 3 weeks. The Universities responded to a google form, telephonic interviews and a written statement of their feelings toward BIM implementation at their schools. From the various questionnaires sent to students and lecturers, the feedback from students resulted in 24 responses and 11 responses from lecturers respectively. The questionnaire comprised various methods of collecting data from checkboxes, linear scales to qualitative interview questions. Data was then examined using graphs. The reliability of data collected was based on a consistent questionnaire compared to interviews. Similar feedback from respondents suggest that the instrument is reliable, and data is true. The section of Findings and Discussion will explain the findings in thorough detail.

4. Findings and Discussion

In this section, the authors investigate a few aspects as described in the research methods, the first few questions are statistical data from interviewees after which the authors delve into the more pressing issues of BIM implementation and use at architecture schools in South Africa.

4.1. Which school do you study or teach at?

In this section, we discuss the statistical profile demographic of the respondents. The data from the questionnaires is significant in terms of understanding who the participants of the study are. It was noted from the responses that students from the University of Witwatersrand (WITS), Tshwane University of Technology (TUT), University of Free state (UFS), Durban University of Technology (DUT), Cape Peninsula University of Technology (CPUT), University of Cape Town (UCT) did not respond to the survey. Students that formed a major part of the study hailed from the University of Kwa-Zulu Natal (UKZN) at 29%, University of Pretoria (UP) at 33%, Nelson Mandela University (NMU) at 25% and University of Johannesburg (UJ) at 13%. Lecturers from the TUT, DUT, UFS, UCT and CPUT did not participate in the study. The UJ turned out to be the highest number of respondents at 55%, UKZN at 18%, UP, WITS and NMU at 9%. The significant number of both lecturers and students give the authors enough data to understand were the crucial issues of BIM implementation lay.

Fig. 1. (a) Students response; (b) Lecturers response.

4.2. Which year level do you study BIM at/ teach BIM at?

Although the questionnaire was sent out to various student year levels, only respondents in postgraduate levels responded to the it. It will be difficult to determine what the lower year levels require or are concerned about. However, the postgraduate students did respond in the interview and suggested how BIM should be taught holistically from the first year. 63% of respondents are in their final year of study (5th Year, Masters) and 37% of Students are in their 4th year of study (Masters). The lecturers on the other hand, revealed their various years of teaching BIM. Significant results prevailed from this demographic. 27% of participants answered in the negative to teaching BIM, however 18%

of respondents taught at 5th year level, 18% of participants taught at 4th year level, 19% of participants taught at 3rd year level, 9% of participants taught at both 1st and 2nd year levels respectively. This data reveals that there is a heavier emphasis of BIM education as the year level increases. There could be various reasons for this such as complexity of design work, workload, exit level outcome etc.

Fig. 2. (a) Students year level; (b) Lecturers year teaching level.

4.3. Do you currently make use of BIM?

When questioned about their current usage of BIM, students responded in the positive with 83% of the results being YES, 17% of students were unsure if they indeed used BIM. This result shows a significant use of BIM taking into consideration the year level i.e. Masters. Other students were unsure if they used BIM to its full magnitude, i.e. modelling, parametric information, analysis etc. The lecturers on the other hand showed significant responses both in the positive and negative, Lecturers answered YES to using BIM with 43% and 45% responded NO, 9% of the participants were unsure if they indeed used or make use of BIM technologies. It is important to note that half the demographic does not make use of BIM. This is indeed troublesome as it shows root cause of faculty staff which have not been trained with the likes of BIM.

Fig. 3. (a) Students use of BIM; (b) Lecturers use of BIM.

4.4. Does your institution offer a BIM Module?

The authors probed the area of BIM module offerings. These results are by far the most troublesome. Students responded YES with 54% saying that their institution does offer a BIM module, 38% of students reported that their institution did not offer a BIM module, 8% were unsure. From the lecturers, a similar response was noted. 46% of lecturers reported that there was a BIM module in place. 36% of Lecturers reported that no BIM module existed at their department. 18% of respondents reported that they were unsure if a BIM module was available.

Fig. 4. (a) BIM Module - Students; (b) BIM Module - Lecturers.

4.5. In your opinion, Does the BIM process assist in understanding Design?

The process of understanding a design is a difficult one. The various parts and parameters of a building is complex, even on small projects. The authors sort to understand the opinions of both students and lecturers in this regard. A linear scale method of questioning was used, where 1 being strongly disagree and 5 being strongly agree. Referring to the provided graphs, the students tended to agree that BIM assists them in understanding their designs better, this is a significant finding as it leads to determining if BIM is truly helpful in design work. On the other hand, lecturers tended to disagree that BIM assisted in understanding design. This has been a popular opinion of Architecture academics throughout the world, it must be understood while the technology has not penetrated the older generation and possibly therefore, the lecturers are not fully aware of the capability of the software.

Fig. 5. (a) BIM process in design-Students; (b) BIM process in design - Lecturers.

4.6. In your opinion, does BIM hinder creativity when designing?

In all architecture schools, the process of creativity is not a rigid one, various theories and pedagogies exist in this space, however a common belief amongst academics is the BIM hinders creativity. The authors posed the question to both students and academics and the results are on either ends of the table. The results of this question revealed that students were almost neutral to the belief that BIM hindered their creativity when designing, however results leaned more towards agreeing that it hindered their creativity. This sets of results indicates that different students have different beliefs when it comes to creativity. The lecturers on the other end leaned toward strongly disagreeing, these results are interesting as it challenges the common belief from academics that BIM hinders creativity. The question posed to both students and lecturers is a very important one as the idea of using a BIM system to design a building is usually a challenge.

Fig. 6. (a) Creativity using BIM-Students; (b) Creativity using BIM – Lecturers.

4.7 What could be improved so that you may better **learn / teach** BIM in the implementation of your design and construction courses?

In this question, the authors asked as an open-ended question to both students and lecturers. The question sort to discover what was lacking in the implementation of BIM at the various institutions. The results obtained from the interview questions help understand the issues both from the lecturers and students. This will be analysed separately.

4.7.1 Students Answers

Below are some responses from students:

“Teaching us the software earlier”

“BIM is very powerful and needs to be thought intensively from first year”

“Learn the software while engaging in studies at University”

“A more intensive module that is incremental throughout all years”

“The use of BIM will only actually be successful if you use more than one package and link the drawings together e.g. Revit and Dynamo. I also believe BIM was strictly designed for exchanging of information between different professionals by using something like Autodesk A360. As a student we won't ever be exposed to this except if it's a significant group project perhaps and all the students have access to a proper internet connection. I think South African's currently do not have the technical knowledge to implement BIM successfully”

“Students should be taught to use BIM as a tool when designing... it goes hand-in-hand with sketching and conceptualizing (a constant balanced process)”

“Better lectures to learn to use the technology properly so it doesn't hinder your design possibilities”

“Consider alternatives to the usual process any student goes through after a brief, in most cases its design focused and construction (tech) is the last thing on your mind, perhaps by altering the brief to reward technical prowess we can encourage design that is rooted in reality and becomes more unique as a result of this process”

Analysing the comments from students, some glaring issues are revealed. Issues pertaining to being taught the software earlier on in the academic programme seems to be a lingering issue, both in South Africa and the world over. This is a common theme and should be investigated carefully to allow for students to learn software earlier on in their course. The issues of teaching BIM as an exchange of information is also a critical issue, BIM is usually taught as a standalone package that is geared specifically towards modelling of a building. This must be investigated further and allow for an exchange, even with other disciplines in an academic setting. An issue that is very prominent with students is the issue of design and BIM, students prefer BIM as a tool when designing, to resolve problems as and when they occur. An integrated course geared to real world issues is also another issue, students finishing their courses must be prepared to take on the challenges faced in the practice. The issue of faculty staff being trained well to teach BIM is an ongoing issue, in this study and many others; lack of trained staff is one the major issues universities around the world face.

4.7.2 Lecturers Answers

Below are some responses from lecturers:

“better learning and interaction spaces”

“The availability of text books and concepts”

“More time is needed to teach the principles and use.”

“attempt to get students on top of the software as quickly as possible so that they can control it rather than it controlling them”

“Integrated learning of BIM within design briefs”

“If we had a BIM lecturer. We need more time to teach BIM”

“Include BIM in the curriculum”

Through analysis of comments put forward by lecturers, some interesting facts are revealed. Lecturers are often faced with the need for facilities to teach BIM, by far many comments from teaching staff lead to the lack of facilities. Universities should try to include the various facilities needed to teach BIM, which includes but not limited to space, equipment and learning materials. Integration into the syllabus is also an important comment received, this will assist or accelerate the learning of BIM within the architectural learning space. The comment that stands out between both students and lecturers is the availability of teaching staff that are highly skilled in BIM. The universities should look at external service providers or candidates from practice to fill in the role of BIM lecturer.

4.8 Barriers affecting BIM Implementation at South African Schools of Architecture

Table 1. Barriers and Recommendations for implementing BIM in order of Importance.

Barriers	Recommendations	Effort Level
1. Integration of BIM into Curricula.	A strong implementation strategy must be developed, for e.g. BIM components in each project as a non-negotiable element, Marking rubric to include BIM elements, Stand alone courses which focus specifically on BIM, BIM implementation must occur from the first year of study to promote and grow the knowledge of students.	10
2. Trained Lecturers in BIM.	The need for staff that are trained and specifically advancing their own knowledge in BIM must be non-negotiable. This component is critical for advancement of student and institution knowledge and advancement. Furthermore, support from BIM teaching staff will give students confidence to advance their knowledge, not only in BIM but design and construction technology.	10
3. Mindset.	The idea of BIM being a hindrance to students is a misnomer, Faculty and students must embrace the technology which will ultimately benefit both parties. A thorough introduction and discourse into the advantages of BIM needs to be understood to further reinforce the positive benefits.	8
4. Availability of space and equipment.	Space and Equipment is vital for the discourse of BIM. Space must be a high priority. The equipment to teach and learn BIM is also of high priority, during this study, it is noted that equipment becomes a significant barrier facing both students and lecturers. It is recommended that the Faculty place this as an ongoing budget to keep equipment up to date.	8
5. Time.	Time to teach, learn and practice is crucial for the advancement of BIM knowledge at universities. Architecture departments must increase the time allocated for training of students with BIM products.	7

The above table gives an insight to the top five barriers affecting the implementation of BIM at South African Architecture schools in order of importance. The authors have further used a rating of effort from 1 to 10, 1 being; little effort and 10 being major effort. Through the questionnaire and interviews, the above, self-explanatory table is used to disseminate the barriers facing architecture schools about BIM implementation.

5 Conclusion and Recommendations

In this section the authors provide conclusions pertaining to the findings in both the literature and empirical data provided in this research. It is critical that these findings be taken seriously if South African Architecture schools wish to pursue a strong BIM output from their curriculum. For this research, the authors intended to discover the level of BIM implementation at South African Schools of Architecture, the study is aimed at gathering data to determine where South African Schools of Architecture currently stand in terms of implementation. Although this study was relatively small, it shows significant representation of common beliefs both amongst students and lecturers.

From literature and empirical study, the authors determine various barriers which prohibit the dissemination of knowledge. For the successful integration of BIM into architecture schools, the various factors must be taken into consideration as a matter of urgency. For immediate effect, the authors propose that courses be structured to integrate

BIM as a component of both design and construction technology to allow students to get grounded knowledge and to advance their discourse simultaneously. By adopting BIM into the studio, the integration will allow for further introspection and learning. Furthermore, trained staff can assist students with BIM in a studio environment to realize their projects which hold much value compared to basic hand and CAD drawings. The authors suggest this mindset to advance the students capabilities and adopt a holistic approach in their specialty. This approach will assist in the issues of time as an integrated approach will allow for more time were students are able to practice both BIM and architectural work.

The authors find commonality between South Africa and other countries in terms of BIM implementation at institutions. However, the authors suggest further research in this area to include other countries for two reasons; one to determine the level of implementation of BIM at institutions and two; to determine what strategies have been employed to implement BIM. This approach can lead to a larger debate in which appropriate solutions to implement BIM in university curricula can be adopted.

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