THE RATE OF BUILDING INFORMATION MODELING ADOPTION AT HIGHER EDUCATION INTUITIONS IN SOUTH AFRICA

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ABSTRACT

PURPOSE

The outcome of this research aims to support South African universities, with regards to BIM integration within programs at higher education institutions. This paper focuses on identifying the challenges and highlighting the benefits of adoption of BIM into Architectural, Engineering and Construction (AEC) education curriculum.

DESIGN

A qualitative research approach was adopted to gather data on the topic of the paper. A systematic literature review and case study research process were used. NVivo software analysis was conducted to provide a thematic analysis and ensure validity of the research study.

FINDINGS

The salient findings for the study indicate that there is a significant lack of BIM implementation at South African higher education institutions, within AEC curriculums; and research further indicates resistance to the adoption of BIM, in part; due to the lack of BIM support by the government.

VALUE

The research study provides insight into the state and rate of BIM implementation at South African higher education institutions with respect to AEC curricula and its need to evolve beyond the conventional methods traditionally taught. The study highlights the challenges and overarching benefits of BIM adoption at higher education institutions as well as provides a framework for successful implementation.

Keywords: Building Information Modeling, Curriculum, Higher Education, Construction

INTRODUCTION

As the global society embraces the fourth industrial revolution, technology is advancing swiftly across all continuums[1]. The South African architectural, engineering and construction (AEC) sector is not exempt from the technological advancements, although it has been slow in its adaptation[19]. Building Information Modeling (BIM) in the era of digitalization is used more intelligently in current society more than it has ever before; to design, record, and construct buildings. BIM exhibits considerable advancements in terms of minimizing errors, understanding buildings, accurate visualization and clash detection[2]. The South African engineering and built environment industry is considered to be complex in a highly unique industry and as a result, the design of construction projects, the use of technology, and the need for better information management are crucial to successful project delivery. BIM aids in the successful completion of construction projects within the allocated budget, schedule limits and with efficient resource management systems; with researchers further highlighting BIM as one of the methodologies that can effectively address construction inefficiencies by adopting BIM as a parametric modeling technique. The South African AEC sector is still mostly a traditional business, and BIM adoption is seen as a gradual integration process[2][16].

The purpose of higher education institutions worldwide, is to provide students with the necessary skills and techniques that they require to develop and pursue future professional careers. Institutions are required to provide students with the knowledge and training necessary to satisfy the demands of the present construction industry. In order to better prepare graduates for the workplace of the twenty-first century, BIM should be implemented in programs for architecture, engineering, and construction that produce successful engineering and the built environment professionals. It is therefore imperative that importance is given on the manner in which connections between academic pursuits and professional practice are strengthened, as well as between institutional education and the demands of industry[20]. According to the researchers, the current AEC curriculum offered in South Africa's higher education systems is insufficient to completely provide graduates with the skills required for the labor market today. The incorporation of BIM into the curriculum will provide a pipeline of graduates who will be BIM-ready for the South African industry as well as the global business because we are living in a digital age where change is continual[32]. By enabling students to meet new occupational challenges with high levels of efficiency made possible by BIM, the adoption of BIM in undergraduate studies at a higher education institution will not only have an impact on the demand for BIM professionals but will also open up new career opportunities for students[3]. The current state of BIM integration at several higher education institutions is examined in this study, along with the benefits of incorporating BIM into the curricula at these institutions[16]. A systematic review of the literature and case study research were used in this study's qualitative method approach. The theoretical framework the researchers utilize for this research paper provides a structure and support for the study's justification, the problem-solving strategy, the purpose, the significance, and the research questions. The chapter on data analysis and findings made the most use of the theoretical framework[35].

LITERATURE REVIEW

A BRIEF HISTORY OF BUILDING INFORMATION MODELLING

Pronto was developed in 1957 by Dr. Patrick J. Hanratty, a citizen of the United States of America. It was the original piece of CAM software for manufacturing. Hanratty turned to computer-generated pictures shortly after 1961, which resulted in the publication of DAC (Design Automatic by Computer). This CAM/CAD system marked the debut of interactive visualizations. After that, the systems continued to improve steadily. "Sketchpad," the first computer-aided design (CAD) tool with a graphical user interface, was developed by Ivan Sutherland in 1963. This enormous development in computer graphics finally had an impact on BIM. Gábor Bojár, a computer genius during the Cold War, snuck Apple machines into Hungary to work on software and began working on ArchiCAD in 1982. Later, ArchiCAD was the first BIM-capable computer program made available[19].

BIM INTERNATIONALLY AND NATIONALLY

The significance of BIM has been acknowledged by the global construction industry, and certain countries are actively pushing it through national programs and initiatives. However, the South African construction industry (SACI) struggles to implement BIM effectively and widely. Although the use of BIM is increasing quickly in affluent nations, it is rarely used in poor nations. According to studies, the socioeconomic and technological environments prevalent in developing countries provide a number of difficulties for the construction industry. Difficulties include the lack of national BIM implementation programs and a lack of technically qualified staff. Developing nations such as South Africa, have begun to utilize BIM at the design stage of a construction project. The benefits include coordination, clash detection, material cost estimation, building simulation, shop drawing creation, and submission review. The fact that BIM must be used at every stage of a building project due to its inherent nature as a collaborative tool, however, limits the benefits of this. To ensure widespread adoption of BIM in South Africa, government, stakeholders, and the professional associations have not worked hard enough[10].

Since 2016, the United Kingdom (UK) has mandated that all public sector projects and stakeholders involved are required to adopt BIM design methods and as well as a preferred fully merged 3D BIM. In order to meet state and industry demands of the Architectural, Engineering, and Construction (AEC) sector, many higher education institutions in the UK have started integrating the BIM concept into AEC curricula. Researchers[11] have listed the following institutions that are leading in the provision of BIM-related courses in their AEC programs. These include Westminster University, Middlesex, Salford, Liverpool, the University of West of England, Northumbria University, and the University of South Wales[19].

BIM IN THE CONSTRUCTION SECTOR

As BIM moves beyond its infancy, the training of expert consultants in the sector is rapidly approaching. BIM has caught on in the AEC industry on a global scale, and consulting firms are looking for job seekers that are highly proficient in the technology. Although the industry believes academic institutions should continue to be in charge of educating students how to obtain these specialized abilities, a candidate who is new to the built environment job market is expected to have skills that are part of a BIM skill set. The introduction of BIM will aid projects both during the construction phase and after the project's lifecycle, as it has been demonstrated to have a good effect in other nations. As the BIM in the construction business grows daily and is known to provide an average of 31% of the GDP, it is also referred to as one of the fundamental ideas that would aid the sector in increasing income. The professionals that play key roles in the construction sector have continually sought out strategies for increasing quality and efficiency while minimizing project costs and length. All of this might be made possible by BIM[9].

The goal of using BIM in the AEC sector is to move past the traditional techniques that were employed decades ago and make use of techniques that have been proven to be more effective at reducing costs, eliminating waste, and improving the standard of infrastructure across the continent. The disparities in the African construction industry are shocking; information is dispersed in an unstructured manner, health and safety are essentially nonexistent, communication is a mess, and collaboration is next to impossible due to a variety of factors, one of which is the lack of network connectivity and education regarding the importance of digital technology and processes. As the usage of BIM grows, so should communication among project teams, resulting in increased profitability, lower costs, better time management, and greater customer-client relationships[26].

BIM IN HIGHER EDUCATION

All tertiary institutions that provide higher education, including universities and colleges, are considered to be a vital cultural and scientific resource that promotes personal development and speeds up economic, technological, and social change. While providing students with the tools they need to adapt to the continuously changing nature of the labor market, it promotes information sharing, research, and innovation. It acts as a ticket to financial security and a bright future for students who are in precarious situations. Higher education institutions (HEIs) have the ability to mobilize educational resources, provide learning opportunities for a diversity of people, and have a unique capability to foster knowledge and develop skills[37].

The decision to include BIM into academic programs is a very recent one. Although they mostly focus on software instruction, BIM teaching programs are offered by many higher education systems around the world. Education is essential to the implementation of BIM in order to meet the expanding industry demand for university graduates with BIM skills or capabilities[28]. While prior BIM-related research had mainly focused on its technological advances, such as information exchange and coordination in building design and construction, the study on education and training had been under-represented[1].

The existing AEC programs offered by higher education institutions do not adequately impart the knowledge and skills needed by industry. BIM is more than just a transition from paper-based to computer-based design; it represents a paradigm leap for the construction sector. In order to alter the way experts throughout the world think about how technology may be used to manage, build, and design buildings, Autodesk introduced BIM in 2002[24]. BIM is a cutting-edge new approach for managing, building, and designing buildings. As it provides AEC professionals with all the information they require to plan, design, build, and manage infrastructure and buildings, BIM is essential to the construction sector. It also offers superior design choices, real-time communication throughout the project life cycle, and improved building performance. Finally, the only technology utilized by the pertinent trades to achieve greater accuracy than ever is BIM[23].

BIM CURRICULUM IN HIGHER EDUCATION

AEC undergraduate programs at 25 institutions, the bulk of which were in the USA, were investigated by Barison and Santos, who gave an example of a contemporary approach to creating a BIM curriculum[8]. They concluded that six universities taught BIM at the introductory level, twelve universities taught it at the intermediate level, and seven institutions taught it at the advanced level. Since there are no requirements, first-year students can enroll in BIM at the introductory level without needing CAD or advanced computing skills. Researchers highlight that the purpose of teaching BIM through online collaboration is to simulate actual collaborative working among geographically dispersed students in multiple universities[8]. Institutions that have adopted this approach include, the University of Wyoming and University of Nebraska-Lincoln[9].

In addition to changing the demand for BIM professional, implementing BIM in undergraduate programs at a higher education institution will give students access to new career opportunities by allowing them to effectively address new occupational challenges. Therefore, BIM application prospects and competencies should be covered in undergraduate-level courses[42], As a possible essential component of AEC professional disciplines, BIM must be designed and developed with a number of factors in mind. Some of these characteristics include prerequisites, goals, objectives, themes, teaching methods, and assessments[6]. The following topics should be covered in a BIM curriculum, as shown in Figure 1.

Technical Considerations	Operational Considerations	Functional Concerns	Implementations Considerations	Administrative Procedures
• Modelling • Drafting • Model management	• Designing • Simulating • Quantifying	• Collaboration • Facilitation • Project management	• Standardization • Technical training • Component development	• Tendering and procurement • Contract management • Human resources

Figure 1: *The components of BIM curriculum[42]*

The process of enhancing the present curriculum of AEC programs at higher education institutions involves developing curriculum relating to BIM[6]. It has become clear through the process of implementing BIM in curriculum that this process is more involved than merely adding new courses to the curriculum. The following factors should be taken account when adapting BIM curriculum. Five parts make up the commonly used process for developing curriculum:

(1) analysis,
(2) objective design,
(3) selection of suitable teaching, learning, and assessment techniques,
(4) establishment of a committee for the implementation and evaluation of the curriculum,
(5) curriculum review.

However, the South African construction industry has continued to use non-computational data strategies with tools like two-dimensional (2D) computer-aided design, which has resulted in ineffective design management among stakeholders, overlapping work streams, and prolonged lead times. In order to overcome the fragmented nature of the construction business, a shift toward the adoption of a more computational and collaborative strategy is required. This strategy will improve efficiency, cut expenses, and better prevent duplication[31]. It should be noted that many higher education institutions in the UK have started incorporating the BIM idea into AEC courses, and this has been proving to be successful in the studies in these countries[25]. In contrast, there has not been effective BIM implementation in South Africa's higher education institution curriculum. Some of the challenges in developing nations that are holding back innovation for students at higher education institutions include a lack of understanding about BIM, the readiness of South African institutions, and a shortage of professors who can teach BIM.

RESEARCH METHODOLOGY

The study adopted a constructivist approach with a qualitative research design, as it gathers and analyzes data in great depth, by understanding the various possibilities related to the subject matter being researched. A qualitative research approach provided a more structured approach to the information and allowed for a subjective analysis. Some of the earlier theories seem to be significant and a solid foundation that ought to be acknowledged[1]. To accomplish the study's research aims and objectives, the study employed a collective and comprehensive case study analysis[10][36][40].

A triangulation of data collection methods was utilized to increase the dependability of the findings. To do this, information was acquired from a number of sources. Triangulation is using a variety of methods, data sources, observers, or hypotheses to gain a greater understanding of the topic being studied. It is used to make sure that the research findings are reliable, comprehensive, rich, and well-developed. The criterion used for the research study was categorized in a three-phase process[39]. The first phase was the primary process. The second phase was the secondary process, and the third phase was the tertiary process. The processes were conducted as follows:

- **Primary process:** The researchers identified a range of data sources via The Scopus and Web of Science (WoS) databases due to their comprehensiveness and wide coverage of publications. A two-step screening process was conducted to filter relevant publications based on the type of publications and selection criterion. The online retrieval was conducted on July 1st, 2023 with 74 data records having been obtained. The key words used were "BIM" AND "higher education institutions" AND "frameworks" AND "AEC" AND "education programs".
- **Secondary process:** During this stage the researchers perused through the articles and further filtered through the selected data records by reviewing the respective titles and abstracts to ensure the article meets the inclusion criterion. A total of 59 papers were identified, largely from the United States of America, the United Kingdom, Malaysia, Australia and South Africa.
- **Tertiary process:** After conducting the two-stage literature selection; the final stage was referred to as the elimination stage. A further selection and elimination of extraneous evidence, three filter criterions were applied to select publications that aligned with the research topic and theme. The researchers eliminated articles that do not relate to 1. BIM curriculum at higher education institutions; 2. articles collected that were not in the English language and 3. publications that did not meet the inclusion requirements of having been published within a ten-year period, beginning on January 1st, 2013, and ending on July 1st, 2023[2]. After the refinement process, a total of 42 papers where identified with 25 papers having been identified from South Africa. Even though the South African higher education system has evolved over the course of a decade, as indicated by literature samples ranging from 2013 to 2023; studies and programmes regarding BIM education is still in its infancy unlike other nations.

To guarantee the credibility of the research, the researchers have chosen to employ the software NVivo 12. NVivo assisted the qualitative researchers in organizing, analysing, and deriving conclusions from unstructured or qualitative data such as interviews, open-ended survey responses, journal articles, social media, and online material. The NVivo 12 program offers a compelling choice for conducting theme analysis. The application is designed to assist scholars in quickly and accurately analysing enormous amounts of data and spotting hidden patterns. Although it is a technique that may be applied to numerous approaches, rather than a methodology in and of itself, thematic analysis was originally recognized as an approach in the 1970s[10]. It is used to find recurrent themes in text sources, such as documents, interview transcripts, open-ended survey questions, articles shared on social media, and online videos and photos. The researchers were able to make better conclusions by using thematic analysis to understand the underlying topics and find connections within our content.
The following tests to test the reliability of the data were also considered by the researchers:

- Refutational analysis.
- Use of comprehensive data.
- Use of tables to record data.

Ethical considerations where considered and maintained in accordance with Durban University of Technology (DUT) Institutional Research and Ethics Committee (IREC) guidelines. The researchers completed, submitted and gained approval of the PG1 and PG2 forms. The research is classified as Category One research as it involved the use of existing data collections and records. As a result, no participants were involved as it was based on a systematic literature review and was conducted using a case study analysis. It was considered negligible risk research as there was no foreseeable risk of harm or discomfort, and any foreseeable risk was no more than that of inconvenience. Further ethical consideration codes where adhered to such as honesty and integrity; intellectual property protection; carefulness and morality.

FINDINGS

NVivo 12 was adopted for a critical review as it is an excellent tool for conducting a thematic analysis. The application is designed to assist academics in identifying underlying trends and analyzing large amounts of data quickly and correctly. Thematic analysis was initially identified as an approach in the 1970s, albeit it is a tool that may be used to a variety of techniques rather than a methodology in and of itself[13]. It is used to find recurrent themes in text sources like as papers, transcripts of interviews, open-ended survey questions, social media postings, videos, and photos on the internet. Thematic analysis supported the researchers in making better informed selections by detecting relationships within our content and recognizing the underlying themes. The most common approach of thematic analysis consists of six steps: familiarization, coding, topic generation, theme review, theme definition and labeling, and writing up. This approach was utilized by the researchers to assess data to guarantee that the study was free of confirmation bias. The steps will be detailed further below.

1: Familiarization - The researchers were acquainted with the data, which was the first phase. Before entering into the study of particular objects, it was vital that the researchers first had a full picture of all the data we acquired. Listening to the audio, reading the text and taking some preliminary notes, and generally examining the data to become acquainted with it were all part of this process.

2: Coding - The researchers were looking for themes or coding patterns at this point. The change from codes to themes was not straightforward or easy. To gain a better understanding of the data, the researchers had to employ additional codes or themes. When the researchers reviewed the material, they discovered sub-themes and subdivides of themes that focus on a significant or pertinent feature.

3: Developing themes - Following coding, the researchers analyzed the codes that they had written, identified trends, and proceeded to build themes. Themes were often more expansive than codes. Multiple codes were integrated into a single theme by the researchers. The researchers also found that several of the codes can be deleted since they were too vague or regarded unimportant at this point.

4: Theme review - It was now the researcher's obligation to ensure that the themes accurately and productively depicted the facts. They returned to the original data set and examined the themes while taking it into account. The researchers considered the following questions after evaluating the initial data and topics.

- Is there anything more that the study requires?
- Do these themes appear in the data?
- How can they make the themes more functional?

All of the problems the researchers uncovered with the themes were either split, combined, deleted, or replaced with new ones that were more accurate and useful.

5: Defining and categorizing themes - After reviewing and finalizing all of the themes, it was time to give them distinct names and meanings. Defining themes requires explicitly defining each notion and establishing how it contributed to the comprehension of the facts. The method of naming is to come up with a clear, short name for each subject.

6: Writing – The researchers completed the data analysis by writing up the findings. Writing a theme analysis, like any other academic work, begins with an introduction that explains our study subject, aims, and methods. This sub-section addressed every subject. The researchers presented the themes and their frequency of occurrence, backed up with data samples. The conclusion summarized the main findings and demonstrated how the study met the three research goals. The two major themes identified through critical analysis were the challenges of integrating BIM into higher education AEC curriculum and programs as well as the perceived benefits of integrating BIM into higher education AEC curriculum and programs.

CHALLENGES OF INTEGRATING BIM INTO HIGHER EDUCATION AEC CURRICULUM

Opposition to change is seen by the academic community as a structural barrier. While multi-disciplinary collaboration is naturally supported and encouraged by BIM, academic fields are used to operating in silos and competing for resources, prestige, and position. As a collaborative approach will work much better in an unclear domain, higher education institutions need to work together to successfully integrate BIM into the current curriculum in AEC programs. The incorporation of BIM into the present curriculum is fraught with difficulties[18]. Table 1 provides a summary of a few of these difficulties.

Table 1: Challenges of BIM Integration into AEC Curriculum

No.	CHALLENGES	REFERENCES
1	Unfavorable accreditation processes	[18]
2	Lack of alignment with industry requirements	[5]
3	Lack of industry attention to educational challenges	[22]
4	The current curriculum is congested.	[18]
5	Difficulty of designing BIM related modules	[18]
6	Difficulty of designing both horizontal and vertical curriculum	[23]
7	Inadequate software and cost for proper computers	[23]
8	Current academic culture does not favor change.	[5]
9	The certainty of traditional methods of teaching	[23]
10	Lack of support from professional bodies and leaders.	[18]
11	Lack of appropriate experience for educators	[18]
12	Lack of collaboration between universities	[18]
13	Academic content and current industry practice are not synchronized	[5]

Reference: [18],[5],[22]and[23]

Although integrating BIM into the curriculum presents a number of challenges, it is thought that the requirement that the lecturers assigned to teach BIM have practical expertise in BIM applications, is a significant challenge in the integration of BIM into AEC programs at higher education institutions in South Africa. Authors highlights that the ignorance of academics are the primary barrier to incorporating BIM into QS programs[18]. Integrating BIM into an AEC curriculum will require a collaborative effort between higher education professionals and construction industry[5]. The second primary obstacle is the high costs of BIM software purchase, material, maintenance; and the requirement for frequent program upgrades[22][23].

BENEFITS OF INTEGRATING BIM INTO HIGHER EDUCATION AEC CURRICULUM

From the perspective of industry need and graduate employability, BIM education in all its manifestations is unquestionably important[14]. Many academics advocate switching from an outdated, conventional educational system to a new one that is BIM-enabled. By combining work and information flows for whole projects, BIM has changed the way projects are traditionally divided into specialized sectors. Consequently, conventional professional practice as well as connections of power and influence are redefined. University faculties struggle to adjust to this change while being under intense pressure to rethink built environment professional education and contribute to the creation of new working methods, as they reflect the traditional divisions and structures of the construction industry[9].

The usage of BIM in the construction sector is growing, which is only one of the many reasons why students studying AEC in South African higher education institutions should be introduced to it. However, teaching BIM has additional benefits that increase the overall quality of the students' education. A BIM-based teaching technique might increase AEC students' capacity to learn building details and their understanding of the core concepts behind material quantity take-offs. Using BIM, students may better visualize numerous construction processes, such as safety, sequencing, and operations, as well as better understand the links between complex building components[26]. The main benefit of incorporating BIM into the current curriculum in AEC programs at higher education institutions in South Africa is to produce a pipeline of graduates who are adequately equipped for the global construction industry[33], but it also contributes to the industry in other ways, which are listed in Table 2:

Table 2: Benefits of BIM Integration into AEC Curriculum

No.	BENEFITS	REFERENCES
1	Enables students with cost reduction techniques.	[5]
2	The professional team will speak the same language.	[39]
3	The BIM environment allows students to apply abstract notions taught which has been found to improve students' knowledge of engineering principles.	[27]
4	BIM allows for 3D visualizations and interactive, nonverbal simulations, allowing for the conveyance of complex ideas across disciplines and cultural-linguistic groups. These have been shown to improve student understanding and performance.	[39]
5	For teaching, BIM allows for the simulation of more realistic project conditions.	[42]
6	BIM is both driving the rising need for more interdisciplinary communication and teamwork and directly giving possibilities for improving multidisciplinary collaboration competencies	[5]

Reference: [39],[42],[27]and[5].

DISCUSSION

The goal of using BIM in the AEC business is to go beyond the traditional methods utilized decades ago and use processes that have been proved to be more efficient at decreasing costs, minimizing waste, and boosting the grade of infrastructure throughout the continent. The main benefit of incorporating BIM into the current curriculum in AEC programs at higher education institutions in South Africa is to produce a pipeline of graduates who are adequately equipped for the global construction industry[33], but it also contributes to the industry in other ways. The researchers believe that the CEF framework highlighted below is appropriate for adaptation in South African higher education institutions, as it demands industry participation that may begin the process in bridging the gap between the South African construction industry and the academic sector.

FRAMEWORK FOR BIM ADOPTION IN HEI'S AEC PROGRAMMES

A BIM educational framework is an organized set of standards or learning objectives that outline the BIM material that AEC students must acquire throughout their higher education levels in order to graduate as BIM-ready graduates. The foundation for incorporating BIM into the curriculum at South African higher education institutions must be robust enough, as developing nations such as South Africa have been resistive to this transition[17]. The Australian industry, similar to that of South Africa, has proven resistant to BIM adoption. As a result, the Australian academic and AEC sectors worked to develop the collaborative education framework (CEF). After critical review of various case studies and frameworks adopted on a global scale, the researchers identified that a similar framework is appropriate for adaptation in South Africa as it promotes industry participation, and bridges the gap between the construction industry and the academic sector. The CEF is based on the BIM Framework's concepts, models, taxonomies, and classifications and was first issued as part of the AIA/CA BIM in Practice and BIM Education position papers[36].

A precise educational framework is essential for the delivery of BIM education in the 21st century within the South African Higher Education system. The Australian BIM Academic Forum (ABAF) aimed to promote BIM education and learning in Australian universities and developed the minimum curricula to bridge the gap between education outcomes and workplace performance. This framework established minimum requirements for BIM/DE education in Australian universities, aiming to create a sustainable pipeline of graduates with the necessary knowledge, skills, and abilities for the Australian AEC industry[36]. As a result, the researchers recommend the development of a collaborative education framework (CEF) similar to those adopted by the Australian higher education system, that consists of six major complimentary components that examines AEC curriculum development and course assessment of BIM education in the South African Higher Education system[3].

- **Component 1:** Identifying BIM Competencies - Peer-reviewed studies, industry surveys, and industry organizations' specialized knowledge and experience will all be used to determine BIM competencies.
- **Component 2:** Classifying BIM Competencies - A top-level taxonomy will organize BIM competency items into tiers, sets, and topics, and several classifications such as role groups, disciplines, difficulty levels, delivery modes, and so on will be used to filter BIM competencies to meet learner needs. This ensures that BIM competences are clearly and consistently established across all themes.
- **Component 3:** Developing BIM Learning Modules and Gathering Competencies - A dedicated online BIM learning center will be established to oversee the production and dissemination of BIM learning modules.
- **Component 4:** A Framework for Professional Development in the Industry - Industry organizations will design a framework for collaboration to foster collaborative, BIM-focused Continuing Professional Development (CPD) across disciplines, specialties, and industrial crafts.
- **Component 5:** A Framework for Academic BIM Education - To encourage academic institutions to contribute to and benefit from the BIM learning center, an academic framework for tertiary and vocational BIM education will be implemented or changed.
- **Component 6:** The establishment of a BIM institute - A BIM institute will be established to support the creation and delivery of BIM training across industry sectors, create and maintain classification systems for BIM learning organizations, create and maintain the BIM learning hub, create and maintain a coordination framework between professional associations for the purpose of multi-disciplinary BIM training and continuing professional development, and create and maintain the BIM learning hub.

CONCLUSION AND RECOMMENDATIONS

BIM is a complex multi-dimensional model-based method that has been a crucial driver in the design and execution of building construction across the world during the last decade. BIM provides a structured framework of information required by AEC professionals to plan, design, construct and maintain global infrastructure. It further improves design decisions, real-time communication and building performance throughout the life cycle of a project life cycle. Building information modelling has redefined the manner in which engineering and built environment professionals conceptualize, plan, record, and execute building construction now, more than ever. BIM in its nature, is simply not a catchphrase for great software, but rather a complicated design and documentation system that allows for mistake reduction, design complexity, visualization, virtual building, and other cost and time savings[29].

BIM has the ability to increase the efficiency of the AEC industry, and its benefits have been widely acknowledged and highlighted in a variety of academic and business journals. The aim behind implementing BIM in the AEC industry is to move beyond the conventional methods that were used decades ago and utilize procedures that have been shown to be more efficient at lowering costs, cutting waste, and raising the calibre of infrastructure across the continent. The introduction of BIM in the academic sector has the potential to transform the South African construction industry[39].

PRACTICAL RECOMMENDATIONS

1. Further quantitative analysis for the adoption of the strategic framework.
2. It is imperative that the government develop a national BIM policy, which should permeate university curricula. Despite the lack of national implementation of BIM, higher education institutions should work together to improve the BIM proficiency of their graduates.
3. Universities need to introduce and support the extensive training of academic staff to adequately equip them with the skillsets needed to deliver BIM courses at their institutions.

THEORETICAL RECOMMENDATION

1. Significant efforts are needed to communicate the idea of BIM to AEC students, particularly by higher education institutions. Future studies can examine how to teach the BIM idea in developing country colleges and how to create policies for the AEC sector that will incentivize businesses to use BIM in their projects.

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