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Building Information Modeling Education and Training in Ethiopia

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Abstract: The construction industry will inevitably require information-based interventions, such as Building Information Modeling (BIM). BIM is used to improve design efficiency, track construction progress, evaluate design development, and minimize conflicts while also increasing productivity. Although BIM's use in developed countries is encouraging, its applicability in developing countries—particularly in infrastructure—remains limited. BIM training and education are crucial in this respect. Therefore, the goal of this study is to find out how BIM education and training are used by Ethiopian students and professionals in the construction industry. The study's specific objectives are to examine the current state of BIM education, training, and support, identify the main obstacles to BIM education and training in Ethiopia, and suggest a suitable framework for BIM education and training that is suited to the demands of the nation's construction sector. To achieve this goal, an interview, document analysis, analysis of yearly and monthly plans and reports, and a review of the literature were conducted. The practices of important stakeholders who are believed to have potential roles in the adoption and use of BIM technology were the main focus of the investigation. Accordingly, the findings indicate that even if there is an initial work by the Ethiopian Construction Management Institute (CMI) to teach BIM topics and financing for BIM, it can be thought that BIM education and training are in an early stage in Ethiopia. Among the selected first-generation universities for this study, only Addis Ababa Science and Technology University, Bahir Dar University, and Hawassa University have included BIM as a course/topic in their curriculum, which shows a lot will be expected from the Ministry of Science and Higher Education (MOSHE) in enabling higher education to include BIM in their curriculum. In addition, the findings revealed that universities show less interest in the open right of entry access opportunity and free software license application provided by Autodesk. Professional associations have an awareness of BIM from the seminars and workshops they attended, but they didn't contribute to promoting BIM education and training in the construction sector. The respondents identified the following as the main challenges: a lack of government leadership or direction; a lack of budget to purchase BIM software and the associated costs of necessary hardware updates; a lack of general awareness among stakeholders regarding the advantages, tools, processes, and workflows needed to implement BIM education and training in the nation; and a shortage of experienced, trained professionals. The literature on BIM education and an analysis of other BIM education frameworks of this kind around the world were used to create the framework that can work for our construction industry. The study concluded that in order to develop and promote BIM training and education, cooperation between industry associations and academic institutions is required.

Keywords: Building Information Modeling, Ethiopia, Construction Industry, Digital Construction, BIM Education, BIM Training.

1. Introduction

The global construction industry is undergoing rapid digital transformation, driven by the need for efficient project delivery, improved collaboration, and sustainability (Nuramo & Haupt, 2016). Software for project management offers a standardized approach to work management. For every facet of project management, financial planning, field communications, and daily operations, construction management software offers professionals integrated, customizable applications. (Bataw et al., 2015). Due to the benefits, many government enterprises and private companies are investing in different construction management packages all over the world. Among these, BIM (Building Information Modeling) is extensively utilized in many regions of the world and includes details on design, construction, logistics, operation, maintenance, budgets, schedules, and many other tasks (Solutions, 2003).

From planning to design, construction, and operations, building information modeling (BIM) is a digital tool used to manage construction project information holistically (Silverio et al., 2017). Additionally, it is a catalyst for change and an enabler of Integrated Project Delivery (IPD), which permits the longitudinal and lateral integration of industry players, disciplines, and construction phases, such as design, fabrication, assembly, and delivery (Musonda et al., 2023; Nuramo & Haupt, 2016). Beyond just a drawing tool, BIM is a new way to manage information about construction projects holistically, from the planning stage to the design, construction, and operation stages (Low, 2023). Utilizing new technology to improve construction process control, cross-disciplinary collaboration, internal coordination, problem-solving, risk management, and project management and execution is a new method of working (MoUDC and ECPMI, 2019; Solutions, 2003).

Even though BIM has garnered a lot of attention globally, Ethiopia's current construction projects management system is mostly dependent on two-dimensional drawings and has poor interoperability due to "the highly fragmented nature of the industry, the industry’s continued paper-based business practices, a lack of standardization, and inconsistent technology adoption among stakeholders," which results in a significant loss of resources (Belay et al., 2021; MoUDC and ECPMI, 2019).

Although BIM adoption in the developed world is very encouraging, it is not widely used in developing nations like Ethiopia, particularly when it comes to infrastructure (MoUDC and ECPMI, 2019). In this sense, education and training are essential to the spread of this technology in the sector (Puolitaival & Forsythe, 2016). This could also be the root cause of people's resistance to using BIM, which eventually permeates their company culture. Lack of motivation to comprehend how technology improves processes and merely using it mechanically may cause learning challenges, which could result in additional technical problems when using it. Consequently, the need for training and education will increase (Alemayehu et al., 2021). Consequently, it is maintained that one of the obstacles to the effective adoption of technology is a shortage of professionals with the necessary training and expertise (Low, 2023). This implies the need to study the present trend in BIM education and training for construction industry professionals and students in Ethiopia (Desbalo, 2020).

Among the main enablers that encourage the implementation of BIM, training, education, awareness, government support, and software are the most important. Training's primary objectives are skill, practice, and learning how to do things (Gangatheepan, 2022). The purpose of education is to develop the mind by exposing it to information about the material and cultural worlds and by encouraging it to think on its own (Peter Rickman, 2004).

Due to the presence of huge input and complex processes in sustainable infrastructure design and delivery, the need for innovative information-based interventions like BIM (Building Information Modeling) is inevitable (Nuramo & Haupt, 2016). So, it is impossible to examine the final project outlook and operation without the use of modern integrated software; building information modeling and this software needs specialized personnel who can convert a project plan to the final project model, which helps different stakeholders know the final stance of their project (Criminale & Langar, 2017).

The adoption of BIM in the industry is primarily driven by the public sector (Jowett, 2024). In some nations, the public sector is the major driver of BIM adoption (Nuramo & Haupt, 2016). Public sector demonstrations and support are unquestionably essential to the development of BIM. Among these, establishing training programs, training plans, and enhancing BIM education are expected from public bodies as educators. Even though BIM has recently gained a little attention in the Ethiopian construction industry, it is claimed that the practice and strategy of education and training are not known (MoUDC and ECPMI, 2019). Therefore, this study attempted to study Building Information Modeling education and training for construction industry professionals and students in Ethiopia.

This study aims to address two important questions: 1) What are the main obstacles to Ethiopia's successful adoption of BIM training and education? 2) What kind of BIM education and training framework would be appropriate for addressing these challenges in the Ethiopian construction industry? Although the exact causes of the construction project management system's struggles to thrive are unknown, it is suggested that the current issue is caused, at least in part, by the lack of an efficient project management technology education, training, and support system. Hence, the industry is known for its low technology industry, and it's critical in guaranteeing the prosperous transformation of the economy, but due to difficulties and restrictions in communication, coordination, and standardization of the industry, the sector is facing a problem (Criminale & Langar, 2017). To reverse the current situation, preserve the time and money spent on traditional approaches, and produce highly qualified personnel for the design and delivery of sustainable infrastructure through the application of BIM, steps must be taken to improve BIM education and training (Nenonen et al., 2016).

2. Methodology

2.1 Description of the study area and subject

The study area of this research is the Federal Democratic Republic of Ethiopia (FDRE), Ethiopia is one of the landlocked countries in the Horn of Africa. It shares a border with Eritrea to the north, Djibouti to the northeast, Somalia to the east, Kenya to the south, South Sudan to the west, and Sudan to the northwest. The country has a total area of 1,100,000square kilometers; its capital and largest city is Addis Ababa, which is located at 9°1′48″N 38°44′24″E (Weldeghebrael et al., 2021).

The study focuses on BIM education and training for construction industry professionals in Ethiopia. The practice of the Ethiopian Construction Management Institute, First Generation Universities, and Professional Associations (Ethiopian Construction Technology and Management Professional Association (Ethiopian Construction Technology and Management Professionals Association (ECoTMPA), Ethiopian Association of Civil Engineers (EACE), and Association of Ethiopian Architects (AEA)) in promoting BIM education and training was assessed. Curricula and plans were used as a source of data. Desk study and interviews were conducted with experts from each of key stakeholders mentioned above.

2.2 Research Design

According to this study, the choice of methodology should be based on the research problem as well as other significant elements that influence the process's rigor and its results, such as the researcher's experience and philosophical stance. Because construction project management is a multidisciplinary endeavor, research aimed at improving it must concentrate on several issues about both "thing" and human aspects. It employs a qualitative approach in terms of methodology. This is because the study focuses on explaining data and analyzing and synthesizing it towards a theoretical generalization, rather than frequency and statistical generalization. In light of the research's goals of investigating and evaluating the state of BIM education and training today (as well as the difficulties that accompany it), extensive data should be explained and directed toward the creation of a framework for potential improvement strategies (Desta, 2015).

The major objectives of this research are to find out what is currently available and/or offered to construction industry professionals and students in terms of BIM education, training, and support, and identify challenges of BIM education and training to frame approaches that would improve the current practices (Solomon, 2015). These objectives, at a general level, call for descriptive explorations of the characteristics of BIM education and training in the industry and explanatory investigation to establish causal links between the practices (and challenges) and improved performance (Solomon, 2015).

Authors note that case study research can be used for exploratory, descriptive, and explanatory studies (JOHN GERRING, 2004; Robert Stake, 1995; Yin, 2009). They note that, generally, case studies are suitable for explanatory research where 'how' and 'why' issues, over which the investigator has little control, are investigated, and when contemporary phenomena with a real-life context are sought, they can also be used in exploratory and descriptive studies (Yin, 2009). Similarly, Stake, noting that often researchers take a case '…to know it well ... what it is and what it does' argues that the first business of a case study is 'understanding the case itself (Robert, 1995).

In this context, thus, the most suitable research strategy that combines the research's objectives of exploring and describing the practice of BIM education and training in the industry and establishing causal links between issues that are affecting better handling of BIM education and training and how they can be mitigated is the case study. In addition, as noted by Yin, one of the major appeals of a case study is its capacity to be tailored to contexts (Yin, 2009). This method will enable contextualizing BIM education, training, and the challenges experienced in the environment in which they are experienced. These traits of a case study, along with proper design of theory formulation, data collection, and analysis techniques, will make the strategy a better option for the study. In the wake of these relative appeals of the case study and its relevance for the research questions posed, the study adopted a combination of descriptive and explanatory case study to explore, describe, and establish a causal relationship of the practice, the major challenges, and possible mechanisms that would lead to improved performance of BIM education training in Ethiopia.

2.3 Target Population

A research population is generally a large collection of individuals or objects that is the focus of a scientific query (Castillo, 2009). The target population for this study will be key stakeholders who are believed to have potential roles in the adoption and implementation of BIM Technology in the Ethiopian Construction industry.

2.4 Sample Size and Sampling Technique

For case study work, the selection of cases (qualitative sampling) is generally purposive (Kuzel, A., 1992) and is 'decidedly theory-driven' (Miles & Huberman, 1994). In addition, samples (cases) in a qualitative study may not be wholly pre-specified, as they could be adjusted and evolve as works progress. In general, however, at least as a starting point, in terms of number of cases, while a single case can be used when suited to the situation (e.g., critical case), often, for replication purposes, multiple case studies are used. In this regard, Eisenhardt recommends the use of four to ten cases for better external validity (Kathleen and Eisenhardt, 1989). However, Yin notes that while a larger case number may be needed for theoretical replication, when fit, even two cases may be enough for literal replication (Yin, 2009). In terms of the best-suited cases, selection fundamentally depends on what the research envisages to achieve. For example, if the research envisages explicating as much information as possible from the case, extreme cases may be the preferred option.

As outlined in the roadmap for the adoption and implementation of BIM Technology in the Ethiopian Built Environment Industry, in recent times, the key stakeholders that are believed to have potential roles in the adoption and implementation of BIM Technology have been identified. In this regard, the Ethiopian Construction Management Institute, Public clients, Universities, and Professional Associations can be taken as candidates for this study. However, the role of public clients is a leadership role in BIM adoption and implementation through taking the lead to create market demand, and due to this, public clients will not be considered in the study. In addition, public clients available in Ethiopia are enormous in number, and as the practice has not grown well, it is not very relevant for the study.

On the other hand, the Ethiopian Construction Industry Council, the Minister of Innovation and Technology, the Ministry of Urban Development and Construction, the Ministry of Science and Higher Education, the Ethiopian Construction Project Management Institute, and Professional Associations (ECoTMPA, EACE and AEA) have a role in formulating strategies, creating awareness, providing funds and necessary manpower.

Employing the sample size determination formula for small-sized populations suggested by Kothari for the total of 8 (eight) first-generation universities that stream construction-related programs and are expected to have good standing in research, technology, education, and training in the country, the sample size under this study will constitute all 8 (eight) universities (Kothari, 2004). The appropriate formula to determine sample size based on a small population is as follows:

$$n = \frac{Z^2\ pqN}{e^2\ (N-1) + Z^2\ pq} \qquad (1$$

Where:
n = Sample size required
N = Total number of universities
Z = Level of confidence considers 95% and the reading result taken from the Z chart is 1.61
p = Sample proportion, $q = 1 - p$ and $p = 0.02$
e = Sampling error, which shows precision taken at 3%

2.5 Data Collection Methods

For this study, given the nature and scope of the study (where observing the whole practice of BIM education and training takes significant time), the primary data sources selected are documents (strategic plans and curricula), along with interviews. Documents and archives, notwithstanding their drawbacks such as reporting bias, biased selectivity, and accessibility, are important sources of data (Yin, 2009). Particularly in this case, where it can be expected that education and training plans and reports are prepared formally in these public institutions, universities, and associations, a desk study can be argued to be an important data source.

Interviews provide an opportunity to interact with informants; hence, they offer distinct advantages for a targeted, insightful perspective of informants (Johnson, 1990). Parallel to this, one of the most important issues concerning interviews is the selection of the informant, as the informant's knowledge of the issue and recall of the same have an important bearing on the information relayed. For this study, informants were selected from pools of personnel who are thought to have been well informed about the issue under discussion. The information gathered was used to add additional insights and to identify aspects that should be included in the framework. A semi-structured (focused) interview where the interviewer comes up with probing questions to guide the interviewing process was adopted. The semi-structured interview is needed to guide the interview within the study protocol and to supplement the information gained from the documents.

2.6 Data Management and Analysis

The study used documents and interviews as its main data sources. The process of document analysis as a data source generally calls for elements of content analysis and thematic analysis (Bowen, 2009). Content analysis is defined as 'the process of organizing information into categories related to the questions of the research' (Bowen, 2009), while thematic analysis can be defined as a form of pattern recognition within the data, with emerging themes becoming the categories for analysis (Bulmer, M., 1979). In this study, the analysis used a conceptual framework and the concepts and 'international practices' from the literature review as its main theme of categorization of data and analysis.

Miles and Huberman identify two major types of within-case analysis and display of qualitative data (Miles & Huberman, 1994). These are "explaining and prescribing," which offers explanations for why events occur the way they do and suggests possible changes to the way phenomena are applied, and "elevating and describing," which describes the phenomenon under study (after investigating it). This study initially describes the BIM training and education practices and the difficulties in managing them in parallel with this classification. The study then looks for reasons for the "poor" performances that have been identified and suggests ways to improve them, all while developing a framework based on the best practices and recommendations found in the literature.

3. Analysis and Discussion

BIM education is a continuous learning process that covers the knowledge required for individuals to be capable of being part of and understanding what a BIM process is. Such a learning process needs to include the essential aspects of BIM implementation; the performance of the participants and the technical skills individuals need to acquire, depending on the discipline they belong to and their role in the construction team. BIM education and training is necessary not only within the whole construction industry but also must be directed to different levels: undergraduate, master's level, project offices, and even at the strategic level (Lee, 2013).

There are numerous stakeholders involved in the delivery of BIM education in the world. Academia is the biggest domain among all of them since it covers educational institutions that provide education to a significant number of people. The industry is another important domain, but what they mostly offer is training to their employees to develop the skills the company requires, depending on their objectives and type of work. The remaining providers have a narrower scope. Software companies provide software training only. Associations in the developed countries give training to their professionals. From the UK, can be mentioned: BSI (British Standards Institution), BRE (Building Research Establishment), CIOB (Chartered Institute of Building), RICS (Royal Institution of Chartered

Surveyor); Australia: CITB (Construction Industry Training Board). From the USA, AGC (Associated General Contractors) of America, etc. The BIM knowledge provided by BIM learners is the one they share with their colleagues, which can be acquired through professional experience, academic background, or learned by themselves. The variety and number of BIM education providers could indicate that the need for BIM education is being addressed. However, the reports of the lack of BIM-skilled personnel in the industry suggest that the way BIM education is being delivered and disseminated needs to be improved (Silverio et al., 2017).

In contrast, only the Ethiopian Construction Management Institute is providing BIM education and training in our country, which shows the contribution of the academy and other industry bodies is low. To create BIM awareness and develop BIM education with practices, CMI is working on training academicians and industry professionals. Following the purpose and scope of this study, the investigation considered only the delivery of BIM education from the most important BIM education providers: CMI and academic institutions in the country. In this chapter, the discussion of BIM training and education practices, challenges in managing BIM training and education and mitigation measures and framework towards improving BIM training and education were discussed.

3.1 BIM Training and Education Practices in Ethiopia

Some governmental institutions in Ethiopia have begun to delve into BIM topics in the past few years and widen the application of information technology in the construction industry. Despite this, it can be said that BIM is at its infancy stage in Ethiopia. The research tried to study the practices of BIM training and Education by selecting the key stakeholders who are expected to be more responsible for developing BIM training and education in the country.

- The study results revealed that CMI is working on training the academicians and industry professionals to create BIM awareness and develop BIM education with practices. CMI has begun to delve into BIM topics in the past few years and has widened the application of information technology in the construction industry. Despite this, it can be said that BIM education and training are in their infancy in Ethiopia.
- To enable BIM with infrastructures, CMI acquired a real server-based BIM software package, along with training manuals and a three-year maintenance subscription license, and 25 desktop computers that are compatible with BIM. They also trained and certified trainees in the use of BIM technology, gave them additional BIM technology practice to hone their skills, piloted four projects (converting the conventional design packages of 40/60 2B+G+13 and B+G+7 ECWC (ICT Park) Buildings to Integrated Design using BIM technology, and created a BIM Road Map for BIM adoption(Woldesenbet, 2020).
- The Ministry of Urban Development and Construction has shown concern for the implementation of BIM education and training and allocated a fund for incentivizing the BIM adopters and supporting investment on BIM technologies through the Ethiopian Construction Management Institute. The institute has planned to facilitate the adoption and implementation of BIM technology in the constructions industry and in collaboration with the Ministry of Finance, work on ways of changing procurement practice.
- Addis Ababa Science and Technology University has added BIM as a course in the undergraduate program, while Bahir Dar University has included BIM in the MSc program of Construction Technology and Management. The Department of Architecture of Hawassa University has included BIM as a topic in a course. The Construction Technology and Management department of Hawassa

University attempts to add the course as an elective in the undergraduate program and as a topic in the MSc program. In contrast, Jimma University, University of Gondar, Haramaya University, and Arba Minch University were not successful in including BIM as a course or topic in their curriculum. This shows that the Ministry of Science and Higher Education should push for the implementation of BIM by formulating strategies to enable higher education to address the development needs of the country and the way BIM technology will be part of their curriculum. Beyond this the ministry should work in formulating strategies that are compatible with domestic and international developments and working collaboratively on the development of BIM guides, manuals and checklists.

- According to a memorandum of agreement between the Ethiopian Construction Management Institute and Autodesk to establish a partnership and develop collaborative efforts towards the adaptation and implementation of Building Information Modeling (BIM) as a standard in the design. In the engineering and construction industry of Ethiopia, Autodesk has sponsored and opened access through CMI for BIM software license application in the academic environments of public and private higher learning institutions that CMI proposed in consideration of the programs they are running in connection to AEC Industry. As a result, right of entry is given to the universities and TVET to access the Autodesk AEC software package and additional training through the link provided. Following this, Jimma University has created awareness to the staff to access BIM software and training. Similarly, the University of Gondar has alerted the staff to BIM use and is on the way to facilitate the infrastructure needed to establish BIM center. Bahir Dar University has conducted a workshop with regional enterprises, and awareness is given on the use of implementing BIM in the construction industry.
- The results show that the Association of Ethiopian Architects, the Ethiopian Association of Civil Engineers, and the Ethiopian Construction Technology and Management Professionals Association have created awareness on Building Information Modeling in their seminars and workshops. All of them confirmed that they have trained professionals in BIM through the opportunity given by the Ethiopian Construction Management Institute. There are also members who have published research that focuses on Building Information Modeling. All the associations agree that a lot is expected from them to collaborate for the implementation and adoption of BIM technology in the construction industry.

3.2 Challenges of BIM Training and Education

As it is known that any new change to an industry is accompanied by challenges, BIM education on projects is no exception; it is accompanied by realistic and perceived barriers. Identification of the barriers and challenges to BIM implementation is important for successful BIM implementation (Belay et al., 2021). To ensure the achievement of BIM objectives, there is a need for a systematic evaluation of the barriers and challenges to ensure understanding for optimization of functions, business processes flow, and effective communication (Alemayehu et al., 2021). Research demonstrates that many challenges face the construction industry in general, which is a major cause for the poor implementation of BIM education and training (Mohammed etal., 2017; Stefan Mordue & David, 2016).

The lack of awareness and collaboration among stakeholders, inadequacy of requisite experience, knowledge, and skills from the workforce, longer time in adapting to new technologies, lack of understanding of the processes and workflows required for BIM and sustainability, low level of research in the industry and academia, fragmented nature of the construction industry, the risk of losing intellectual property and rights, difficulty in allocating and sharing BIM-related risks, lack of legal framework, increased risk and liability, incompatibility issues with different software packages, absence of industry standards for BIM, insufficient level of support from the BIM software developers, user-unfriendliness of BIM analysis software programs (Mohammed et al., 2017; Olawumi et al., 2018).

The top ten obstacles to the application of Building Information Modeling (BIM) in the Gaza Strip industry were determined by AbuHamra's master's thesis. These include a lack of awareness, a lack of interest in BIM, a lack of qualified engineers and architects, a lack of education and training, a lack of client interest, a lack of government regulations, and the conviction that the CAD systems and other traditional programs currently in use are adequate for effective project design and completion. AbuHamra also emphasized the dearth of actual examples of BIM implementations that have been successful and shown a positive return on investment in the Gaza Strip or the surrounding areas. To raise interest in and awareness of BIM, she suggested education and training (AbuHamra, 2015).

The limitations and difficulties of implementing BIM in the Jordanian construction sector were investigated by Matarneh and Hamed (2017). They found that lack of training staff on new process and workflow; lack of training staff on new software and technology; absence of effective implementation of the new process and workflow; the lack of establishing the new process, workflow and client expectations; lack of understanding BIM enough to implement it; the lack of familiarity with BIM use; reluctance to initiate new workflows or train staff; lack of the capital to invest, the risky nature of BIM tools from a liability standpoint; resistance to culture change are some of the challenges and barriers of BIM implementation in the Jordanian construction industry (Matarneh & Hamed, 2017). To alleviate these barriers they recommended training, client and government support to effectively mitigate the barriers and challenges to implementation, and they highlighted an implementation guideline to help address BIM implementation issues (Sriyolja et al., 2021; Umar, 2021).

By offering guidelines on how to use BIM, defining levels of BIM work, offering training, creating data exchange standards, and creating new contract forms to address the obstacles to BIM implementation among Hong Kong designers, Chan and Caroline suggested expanding the adoption of BIM support from governmental and professional organizations. She found that: lack of qualified in-house staff to carry out the BIM related works; lack of training/education; lack of standards; lack of client demand; lack of governments lead/direction; High cost; uncertainties over interoperability of BIM software with other software; lack of IT infrastructure; uncertainties over ownership of data and responsibilities; lack of new and/or amended forms of construction contracts; current professional indemnity and insurance terms are some of the prevalent BIM barriers in designers in Hong Kong (Chan, 2014).

Different documents have classified these BIM implementation barriers in to different sections. Chuck classified them into two categories: process barriers to the business, including legal and organizational issues that prevent BIM implementation; and technology barriers related to readiness and implementation (Desbalo, 2020; Sacks et al., 2018). Majed classified them into six sections as: personal barriers, BIM process barriers, business barriers, technical barriers, organizational barriers, and market barriers (Majed, 2015). Abdul-Majeed classified these barriers as; BIM-specific, design specific, team oriented, project related, organizational, industry related, and cost related (Mahamadu et al., 2017). A study by Shijing aimed to identify, classify, and prioritize barriers to BIM implementation in the AEC industry have categorized these barriers into five groups (Shijing et al., 2015). There are subgroups within these main categories. The absence of a national standard (incomplete national standard, lack of information sharing in BIM), high application costs (high initial software cost, high implementation process cost), a shortage of qualified staff (lack of professionals, high training and education costs), organizational problems (process issues, learning curve, lack of senior support), and legal issues (ownership, responsibility for inaccuracies) are the five main groups and their subgroups.

Javad reviewed over 100 studies to summarize available information related to the implementation of BIM (Majrouhi S. et al., 2018). They found that using BIM presents many difficulties, but that some of these issues have been mostly addressed over time and with advancements in related technologies. The biggest barriers to implementing this technology are those related to contracts and laws, cultural issues, management systems, and security and economic concerns. They concluded that many barriers would be solved over time by knowing the issues of today and providing more real-world examples. They pointed out that the support and guidance of governments plus the mandatory use of BIM in specific projects, will increase the speed of BIM implementation (Majed, 2015; Majrouhi et al., 2018).

The above-reviewed literature on the barriers of BIM implementation and adoption shows that a lack of training and education is among the top factors that affect the spread of BIM technology in general. The researchers conducted an interview with the study population to know the major challenges that were faced by the stakeholders in promoting and implementing the BIM training and education in their organization and the results are presented below. Annual plans and the respective monthly reports were also analyzed to identify the challenges that these organizations face in an attempt to implement BIM education and training.

For the ease of the report, the researchers classified the study results of the challenges that limit the application of BIM training and education in Ethiopia into five groups: Technology related, Cost related, Management related, Personnel related, and Legal related. Technology challenges include issues with BIM tools that prevent BIM from being used, like a lack of standards and protocols, and information about the availability of BIM software. Financial limitations in the BIM application process, including the acquisition of BIM-based hardware and software, software service fees, and training expenses, are referred to as cost-related issues. The fragmented nature of the construction industry, inappropriate business models, a lack of cooperation from other industry partners, the attitudes of participants toward BIM applications, the absence of successful cases and management standards for reference, and other management factors were the process and organization-related limiting factors (Sun et al., 2017). The personal factors mentioned by the respondents were the professional-related limiting factors, such as; lack of experienced personnel who are familiar with BIM and professionals' hesitation to use BIM. There was also noticed legal factor that shows the lack of a mature contractual and regulatory environment.

The Ethiopian Construction Management Institute trains only 25 trainees in one round due to the limitation on the number of BIM-compatible computers and the infrastructure available in general. Similarly, the high costs to buy BIM software and the costs of the necessary hardware updates are a major bottleneck for the stagnation of the process in almost all studied universities. In addition, the high cost of the training process includes other costs which are related to the trainees' consumable costs such as goods, canteens, per-dem, hotel fees, etc.

The major challenge mentioned by all stakeholders is the lack of overall awareness by stakeholders about the benefits, tools, processes, and workflows required to implement BIM education and training in the country (Alemayehu et al., 2021; Puolitaival & Forsythe, 2016). The other gap is that there is a lack of effective collaboration among project stakeholders to exchange necessary information for BIM promotion, due to less concern given to developing BIM education and training. The results obtained from the respondents show that there is a resistance to change which means resistance by institutions to any change that occurs in the teaching system and the refusal to adopt a new technology education due to the inflexible system for revising curricula in this way. The universities also mentioned that the Ministry of Science and Higher Education by itself should initiate universities to include BIM courses in their curriculum. Hence, it can be said that lack of government's lead/direction is a cause for the less experience of universities on including BIM in the curriculum.

The respondents also commented that the government should provide incentives to the researchers, professionals and groups who research, teach, and promote BIM education and training in the country. Low level of research in the industry and academia related to Building Information Modeling (BIM) is also identified as a challenge to promote BIM education and training in Ethiopia.

Technical obstacles to the implementation of BIM education and training programs include inadequate information technology infrastructures, a lack of interoperability because of software incompatibilities between various design and analysis programs, which prevents integrated models and collaborative working, and a complex and time-consuming modeling process implementation. The respondents also noted that universities lack qualified professionals with BIM experience, knowledge, and skills in BIM tools and BIM implementation, that it takes longer to adopt new technologies, and that they believe the current computer-aided design system and other traditional programs are adequate for designing, carrying out, and finishing projects efficiently. Incompleteness or unclear national standards and strategies for BIM are also another legal-related challenge for BIM education and training.

Throughout the interview, the respondents frequently cited the following top challenges: a lack of government leadership or direction; a lack of budget to purchase BIM software and pay for necessary hardware updates; a lack of professionals with experience, knowledge, and skills in BIM tools and BI; and a lack of general awareness among stakeholders regarding the benefits, tools, processes, and workflows needed to implement BIM education and training in the nation.

The reports of the Ethiopian Construction Management Institute reveal that universities are not active when they are requested to send the list of trainees for BIM training and they don't send staffs in the four disciplines needed i.e., project management, architecture, MEP (mechanical, electrical and plumbing) and mechanical engineering rather they send in a scattered way or they send staff in one discipline only. In addition, universities don't ask the staff when they return to their office during post training regarding what they got from the BIM training and subsequent actions. This shows the less interest of the universities in disseminating BIM education and training. Universities have failed to use an open access opportunity to BIM software and training that was provided by CMI by collaborating with Autodesk.

Lack of academic expertise and experience, reluctance to alter conventional teaching methods, and a shortage of space for new courses are some of the obstacles to the adoption of Building Information Modeling (BIM) in higher education and business. The objective is to adapt the curriculum to incorporate BIM if it is eventually replaced by another technological process. Concerns have also been raised regarding the curriculum's accreditation status, the small number of programs available to students, and the conventional departmentalization of students. Additionally, students might be reluctant or uninterested in examining new technology. Academics may feel overburdened when attempting to keep up with the rapid evolution of BIM processes. Because BIM demands a resolute understanding of business practice and workflow, the current staff may find it difficult to adjust to the new skills required. Books and training materials are also in short supply, and BIM necessitates expensive software and cutting-edge IT hardware. Questions concerning who oversees and will pay for multidisciplinary courses may arise as a result of universities' difficulties in locating the ideal IT environment and potential mistrust among academic professionals.

3.3 BIM Training and Education Framework

Industry stakeholders need to learn and implement a wide range of concepts, tools, and workflows that are part of BIM, a transformative approach to design, construction, and operation in the built environment (Gangatheepan, 2022). BIM education has been led by countries such as the USA, UK, Germany, Canada, and France (Liu et al., 2022; McGraw Hill Construction, 2014).

The U.S. has long been a world leader in this process (Kassem & Succar, 2017). In 2007, they ordered the use of BIM to validate spatial programs in all their projects and developed internationally recognized guidelines and standards (Khemlani, 2012). The UK government introduced an implementation strategy considered to be the most ambitious centrally driven one in the world (Byrne, 2015). In 2011, through an implementation phase, the UK required that, by 2016, all government projects would require BIM (Smith, 2014). The world's top adopters of BIM are Norway, Denmark, and Finland. Their creation has generated interest around the world, and they released universal guidelines for industry to set a standard in the European Union. They also make large R&D investments. China, Brazil, Australia, and Singapore have all supported programs, guidelines, and tactics for successfully putting BIM into practice (Smith, 2014).

Role of Government

The involvement of the government is vital in the spread of the implementation of BIM and the delivery of BIM education (Silverio et al., 2017). Byrne recommends governments to give guidance in BIM education by implementing an organized method of collaboration through identifying and funding a proper and valued industry organization to carry out a lead role for BIM; promoting BIM alliances among industry and educational institutions for research and the development of construction projects; and creating a BIM learning framework for academics, current practitioners, clients and new entrants (Silverio et al., 2017). The following are strategies that governments of various BIM leader countries have adopted to support and promote BIM education (Walking et al., 2020):

- To get ready for the adoption of BIM Level 2 in supply chains and government, the UK government formed the BIM Task Group (Silverio et al., 2017). This organization has set opportunities to deliver resources, education, and training to the government and the industry (McGraw Hill Construction, 2014). In addition, representatives from numerous UK universities have joined the BIM Academic Forum (BAF), which is devoted to improving BIM education. This group focused on creating an academic framework for BIM (Walking et al., 2020).
- The Scandinavia region (Finland, Norway and Denmark) has provided resources for education training and diffusion of case studies; and has worked for the enhancement of BIM education at university level.
- Singapore’s Building Construction Authority (BCA) created a roadmap where education and motivational programs were set up to support the adoption of BIM in the AEC industry (McGraw Hill Construction, 2014).

As per Sanchez, Kraatz, & Hampson, a government mandate would give the required context for BIM education providers (such as higher education and technical institutions) and professional organizations to cooperate in the creation of new courses to upskill the professionals of the construction industry who are getting ready for the mandate (Grierson, 2009).

Curriculum design strategies for BIM-related subjects

BIM integration in companies means that new pedagogical strategies must be introduced into curricula to adequately train students and future members of the professional sector (Besné et al., 2021; Fridrich & Karel, 2014; Grierson, 2009; Shelbourn et al., 2017). In other words, for future professionals to be competitive in BIM methodology, universities must be able to train their students today (Besné et al., 2021). For this reason, higher education institutions, as generators and promoters of knowledge (Romero et al., 2020), need to implement BIM in their curricula now.

Curricula have one objective, which is to provide students with the necessary competencies for their future professional work (Besné et al., 2021). It is necessary for institutions to train students such that they achieve the knowledge and skills necessary to meet the requirements of the construction industry (Besné et al., 2021). The incorporation of BIM in architecture, engineering, and construction (AEC) degrees should not change this objective or its content, but rather it should change the teaching/learning methodology (Alfaro González et al., 2019).

Reflection is needed on how to strengthen the link between academic activities and subsequent professional practice, and between institutional education and the practical requirements of the industry (Vimonsatit & Htut, 2016). Industry-wide BIM practices depend on cooperation and uniformity. To put it another way, a variety of standards make BIM installations and collaborative work easier. A future professional must be taught collaboratively in order to work collaboratively, as multiple publications have shown. This approach brings the student closer to real-world practice. Therefore, collaboration is required if curriculum implementation is to be carried out. This is a reference to a standards-based curriculum (Besné et al., 2021).

For students to experience and gain knowledge of BIM implementation procedures, BIM studies are crucial. According to a content analysis of BIM-related subjects, some places more emphasis on developing technical skills, documentation techniques, and BIM execution plans, etc., while others concentrate mainly on the ability to recognize, apply, and characterize the fundamental understanding of BIM principles, maturity levels, and drivers (Walking et al., 2020).

Project-oriented academic programs can teach and use a wide range of BIM-related concepts and tools. In order to improve BIM learning, technical skills related to BIM, teamwork, and the integration of AEC disciplines are all complementary (Nenonen et al., 2016). Advanced technologies like virtual reality (VR), augmented reality (AR), mixed reality (MR), and sensing and tracking (3D laser scanning, photogrammetry, etc.) are taught in higher education institutions around the world.(Walking et al., 2020). Building Information Modeling (BIM) courses are available all over the world and cover topics like digital fabrication, environmental simulation, facility management, BIM coordination, digital fabrication, 3D modeling, 3D visualization, BIM documentation, 4D scheduling, and 5D costing. Modeling, visualization, ISO standards, project briefing, scheduling, costing, environmental simulation, facility management, IFC coordination, model collaboration, change management, scanning tools, incorporating spatial tools, data interoperability, and digital fabrication are all covered in these courses (Alizadehsalehi et al., 2020; Walking et al., 2020).

The most popular BIM application methods, according to the Australian BIM Association, are 3D modeling and BIM documentation. Among the BIM tools used by universities are Revit, ARCHICAD, Microsoft Project, Navisworks, Tekla, Bentley, Intergraph, Dynamo Solibri, Synchro PRO 4D, Autodesk Recap, Autodesk BIM 360, and Unity(Walking et al., 2020). While design-oriented courses like architecture use BIM for visualization, management disciplines emphasize collaboration and communication. To bridge disciplines, interdisciplinary approaches and teamwork are essential, even in the face of diverse educational activities. These findings show how various BIM technologies and tools can be integrated (Porter, 2010; Walking et al., 2020).

Prerequisites in BIM-related subjects

The importance of prerequisites in BIM learning has been a controversial subject within the field of BIM education (Porter, 2010). Whether or not students must learn CAD drawing before learning to use BIM tools is one of the primary questions that researchers posed. According to some researchers, learning CAD, working with physical models, and manually sketching and comprehending drawings are necessary before learning BIM. Furthermore, since BIM must aggregate all the information needed for building realization, BIM users must possess more trade-specific knowledge than CAD technicians. The University of Southern Queensland's BIM-related unit "CMG1002 Residential Construction: Methods, Materials, and Management" requires completion of the course "CMG1001 Introduction to Construction Management and the Built Environment (Walking et al., 2020).

Teaching Mode

Over 90% of universities (19 out of 24) used an on-campus teaching mode, according to an Australian study. Workshops (47.6% – 10 out of 24), practical (52.4% – 11 out of 24), and group activities (66.7% – 14 out of 24) followed. Almost all subjects combined a variety of instructional strategies (Walking et al., 2020). Table 1 below lists the categories of teaching modes. For example, the University of Queensland's "CIVL3510 Project Management with Building Information Modeling" unit blended lectures with workshops and hands-on computer lab experience with BIM and project management software. Only a small number of subjects covered problem-based learning and workplace-based learning. (Melbourne, 2021; Walking et al., 2020).

Table 1: Teaching mode categories(Walking et al., 2020)

Teaching mode	Explanation
On-campus	Face-to-face lectures, classes, and class discussions
Online	Online learning, webinars, and online learning activities
Workshops	Intensive workshops (2-3 days duration), practice-based workshops, group workshops, intensives
Group activities	Team-based learning, tutorials, seminars, and presentations
Practical	Computer laboratory, practical learning, problem-based learning, work-based learning, problem-based exercises, problem-based collaborative learning
Private study	Individual study
Studio	Desk critiques, studio work

Assessment type

Table 2 lists the subject assessment type information pertaining to BIM based on the data that is currently available. The most typical assignment type in BIM-related subjects is modeling and documentation using BIM tools. It should be required of students to prepare both solo and group presentations. Assessments by industry professionals and peer evaluation techniques have been implemented in BIM courses in addition to presentation report and model-based project assessments (Porter, 2010; Walking et al., 2020).

Table 2: BIM-related subject assessment type (Walking et al., 2020)

Teaching mode	Explanation

Presentation	Oral presentations, group presentations, portfolio displays, oral pitches, and class presentations
Quiz	Tests, individual tests, and class quizzes
Exam assignments	Theory tests, continuous assessments, learning outcome-based evaluations, case studies, reports on problem-solving, self-reflection, and personal assessments, as well as written assignments, tender assignments, Microsoft Excel assignments, peer review assignments, concept designs, and energy analysis reports
BIM report	BIM implementation plans, group BIM reports, BIM technical reports, and reports (using software tools)
Group assessments	Workshop exercises, virtual construction and collaboration, group-based case studies, and individual team contributions
Professional activities	Practical projects, industry field studies, month-long on-site events, workplace projects, and facilities management handovers
Practical/model-based/project assessment	CAD Revit tests, detail studies, BIM modeling, construction simulations, quantity extractions, 2D+3D graphical representations, 3D BIM model analysis, group projects, model-based construction detailing, lab exercises, design projects, model development, BIM applications, technical documentation extraction, and real-world applications are all included in this.

Academic Education Frameworks

The frameworks for BIM education examined here are from New Zealand, Australia, and the United Kingdom.

IMAC Framework

The Australian Office of Learning and Teaching (OLT) funded a project called Code BIM for the elaboration of a framework that could assist AEC academics in the insertion of collaborative programs using BIM tools and procedures (Macdonald, 2012). The framework consists of two parts: an independent implementation guide and a benchmarking tool. It does not specify which academic year each of its four stages should be inserted in, but they do describe various levels of accomplishment (Table 3). Although simple, this framework demonstrates an effective approach to BIM education in academic settings: Students receive an introduction to BIM in their field of study first, after which they learn technical skills specific to their field and begin learning about BIM concepts. Following that, they gain the ability to collaborate with individuals from different disciplines on a BIM project and solve problems in their fields (Silverio et al., 2017).

Macdonald states that the benchmarking tool of this framework has been implemented at the three universities part of the Code BIM to benchmark existing courses, projects, and outline goals for future curriculum improvement (Macdonald & Granroth, 2013).

Table 3: Analysis of the Frameworks in the Literature (Silverio et al., 2017)

Sections	Points covered	Actors involved
Frameworks for BIM education in Academia		

Australia's IMAC framework Code BIM Project: University of Technology Sydney, University of South Australia, University of Newcastle, and Australian Office of Learning and Teaching (JMacdonald, 2012; Macdonald & Granroth, 2013; Walking et al., 2020)	Stages of the framework: • Illustration • Manipulation • Application • Collaboration	Provides a benchmarking tool and a guide to assist academics in the insertion of collaborative design education and BIM in AEC curricula	Providers: Academia Beneficiaries: Students (levels not specified)
New Zealand's national draft framework: The University of Auckland (Miller et al., 2013)	Architecture, Engineering, Construction, Software and Technologies, Business, Enterprise, and Management are the three domains covered by the study's outline of the three forms of education necessary for a Building Information Modeling (BIM) educational framework: research, undergraduate and graduate degree programs, and vocational training.	The proposal suggests creating an Integrated BIM master's program, incorporating Building Information Modeling (BIM) into current bachelor's degree programs, and investigating research in other fields outside of the framework.	Providers: • Academia • CPD providers Beneficiated: • Current AEC practitioners • Undergraduate, master's, and research students
Frameworks and roadmaps for BIM education in the industry			
Kumar's framework (UK) (Kumar, 2015)	Elements • BIM champion • Perception of challenges (internal and external) • Training program	A BIM strategy is suggested for organizations to meet the levels of expertise required for the implementation of BIM	Providers: • Industry Beneficiated: • Current AEC practitioners
Kumar's roadmap (UK) (Kumar, 2015)	Through the analysis of BIM Task Group documents and the development of a thorough training plan that is updated based on audits and feedback, the government is disseminating knowledge about its BIM strategies(Kumar, 2015).	• Diffusion of governments' BIM strategies in the organization. • Elaboration of a BIM training strategy	Providers: • Industry • BIM training providers Beneficiated: • Current AEC practitioners
Framework for BIM education in Academia and the industry			
Collaborative BIM education framework from the BIM Education Working Group (EWG) (Australia) (Kassem & Succar, 2017)	The BIM Institute provides an industry framework for professional development, an academic framework for BIM education, and the ability to identify, categorize, organize, design, and implement BIM competencies(Kassem & Succar, 2017; Silverio et al., 2017).	Within an industry framework, the project seeks to identify BIM competencies, create an online BIM learning hub, expand current CPD programs, develop an academic framework, expand current software, and establish a BIM institute.	Providers: • Academia • Industry • BIM training providers Beneficiated: • Current AEC practitioners
Learning Outcomes framework (UK) BIM TASK GROUP and BAF (Underwood & Ayoade, 2015)	The original framework was divided into three categories: technical, management, and strategic. Understanding the fundamentals of BIM, its Level 2 requirements, its relationship to the	Offers the learning objectives (LOF) required for a successful BIM level 2 implementation. It can be used in academia as	Providers: • Academia • Industry • BIM training providers Beneficiated:

	Government Construction Strategy 2025, its implications and organizational value, and the 1192 suite of standards' information management and exchange requirements are the main topics of the final version.	well as the industry. The LOFs are defined for undergraduate levels (4, 5, and 6) and postgraduate levels (7) for implementation in academia.	• Current AEC practitioners • Students (levels not specified)

New Zealand's National Draft Framework

In order to initiate discussions and establish a consensus among academics regarding a national BIM educational framework, the University of Auckland in New Zealand developed a draft educational framework (Silverio et al., 2017). For the development of the framework, knowledge domains were classified and mapped to the NZQF (New Zealand Qualifications Framework) (Table 3). Although the study believed it was too soon to decide on the programs' content, a list of objectives and anticipated learning outcomes was provided to stimulate discussion. The study recommends more research to develop the suggested learning outcomes. The unique requirements of SMEs must be taken into account in such research (Miller et al., 2013; Silverio et al., 2017).

Kumar's Framework

According to Kumar, it is crucial for an organization to develop a BIM strategy in order to ensure that it has the requisite levels of expertise to apply BIM technologies and processes to its projects. This framework outlines three steps that an organization must take in order to be prepared to create training and policy strategies through its three elements (Table 3)(Silverio et al., 2017). The first recommendation is to designate a BIM champion, who must be an enthusiastic individual with extensive BIM knowledge. Secondly, the organization needs to assess the challenges that affect the implementation of BIM. This assessment needs to consider internal (i.e. cultural resistance, lack of BIM skilled personnel) and external challenges (i.e. high competition, lack of BIM qualified professionals locally) (Silverio et al., 2017). After that, the framework states that the organization is ready to create a training and policy strategy (Kumar, 2015; Silverio et al., 2017).

Kumar's Roadmap to be implemented in the UK Construction Industry

Along with the framework, Kumar proposes a roadmap organization can apply once they are ready to develop BIM training (Kumar, 2015). Five phases are taken into consideration in the roadmap (Table 3). The first two concentrate on how the UK BIM strategy spreads throughout the company. An assessment of the organization's training requirements is then recommended. Following the identification of training needs, a training and policy strategy is developed, comprising the following: 1) The training's classification based on the Learning Outcomes Framework (LOF), which will be described in the following framework 2) Staff identification and classification 3) Determining the organization's pertinent staff training needs 4) Creating the training programs. 5) Implementation 6) Audit and feedback (Silverio et al., 2017).

Education Frameworks for Academia and Industry

Collaborative BIM Education Framework from the BIM Education Working Group (EWG)

The framework recommends working together to identify BIM competencies before creating BIM learning modules. To create learning modules that must be analyzed and categorized, these competencies must be categorized and arranged. It is suggested that BIM education providers and other stakeholders collaborate through an online learning hub. The establishment of academic and industry frameworks is suggested by two elements. The industry framework seeks to develop and disseminate cooperative BIM training, including CPD courses. The expansion and development of new accredited programs are the main goals of the academic framework. The establishment of a National BIM Institute to advance BIM education and facilitate the application of the Collaborative framework is the last element (Silverio et al., 2017).

Learning Outcomes Framework (LOF)

In order to inform and guide academia, organizations, training providers, and private educators in developing and delivering training programs to industry professionals, the BIM Task group released a draft BIM Learning Outcomes Framework (LOF)(Silverio et al., 2017). The framework was initially outlined to focus independently on three functions: Strategic, Management, and Technical (Yumpu.com, 2016) Subsequently, the BIM Task Group in collaboration with the BIM Academic Forum (BAF), developed a 2015 version of the LOF. This version contains the BIM level 2 support documents and covers academic and industry feedback on its implementation, presentation format, organization and content (Underwood & Ayoade, 2015) The LOF does not give training or programs content. It presents the topics that should be taken into consideration for standard BIM level 2 executions (Yumpu, 2016).

BAF LOF

BAF held a workshop in 2012 with the goal of showcasing their early work on the BIM academic framework and the preliminary results of previous working group sessions to a larger audience. The workshop also aimed to help further improve the framework and the associated learning outcomes. The learning outcomes (BAF LOF) required for undergraduate degrees (levels 4, 5, and 6) and postgraduate degrees (level 7) were established during the workshop. Architecture, architectural technician/technologist, building services engineering, civil engineering, construction management, construction project/design management, quantity surveying, and BIM Masters are among the fields they take into consideration (Silverio et al., 2017). The learning outcomes are divided into three categories: Knowledge and understanding; practical skills and transferable skills (Underwood & Ayoade, 2015). The term BAF ILO, which means Intended Learning Outcomes, is presented by underwood and refers to the three categories previously mentioned (Underwood & Ayoade, 2015).

Comparison of BIM Education Frameworks

The IMAC is a visual framework that describes the teaching process with an emphasis on learning principles and the best ways to acquire knowledge. It illustrates the steps students must take in a BIM learning process but excludes learning objectives. Since the framework does not specify the year or type of education for each stage, its implementation is open. Research, VT/CPD, bachelor's and master's degrees, and other forms of education are all included in the national draft framework for New Zealand. It only explains VT/CPD education, though, and is ambiguous. To complete the framework with learning outcomes, more research is required(Silverio et al., 2017).

Kumar's framework is a straightforward, visually appealing, and comprehensive planning tool for businesses looking to create a training plan. It aids in self-evaluation and recommends categorizing training using the LOF framework. The only framework that suggests industry and academic cooperation for BIM education is the EWG collaborative BIM education framework. It is a draft that suggests national-level BIM education strategies, much like the framework in New Zealand. It makes two recommendations, one for academia and one for business, emphasizing the value of cooperation in both areas for the improvement and creation of new courses. The process of delivering BIM education in these domains is not described by these two frameworks, nor do they include any BIM learning objectives.

The LOF is a national BIM framework that construction companies and academic institutions use with great efficiency. Although it is tailored to BIM Level 2 requirements, learning outcomes are more universal when used in academic settings (BAF LOF). Compared to undergraduate degrees, master's degrees must meet more learning outcomes according to the framework. There are only two instances of the IMAC and BAF LOF being used practically: one is for developing a new course (UTS) and the other is for using it as a benchmarking tool for course improvement (UniSA). Although the LOF is unique to BIM Level 2, master's degrees are better suited for its general use (Silverio et al., 2017). The usage of the framework as a benchmarking tool could be seen in the study of Tran (Tran et al., 2012) where the mapping process of the two courses against the framework is explained in detail. However, the usage of the framework for the creation of new courses could not be explored very well as Rooney does not specify how this process was done in the IPD Studio Class at UTS, and there were not found no other sources were found containing this information (Rooney, 2017). However, the BAF LOF implementation example at Loughborough University demonstrated the value of learning outcomes for the development and content direction of BIM programs. The three new courses were created under UK BIM Level 2 requirements, and every topic that would be taught to the students was detailed (Silverio et al., 2017).

Proposed BIM Education Framework to the Ethiopian Construction Industry

Students, members of professional associations, anticipated industry practitioners, and current clients are the target audience for the suggested conceptual framework. In order for the public sector to take the lead in industry digitization, the government should encourage stakeholders and industry stakeholders to comprehend how BIM benefits them, adds value rather than cost, and is an essential first step. In order to overcome the constraints imposed by proprietary software, a collaborative environment—a prerequisite for the adoption of BIM—must be established through the use of integrated contracts, new forms of collaboration, and open data-sharing standards(World Economic Forum, 2018). Its development was aided by a review of the literature on BIM training and education as well as the updating of BIM education frameworks around the globe. Because it is based on the findings of a PhD thesis conducted in the Dominican Republic, the framework is advantageous to this nation (Silverio et al., 2017).

The framework tries to follow governmental BIM mandates mentioned in the strategic plans. In the development process, the key stakeholders for an implementation of BIM in Ethiopia were identified; (construction industry council, public clients, ministry of innovation and technology, ministry of urban development and construction, ministry of science and higher education, construction management institute, universities and training institutes and professional associations) and the framework was first grouped in to one for academic and one for industry in general separately.

According to the literature, academia and industry should collaborate to deliver Building Information Modeling (BIM) education. This is because the process requires participation from both domains. While the literature outlines steps to improve BIM education, the industry section is integrated into the academia section. These actions are categorized according to the industry or academic domain in which they must be implemented. The three phases of each area are strategy, implementation, and revision. According to the literature, the most important factor in preparing BIM-skilled professionals is academic BIM education. Compared to the industry framework, the academic framework is more intricate. The EWG framework recommends developing an online platform where all actors can collaborate (Kumar, 2015; Silverio et al., 2017).

Collaboration with industry is the first step in Academia, and leadership is essential for strategy development in both sections of the framework (Kumar, 2015; Silverio et al., 2017). Academics and business professionals should establish appropriate associations to enhance BIM education, ideally with government backing, to influence academia and streamline business procedures (Silverio et al., 2017). The strategy can be established by a BIM champion, who is designated by the company, as suggested by Kumar (Kumar, 2015).

The actions in the implementation stage are very different in both domains (Silverio et al., 2017). In Academia is mostly based on: the preparation of the educators; the creation of BIM programs and the insertion of BIM in existing programs; the elaboration of BIM teaching material; the encouragement for students to develop more their skills through the diffusion of other types of BIM education (workshops, conferences, seminars, etc.); and the creation/support of post-graduate programs (masters, research, etc.). For the preparation of the BIM programs, the developers must include all the aspects needed for professionals to manage a BIM process in a project (Silverio et al., 2017). As stated by Maghiar (2016) BIM programs should teach students the following aspects for them to be able to implement BIM successfully in real-world scenarios: workflow of construction process; how technology is applied in this workflow; roles and responsibilities of the construction parties: designers, owners, construction managers; cooperation and integration of people in the construction delivery; and interoperability and capacity of the software implemented. According to the IMAC framework, students should learn how to collaborate across disciplines on BIM projects by honing their skills and taking part in group projects (Kumar, 2015; Silverio et al., 2017).

Depending on their position within the company, employees must receive education and training during the Building Information Modeling (BIM) implementation stage. If they have qualified employees, public clients, members of professional associations, or trainers from the Construction Management Institute can offer this. Additionally, BIM education can be enrolled in summer or short-term programs offered by Academia or other providers. Even clients who are not employed in the construction industry should be encouraged to engage in the BIM process by the industry. If clients are interested or judged necessary, they can take part in educational activities like seminars and brief programs. Following the BIM education plan's implementation, the revision phase is essential to verifying the plan's effectiveness, with input from students being essential in Academia(Kumar, 2015; Silverio et al., 2017). With their collaboration, it can be identified if all the material and programs provided helped them to get the knowledge they were seeking (Rodríguez, 2020). According to Byrne, this initiative is being implemented in the UK, where universities are being examined by undergraduate students about the BIM content of the programs (Byrne, 2015). By analyzing student performance, instructional strategies, and course materials, academics can determine how effective BIM education programs are. This enables them to fill in knowledge gaps and pinpoint areas in need of development. If internships and partnerships for knowledge transfer are feasible, industry input can be used to pinpoint gaps and enhance teaching methods and curricula. Accreditation is advised following revision to foster confidence among BIM students and promote their spread. This can be accomplished in the workplace by comparing project results before and after BIM training, as well as by assessing the performance of employees and clients. This procedure aids in filling in any knowledge gaps and guarantees the caliber of education (Byrne B., 2015; Kumar, 2015; Silverio et al., 2017).

Table 4: Proposed Framework

Academia			
Strategy stage	Implementation stage		Revision stage
	Actions	Participants involved	
• To develop and promote the required standards, protocols, practices, legal frameworks, and educational programs by an industry-accepted implementation strategy, timeline, and scale, encourage local collaboration, and establish groups across industry bodies and institutions.	Provision of education and training is required for the educators.	Universities and CMI Professional associations Training institutes Industry	Evaluation of the developed programs through input from:
	Elaboration of the learning modules: To be incorporated into existing programs For the development of new programs	Universities and CMI Professional associations Training institutes Researchers	• BIM students: to voice their thoughts regarding courses and learning objectives
	Creation of BIM learning materials for new modules inserted and programs modified.	Universities and CMI Professional associations Training institutes Researchers	• Academics: by examining students' development and performance
• Identify the BIM competencies that each discipline's trainers and students must possess.	Practical implementation of the knowledge acquired: Knowledge transfer partnerships, Internships and Co-ops.	Academics: for planning Industry: to provide opportunities to the BIM learners. Government: to promote this practice in BIM education.	• Industry: by assessing the abilities of BIM students during planned practical implementation exercises.
• These skills are categorized by themes based on the knowledge disciplines of the construction sector.	Dissemination of additional BIM-related education and learning opportunities, including workshops, conferences, seminars, and other events, to increase understanding and acquire transferable skills(Rodríguez, 2020).	Universities and CMI Professional associations Training institutes Researchers Other government bodies	
	Establishing the minimal knowledge needed to pursue advanced degrees, like master's degrees. In other words, students who have knowledge gaps should not be taught new material (Rodríguez, 2020).	Academics Industry: to identify problems in practice and propose research in the field	

Industry			
Strategy stage	Implementation stage		Revision stage
	Actions	Participants involved	
Determining the organization's BIM scope and the BIM skills needed by the employees.	Universities required a large sum of money. A sizeable portion of the budget goes toward training	Universities	Evaluation of the performance of the staff and the client
Determining the training that employees must complete based on their team roles and the demands of the projects they	Acquisition/upskill of software abilities:	Provided by: Software developers; Expert(s) hired by the organization Skilled staff from the	comparisons between project results and

are working on(World Economic Forum, 2018).		company designated by the BIM champion(Silverio et al., 2017)	performance prior to and following the approach(Silverio et al., 2017).
	Learning various transferable skills: Extension initiatives Participate in seminars, conferences, workshops, etc.	Provided by: Organization BIM education providers	
	To obtain advice in the following fields: Overview of BIM Setting the project's BIM objectives: Management of documentation(Rodríguez, 2020)	BIM consultant from: Universities The organization An independent BIM consultant	

4. Conclusion

The practice of BIM education and training among the key stakeholders who are believed to have potential roles in the adoption and implementation of BIM Technology was evaluated, and the following conclusions were drawn from the analysis and discussions.

The findings revealed that the industry's demand for and coverage of BIM education are rapidly increasing. CMI is essential to the training of professionals in academia and business. According to the literature reviewed for this study on the difficulties in adopting and implementing BIM, one of the main things preventing BIM technology from becoming widely used is a lack of education and training. The challenges that were mentioned repetitively during the interview with the respondents and the monthly/ annual report analysis were: lack of overall awareness by stakeholders about the benefits, tools, processes and workflows, required to implement BIM education and training in the country, absence of a budget to buy BIM software and costs of the necessary hardware updates, lack of government’s lead/direction and shortage of trained professionals with experience, knowledge and skills on BIM tools and BIM education and training., a lack of effective collaboration among project stakeholders to exchange necessary information for BIM promotion, longer time adjusting to new technologies and the way professionals believe that the current computer-aided design system and other traditional programs satisfy the need to design and perform the work and complete the project efficiently. According to reports from the Ethiopian Construction Management Institute, universities are not active when asked to send the list of trainees for BIM training, and they do not send staff in the four disciplines that are required—project management, architecture, MEP (mechanical, electrical, and plumbing), and mechanical engineering—instead sending staff in one discipline or in a disorganized manner. Furthermore, when staff members return to their offices following training, universities do not inquire about their experiences with the BIM training and the actions that followed. One reason for the reversal of progress is the universities' decreased interest in spreading BIM training and education. Additionally, through their partnership with Autodesk, CMI offered open access to BIM software and training, which universities have not taken advantage of.

After reviewing the literature on BIM education and examining existing BIM education frameworks of this kind around the world, the framework that is suitable for our building industry was developed. Professors in higher education, researchers, students, working professionals, members of professional associations, and clients are all given access to education. Three phases are described in the framework for planning the introduction of BIM education in both industry and academia. When creating the framework, recommendations from the literature review and examined frameworks were taken into consideration. For this reason, there are similarities between the proposed framework and earlier frameworks. The framework included some strategic recommendations from the Dominican Republic and EWG frameworks for the Academia section. The steps taken during the strategy and execution phases make this clear.

The collaborative nature of the EWG framework was also appropriate for the proposed framework. As stated in the Dominican Republic framework, the literature review suggests that industry and academia work together to enhance BIM education. However, seeing this collaboration in the EWG framework greatly influenced the development of the proposed framework. Like the EWG, the LOF framework takes industry and academia into account; however, it is based on a government plan and presents learning outcomes, which sets it apart from the suggested framework. It should be emphasized that integrating learning outcomes is advantageous, as it ensures that students acquire the knowledge the company needs. However, the proposed framework did not take into account their inclusion because its goal was to create strategies for delivering BIM education, and it was too early to assess learning outcomes for this country. In the industry segment, Kumar's roadmap and the suggested framework are comparable. Kumar pointed out significant actions taken, particularly in the stages of strategy and revision.

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