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Organizational Readiness for Building Information Modeling Implementation in Malawi: Awareness and Competence

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Abstract: In developed countries, the government primarily supports the adoption of BIM. However, adoption is typically driven by the preferences of industry professionals among construction organizations in developing countries, who rely on their BIM awareness and competence. Thus, BIM competence and awareness have become an important indicator of organizational BIM readiness. To assess the level of BIM readiness, this study aims to determine the BIM competence and awareness levels among Malawian construction organizations. The study surveyed 189 construction professionals and analyzed the data using descriptive statistics and reliability tests. The findings revealed that there is a moderate level of BIM awareness among the organizations. The organizations have BIM-capable software. However, the professionals within these organizations possess a limited proficiency in BIM technical abilities, particularly in performing BIM-related services and executing BIM-related tasks. Therefore, construction organizations in Malawi should prepare for the widespread adoption of BIM by addressing the insufficient technical skills and limited awareness of BIM among their workforce. Furthermore, the study indicates that engaging in collaborative efforts could serve as a valuable foundation for the adoption of BIM within construction organizations.

Keywords: Building Information Modeling (BIM); awareness; competence; Malawi; construction organizations; BIM readiness

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1. Introduction

The construction industry in developing countries faces significant challenges in delivering projects efficiently and effectively. These challenges stem from limited resources, inadequate infrastructure, and a rapidly growing population [1]. Insufficient infrastructure can hamper economic progress, hinder social development, and limit access to essential services [2]. As such, it becomes crucial to explore innovative approaches that can overcome these challenges and enhance construction project outcomes to meet these rising infrastructure demands [3]. Therefore, researchers have been constantly working on studying and developing new methods that could improve construction project efficiency and productivity. Building Information Modeling (BIM) is one of the emerging technologies believed by architecture, engineering, and construction (AEC) industry experts to have the ability to improve construction project efficiency and productivity at lower costs [4].

Succar [5] describes BIM as "a set of interacting policies, processes, and technologies generating a methodology to manage the essential building design and project data in digital format throughout the building's life cycle". Experts, scholars, and several construction industry stakeholders consider BIM as a promising driver for change (i.e., modernization, productivity, and new ideas) in the construction industry [6]. BIM implementation has the potential to benefit the industry in various ways if adopted in projects. The most critical benefits are improved quality, cost reductions, and time-saving. The industry has been paying attention to these benefits and in the past decade, BIM interest has been gradually increasing, recognizing the benefits it provides and resources it saves during the various stages of construction projects [7]. These benefits can be realized by distinct construction organizations in all project types, creating digital models of prospective projects with all the necessary details and information for each stage [8]. Regardless of these benefits, BIM adoption has been slow in developing countries, especially Sub-Saharan Africa, but its awareness is slowly increasing [9].

Similar to other countries, BIM is attracting the interest of construction professionals and organizations in Malawi. According to several studies, the level of BIM awareness and knowledge in developing countries such as Malawi represents a significant barrier to its widespread adoption [10,11]. Chagunda et al. [12] state that there is a need to investigate and understand the role of BIM in the construction sector to take advantage of the knowledge generated by developed countries and to adopt BIM in developing countries quickly. The Malawian construction industry has many professionals in various organizations performing various functions. However, BIM readiness in terms of competence and awareness is unexplored. While there have been multiple studies conducted on BIM adoption in various countries, little or no research has specifically explored BIM readiness levels among Malawian organizations [11,13]. To bridge this gap, this paper assessed the BIM readiness of Malawian construction organizations, specifically regarding their level of BIM competence and awareness.

The findings of the study could provide an all-inclusive understanding of the factors influencing BIM adoption in Malawi and offer practical recommendations for overcoming challenges that may arise. Furthermore, the study can benefit the Malawian construction industry by assessing how familiar and prepared construction professionals are to utilize advanced tools for improving project efficiency. In addition, it would raise awareness and ultimately increase the implementation of BIM in the Malawian construction industry.

The study is structured as follows: Section 1 is this introduction, which introduces BIM in terms of competence and awareness, highlighting the reasoning behind the study and also the aim of the study; Section 2 is the literature review, which contains the literature on organizational readiness and organizational BIM awareness and competence; Section 3 is the methodological approach employed for the study; Section 4 presents the results analysis and discussions; and Section 5 concludes the study by emphasizing its implications, identifying its limitations, and suggesting areas for further research.

2. Literature Review

2.1. Organizational Readiness

Improving construction project delivery requires evaluating organizational readiness through various measurable variables. Several key aspects can be explored in the Malawi construction industry to assess organizational readiness for enhancing project delivery outcomes. These variables provide valuable insights into stakeholders' awareness, knowledge, attitudes, and capabilities, guiding efforts toward effective improvement strategies. Stakeholder awareness and knowledge, which includes their comprehension of present project delivery procedures, difficulties, and prospective changes, are significant variables. A basis for assessing readiness is measuring stakeholders' familiarity with project management principles, construction processes, and emerging industry trends [14], as well as the attitudes and views of stakeholders towards innovation and change. Assessing stakeholders' willingness to collaborate and continuously improve, as well as their desire to accept new practices, can assist in determining how ready they are for change [15].

Adopting new technology is a crucial component of improving project delivery. Akintoye et al. [16] and He et al. [17] found that assessing stakeholders' levels of technology adoption, particularly concerning construction project management and digital tools, can reveal how ready organizations are to take advantage of innovations like project management software, BIM, mobile applications, and other technologies that improve efficiency. A successful project delivery depends on effective teamwork and communication. Assessing stakeholders' abilities to collaborate and communicate throughout the project lifecycle provides insights into their readiness for enhanced coordination, decision-making, and information exchange [18].

To complete a project, stakeholders' skills and knowledge are necessary. It is possible to assess if stakeholders can use efficient project management techniques by measuring their skills in project planning, risk management, cost control, scheduling, quality assurance, and stakeholder engagement [19]. Other important issues include the availability and sufficiency of resources and infrastructure. Assessing organizational readiness for improvement includes looking at their access to the technology, financial resources, qualified individuals, and physical infrastructure required for effective change management [20]. Regulatory compliance is an essential variable concerning organizations' adherence to legal and regulatory frameworks, safety protocols, environmental regulations, and quality standards. Assessing stakeholders' understanding and compliance provides insights into their organizations' readiness to meet regulatory requirements [21,22].

The success of a project is influenced by organizational culture and leadership practices. The capacity of stakeholders to inflict positive change can be determined by measuring how much the organizational culture encourages innovation, teamwork, and customer-centric methods, as well as by evaluating the leadership's commitment to continuous improvement and change management [23]. It is important to take key performance metrics into account. The evaluation of stakeholders' performance and readiness for improvement is made possible by identifying and monitoring measures such as project schedule adherence, cost performance, quality indicators, customer satisfaction, and safety records [19]. The accessibility and efficacy of training and development programs are other vital factors. Stakeholders' readiness to advance their project management skills and knowledge can be assessed by looking at their access to professional development opportunities, certifications, and continuous training programs [24,25].

2.2. Organizational BIM Awareness and Competence

In most developed countries like the US, UK, and Singapore, governments at all levels and construction industry professionals (i.e., architects, contractors, engineers, etc.) support the implementation of BIM. In contrast, developing countries like Malawi are majorly driven by the desires of the private sector and industry professionals, based on their BIM awareness and availability of skills among them [26]. The benchmark for measuring BIM implementation readiness is now BIM awareness and competence. Therefore, it is vital to investigate the BIM awareness and competence of construction personnel to assess organizational BIM readiness in the Malawian construction industry. BIM is frequently incorporated into organizations that consist of teams of professionals [27]. These professionals constitute the fundamental and central elements that impact the efficiency and effectiveness of an organization. Organizations depend on capable individuals who possess the necessary skills and knowledge in their respective roles to attain the best possible results. The competence of individuals within an organizational framework serves as a fundamental pillar of the organization's capability [28].

According to Vu [29], competencies encompass abilities, knowledge, and behaviors that lead to successful performance. Similarly, Succar et al. [27] define individual competence as evaluating a person's capacity to execute tasks and produce outcomes, regardless of their role or position. These definitions are congruent with Demirdoven's [30] interpretation of individual BIM competence, which involves an individual's attributes, professional knowledge, and technical skills as requisites for BIM-related tasks and results. These capabilities, tasks, or results should be measurable against performance benchmarks. They should be nurtured through training, education, or development efforts. BIM readiness for individuals/personnel entails elements of knowledge, skill, and experience in BIM adoption [31]. Conversely, organizational BIM readiness encompasses the effective coordination of management strategies, streamlined processes, skilled personnel, and advanced technologies, all of which facilitate seamless collaborative construction and facility management practices [32].

3. Methodology

A comprehensive study (survey) was undertaken across the whole construction industry in Malawi to investigate BIM awareness and competence levels of construction organizations. Snowball and purposive sampling techniques were utilized to select the construction organizations for the study. The researchers obtained the population of targeted organizations from the latest list of registered construction companies (2046) provided by the National Construction Industry Council (NCIC). Three hundred and thirty-five questionnaires were distributed. The questionnaires were distributed through emails and in person, using Google Forms links and hard copies.

The questionnaires were administered in two sections, with Part A specifically tailored to gather the respondents' background data. Participants were obligated to select a single choice from the multiple options given. Part B of the questionnaire evaluated the respondents' BIM awareness and competence. Respondents assessed their levels of awareness using a five-point Likert scale. For competence, respondents provided the frequency of usage of BIM services according to a Likert scale, provided the software they use for such services in their respective organizations, and also rated their ability to use the provided software according to a provided scale.

The scale used to assess levels of awareness is as follows: 5 stands for very high awareness, 4 for high awareness, 3 for moderate awareness, 2 for low awareness, and 1 for very low awareness; various studies have used a similar approach [33,34]. Severity indices and frequency analyses were employed to analyze the organizations' BIM awareness level. The severity indices analysis is a statistical method without specific parameters that scholars in engineering and technology management often use [34,35]. This method is applied to analyze data from questionnaire respondents who provide ordinal assessments of thinking. It uses weighted percentage scores to prioritize and compare the levels of severity of the organization's awareness.

This analysis has been used by several researchers for similar studies in AEC research globally [34,35]. It ranks factors based on frequencies. The severity index is calculated using the following formula:

$$Severity\ index = \left(\sum_{i=1}^{5} \omega i \times \frac{fi}{n} \times 100\right) / (a \times 100)$$

where i is the rating given to each criterion by the respondent, ranging from 1 to 5. ωi represents the weight assigned to each point (on a scale of 1 to 5, with 1 being very low and 5 being very high). fi is the frequency of each point i as reported by all respondents. n is the total number of responses, and a is the highest weight, which is set to 5 in this study.

When assessing the level of BIM awareness, the overall awareness levels were calculated per organization across the Malawian construction industry. Afterwards, it was deemed necessary to also assess the level of awareness based on work experience for each and every organization to see if indeed the level of work experience affected/impacted BIM awareness in the construction industry [36].

When assessing the organizations' BIM competence levels, descriptive statistics were used to rank the frequency of usage of BIM services among organizations. This analysis involved the mean, standard deviation, and skewness. After this, frequency by count was used to present the statistics of the software the organizations in the industry use for BIM services. Furthermore, to determine and finalize the BIM competence level, the respondents were asked to rate their ability to use the software identified. The ability was measured using a scale ranging from none (no skills at all), beginner (which measures familiarity with the fundamentals of the software), intermediate (which measures the basic understanding of how the software functions), advanced (which assesses knowledge that comes with extensive experience with how the software works), and expert (which measures capabilities to think critically to analyze given situations using the software). This assessment approach to BIM competence has been widely used in research [26,27].

Before analyzing the data for the frequency of BIM service usage among organizations, a reliability analysis was conducted to determine the consistency of the research method (see Table 1). Clark and Watson [37] stressed that it is essential to consider the consistency of the scales used. The factors must be checked before analyzing survey data. Several scholars have highlighted Cronbach's alpha test as the most used and reliable test for internal consistency [37,38]. The coefficients of Cronbach's alpha range from 0 to 1, with 0.7 considered reliable, and if less than 0.7, the variable can be removed to improve the scale. George and Mallery [39] produced a widely recognized guideline for explaining Cronbach's alpha coefficients. The guideline is as follows: A coefficient ranging from 0.90 to 1.00 is considered excellent, while a coefficient between 0.80 and 0.89 is regarded as good. An acceptable coefficient falls within the range of 0.70 to 0.79, but a coefficient between 0.60 and 0.69 is deemed suspicious. A coefficient between 0.50 and 0.59 is considered poor, and any coefficient below 0.50 indicates unacceptable reliability. Cronbach's alpha is calculated as follows:

$$\alpha = \frac{n}{n-1}\left(1 - \frac{\sum iV_i}{V_t}\right)$$

where n is the number of items, V_t is the variance of the total scores, and V_i is the variance of the item scores.

Table 1. Reliability test results.

Category	Cronbach's Alpha (α)	No. of Items
Software services available among Malawian construction organizations and frequency of use	0.912	13

Table 1 presents the overall Cronbach's alpha coefficient from the reliability analysis. The results show that the overall Cronbach's alpha for BIM services usage is 0.912, which, according to George and Mallery [39], is considered 'excellent'.

4. Results Analysis and Discussion

The survey results were analyzed using the Statistical Package for Social Sciences (SPSS) version 29.0.0 and Microsoft Excel 2021. A total of 335 questionnaires were delivered to construction organizations. A total of 189 questionnaires were retrieved and evaluated for this study. The 189 questionnaires returned signify a 56.4% response rate. Moser and Kalton [40] contend that with a return of less than 30–40% of questionnaires in a study, the results of a study should be considered biased and of little significance. Therefore, the sample was deemed sufficient for the study.

The demographic background part of the survey included questions aimed at gathering the respondents' profile data. This section intentionally identifies the respondents' positions, years of experience, and organizations. Figure 1 displays the respondents' professional backgrounds.

The above figure implies that all participants are professionals in the fields of engineering, construction, and project management. This indicates that the respondents likely have the requisite skills and expertise to offer accurate and reliable responses to the survey questions.

Figure 2 shows that all of the respondents are from various organizations. Due to their positions, these individuals are deemed highly significant as they are involved in all crucial project decisions and have an essential role in the industry. Given that BIM is mostly considered a hub of information to improve communication among construction team members both within and across various organizations, the input from these professionals in their respective organizations would be highly relevant to the outcomes of this study.

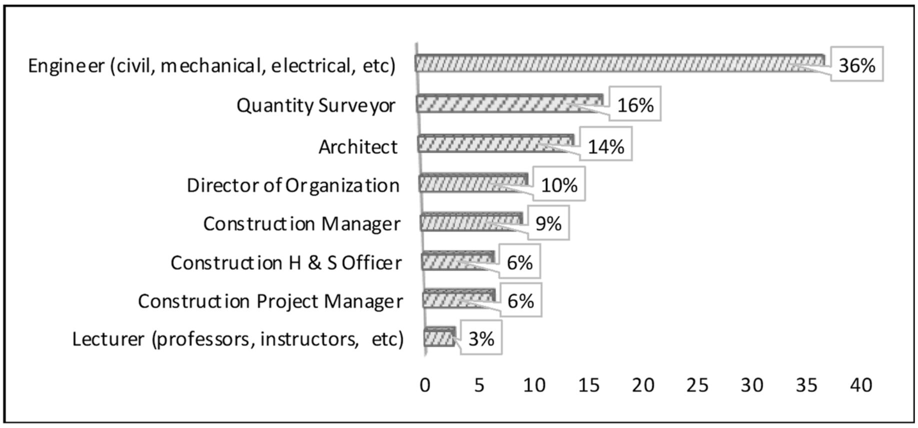

Figure 1. Respondents' professions.

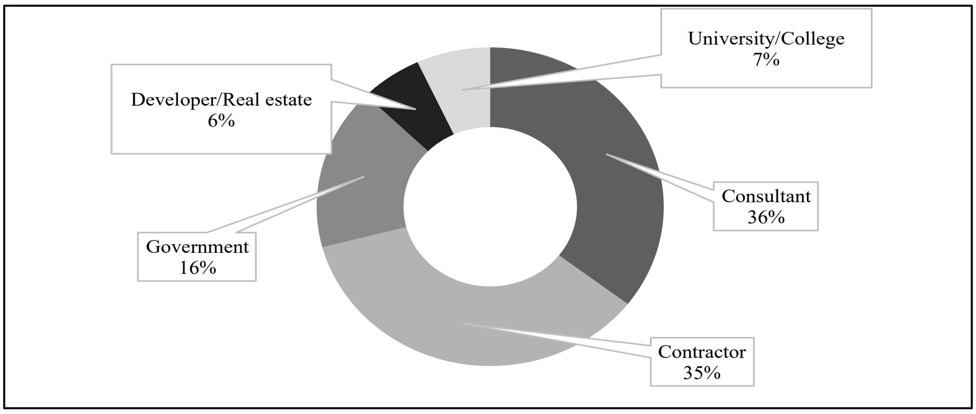

Figure 2. Respondents' current organizations.

The organizational types that participated in the study included real estate, academic institutions, government, consultants, and contractors (Figure 2). In this study, real estate organizations are considered as developers, investors, and managers of real estate projects and facility managers and clients for building and construction projects. Government organizations are public sector entities that oversee and regulate construction activities to ensure safety, compliance with laws, and alignment with public interests. They are also the primary client in the construction industry. Consultant organizations provide specialized expertise and advisory services to various stakeholders involved in construction projects. These services can include project management, architectural design, engineering, environmental assessments, cost estimation, and risk management. Contractor organizations are responsible for the actual execution of construction projects, managing the logistics and workforce to deliver on the project's specifications and timelines. Academic institutions are dedicated to education and research, advancing knowledge, and training future professionals in various disciplines, including construction.

Figure 3 shows the results of the respondents' work experience in the construction industry. A significant finding is that around 91% of the respondents had work experience ranging from 1 to 15 years in their current employment. The results strongly suggest that the majority of them have the expertise to give necessary information on BIM competence and awareness of Malawian construction organizations. Thus, the data supplied by these experienced personnel are considered reasonably reliable and crucial for this study.

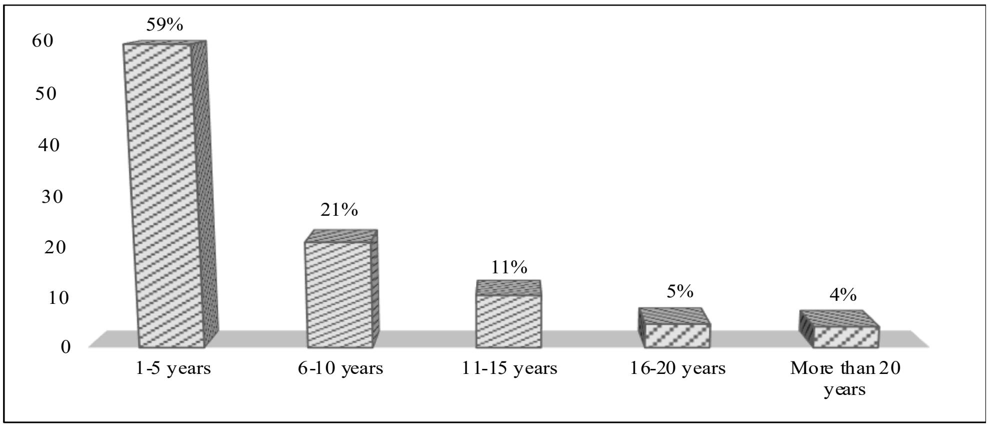

Figure 3. Respondents' years of working experience.

Looking at the demographic information of the respondents to this study, it can be deduced that the Malawian construction industry is still struggling with BIM awareness and competence. This is observed from the results of the survey, which shows that more professionals who are still making up their careers are more familiar with BIM than veterans in the industry. Since BIM is still very new in Malawi, it is understandable for old professionals not to be higher in this study. However, another reason for the imbalance in terms of representation of various qualifications, experience, and organizations was due to time limits and budget constraints when the study was completed, whereby the researchers were forced to proceed with the available data for this study. The sample representing the construction industry is another limitation in that professionals in various disciplines may hold engineering, architecture and quantity surveying degrees due to limited programs offering built environment programs in the country. Hence, the reflection in Figure 1.

4.1. Awareness with BIM

Research has shown that BIM awareness is influenced by several factors, including the type of organization a professional works for and their years of experience in the construction industry [41,42]. Thus, awareness in this study was analyzed based on all the organizations and also based on the experiences of the respondents in their respective organizations. Table 2 displays the level of BIM awareness for all the organizations in the Malawian construction industry.

Table 2. BIM awareness level among Malawian organizations.

	Organization Type					Total
	Consultant	**Contractor**	**Government**	**Property Developer**	**Academic**	
1	12	8	3	0	4	27
2	15	19	6	4	4	48
3	12	12	9	1	3	37
4	16	19	11	5	0	51
5	12	9	2	1	2	26
Severity Index	0.603	0.606	0.619	0.655	0.477	0.592

Table 2 shows that the severity of awareness among the organizations ranges from 0.477 to 0.619. The findings show that almost all the organizations have moderate awareness (0.603 to 0.619), except for academic organizations (0.477), with low awareness.

Overall, the level of awareness in the Malawian construction industry is low to moderate (0.592). This is due to the low adoption rate of BIM in developing countries, especially in Africa, where basic technological infrastructure is inadequate [11]. Also, the low awareness in educational organizations shows a lack of BIM education in higher education institutions in Malawi. The findings align with the study of Babatunde et al. [42], which revealed that the lack of ICT literacy staff in academic institutions is a barrier to BIM awareness and adoption in developing countries. Furthermore, several studies highlight the importance of education in BIM awareness, competence, and adoption [43,44]. In addition, based on several studies globally, the level of BIM awareness for property developers is usually low especially when compared to consultants and contractors [45–47]. The reason for the high value in this study is due to the scarcity of property developers in Malawi, which propelled the researchers to use a low number of property developers who happened to be familiar with BIM. However, this can be seen in the number of respondents included for these organizations. This is why the researchers further analyzed the findings based on years of experience to find a true reflection of the results (Table 3), filling out the gaps caused by the imbalanced representation of the organizations represented in the study.

Table 3. Level of BIM awareness among Malawian construction organizations.

Years of Experience	Valid Count of Awareness Levels					Severity Index	Weighted Average	Rank
	1	2	3	4	5			
Consultants								
1 to 5	11	13	6	5	5	0.500		
6 to 10	1	1	3	7	2	0.714		
11 to 15	0	1	3	2	2	0.725	0.755	1
15 to 20	0	0	0	1	2	0.933		
over 20	0	0	0	1	1	0.900		
Contractors								
1 to 5	8	15	8	10	0	0.498		
6 to 10	0	3	0	7	4	0.771		
11 to 15	0	0	3	1	4	0.825	0.712	2
15 to 20	0	0	0	1	0	0.800		
over 20	0	1	1	0	1	0.667		
Government								
1 to 5	1	3	6	5	0	0.600		
6 to 10	1	3	3	1	1	0.556		
11 to 15	1	0	0	1	0	0.500	0.671	3
15 to 20	0	0	0	3	0	0.800		
over 20	0	0	0	1	1	0.900		
Property Developer								
1 to 5	0	4	0	3	0	0.571		
6 to 10	0	0	1	0	0	0.600		
11 to 15	0	0	0	2	0	0.800	0.594	4
15 to 20	0	0	0	0	1	1.000		
over 20	0	0	0	0	0	0.000		
Academic								
1 to 5	3	4	2	0	0	0.378		
6 to 10	1	0	1	0	0	0.400		
11 to 15	0	0	0	0	0	0.000	0.556	5
15 to 20	0	0	0	0	1	1.000		
over 20	0	0	0	0	1	1.000		

Therefore, to further understand the level of BIM awareness in the Malawian construction industry and formulate ideas on improving it, the awareness level based on respondents' years of working experience under the organizations in Table 2 is shown in Table 3. This approach was influenced by the findings of Aibinu and Venkatesh [36], which revealed that professionals with more years of experience better understood the industry dynamics and technological breakthroughs such as BIM. Table 3 shows the results of the BIM awareness of the organizations based on years of working experience.

From Table 3, it can be seen that under consultants, there is a trend where consultants with more years of experience tend to have higher levels of BIM awareness. Consultants with 15 to 20 years and over 20 years of experience demonstrated higher severity index values, indicating very high awareness levels (0.900 and 0.933, respectively). The findings underscore the importance of experience in fostering BIM awareness among consultant organizations. This means that consultants with longer professional trajectories likely have encountered and engaged with BIM technologies more extensively, leading to a deeper understanding and appreciation of its benefits.

The findings align with the findings of Masood et al. [48], which highlight that professionals with working experience of over ten years have more exposure to BIM. Furthermore, a study in the UK revealed that consultants with 0 to 15 years of experience had high awareness (71.7%) but low utilization (23.4%) of BIM [49]. Thus, this awareness level among consultants in Malawi does not imply BIM use or adoption.

Contrary to the findings among consultants, the relationship between years of experience and BIM awareness among contractor organizations shows a more varied pattern. While contractors with 11 to 20 years of experience demonstrate higher severity index values, indicating moderate to high awareness levels, those with fewer (1 to 10 years) or more than 20 years of experience exhibit lower awareness levels. The variability in BIM awareness levels among contractors suggests that factors beyond years of experience may significantly influence awareness. Factors such as exposure to BIM projects, training opportunities, etc., could significantly shape BIM awareness among contractors. Ahankoob et al. [41] clarify that contractors' BIM experience plays a crucial role in realizing the potential values of BIM. While years of working experience alone may not directly influence awareness, it can impact how effectively contractors leverage BIM for project benefits.

Like contractors, the government, property developers, and academic organizations, the findings show a mixed level of BIM awareness, with notable variability across different experience categories. However, a couple of factors contribute to the findings among these organizations, including the small population representing them, especially property developers and academic institutions. Nonetheless, the government has higher awareness levels than the property developers, and the property developers have higher awareness over academic organizations, even though, collectively, they show a moderate level of awareness. This is because the factors that influence BIM awareness among these organizations vary. According to Ullah et al. [10], the factors that influence BIM awareness in the government include legal mandates, public procurement policies, and inter-agency collaboration; property developers include return on investment, market trends, and technology integration; and academic organizations include curriculum development, research funding, and industry partnerships.

The average in Table 3 shows a true reflection of the awareness levels among organizations, while the severity index in Table 1 shows the awareness levels if experience is not included. Table 1 cannot be used to rank the awareness levels among these organizations because it does not factor in the variation in the number of respondents across various organizations. However, it is a build-up to the ultimate findings in Table 3. Therefore, overall, consultants have high awareness (0.755), and the awareness level is directly related to their years of experience. The other organizations show variability concerning BIM awareness and years of work experience. Nonetheless, contractors are second with an awareness of 0.712. This implies that contractors and consultants have high BIM awareness. The government is third (0.671), followed by property developers (0.594), and the least is academic institutions (0.556), implying that these organizations have moderate BIM awareness.

4.2. Competence with BIM

To measure BIM competence among construction organizations in Malawi, the respondents were asked to rate the frequency of using pre-identified BIM software services in their respective organizations. Subsequently, they were asked to provide the software they use or that is available in their organizations for such services. Lastly, they were asked to rate their competency or ability to use the software they identified as available in their respective organizations. As much as these questions were meant to measure the competence level of BIM, they were also used to determine the BIM maturity level in the Malawian construction industry. Succar et al. [50] define BIM maturity level as an essential stage to assess the extent of BIM implementation in an organization, a project, or the construction industry within a specified region.

There are four BIM maturity levels, i.e., 0, 1, 2, and 3. When defined using collaboration, level 0 represents minimum collaboration or none; level 1 represents a step towards increased collaboration (using 2D software, 3D software, and digital file management); level 2 represents a massive shift towards full collaboration with significant 3D modeling and level 3 is the highest level of BIM maturity, which points out comprehensive integration across all aspects of the construction processes [46,51]. Table 4 presents the analysis of the frequency of BIM software services usage among construction organizations in Malawi.

Table 4. Software services available among Malawian construction organizations and frequency of use.

S/N		N	Mean		Std. Deviation	Skewness		Rank
		Statistic	Statistic	Std. Error	Statistic	Statistic	Std. Error	
S1	3D Modelling	189	3.55	0.078	1.074	−0.536	0.177	1st
S2	2D Drafting	189	3.54	0.081	1.113	−0.463	0.177	2nd
S3	Project Delivery Management	189	3.12	0.099	1.359	−0.290	0.177	3rd
S4	Visualization	189	3.10	0.100	1.374	−0.270	0.177	4th
S5	Design Analysis and Appraisal	189	2.90	0.097	1.329	−0.098	0.177	5th
S6	4D—Time (Scheduling)	189	2.83	0.081	1.119	−0.134	0.177	6th
S7	5D—Cost Analysis and management	189	2.83	0.099	1.355	−0.041	0.177	7th
S8	Project Information Management System (PIMS)	189	2.60	0.092	1.262	0.222	0.177	8th
S9	Energy Assessment	189	2.41	0.082	1.124	0.461	0.177	9th
S10	Clash detection	189	2.28	0.080	1.096	0.416	0.177	10th
S11	Common data environment (CDE)	189	2.22	0.079	1.092	0.649	0.177	11th
S12	Construction-Operations Building information exchange (COBie)	189	2.14	0.077	1.053	0.688	0.177	12th
S13	International Foundation Class (IFC) Generation	189	2.14	0.076	1.043	0.631	0.177	13th

4.2.1. Software Services Available among Organizations

The respondents were asked to rate the software services in Table 4 using a five-point Likert scale (1 = Never; 2 = Rarely; 3 = Sometimes; 4 = Very Often; 5 = Always). Considering the results, it can be concluded that 3D modeling and 2D drafting are used very often, with a mean of 3.55 and 3.54 and a standard deviation of 1.074 and 1.113, respectively. Sometimes-used services include project delivery management, visualization, and design analysis and appraisal, with a mean of 3.12, 3.10, and 2.9 and a standard deviation of 1.359, 1.374, and 1.329, respectively. Many services correlating with BIM maturity levels 2 and 3 are rarely used in Malawi. These services include, but are not limited to: common data environment (CDE) (mean = 2.22 and std. deviation = 1.092), international foundation class (IFC) generation (mean = 2.14 and std. deviation = 1.043), and Construction-Operations Building information exchange (COBie) (mean = 2.14 and std. deviation = 1.053). Looking at the frequency and services used, the results show that the Malawian construction industry is on BIM maturity level 1, which agrees with the study of Adekunle et al. [11] on BIM diffusion in developing countries, highlighting that most developing countries, especially in Africa, are at BIM maturity level 1.

Furthermore, the standard mean error is very close to zero, meaning that the means describing the frequency of the usage of the services were reliable. To further add to that, the standard deviation is quite low, meaning there is less variation in the manner in which the respondents answered the question. Lastly, the skewness indicates that the results are skewed to the left, with the top seven services being negative and all the remaining ones closer to one. This is to add to the consistency of the respondents when rating the services.

The findings helped in understanding the stage/level in which the respondents in this study are competent, i.e., BIM maturity level 1, and some of the BIM services such as 3D modeling, 2D drafting, project delivery management, visualization, design analysis, appraisal, etc. To further unravel the details of BIM competence, the respondents were asked to provide the software they use in their respective organizations when performing these services. This question was deemed necessary because one of the parameters of measuring competence is the ability or skill level, as specified by Vu et al. [29] and Succar et al. [27], and competence is a composition of knowledge and skill.

4.2.2. Software Available among Organizations

Figure 4 below shows the findings of the software available among organizations in the Malawian construction industry. Most respondents mentioned using AutoCAD (120), Revit (38), MS Office/Project (28), Sketchup (21), RIB Cost X (18), Sage (13), ArchiCAD (12), Rhino 3D (8), Civil 3D (8), etc., in their organizations. The literature in this study has highlighted most of this software as BIM-capable. Abanda et al. [52] highlight AutoCAD, ArchiCAD, and Revit as architectural software capable of 3D modeling. However, it is worth noting that the software available in Malawi aligns mostly with BIM maturity level 1 [46,47].

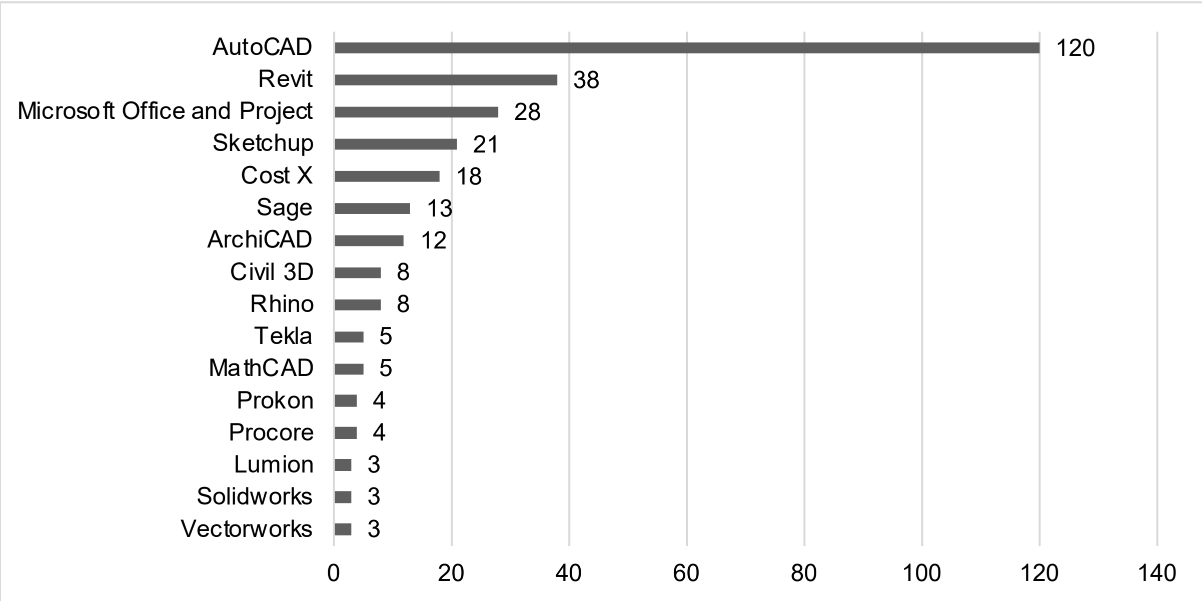

Figure 4. Major software available among Malawian construction organizations.

The identified software in Figure 4 were the ones the organizations were using to perform the services discussed above. This is to show the capabilities of these organizations with regard to technological infrastructure. Competence can be measured based on the systems available; the question to be asked would be: do the organizations have the basic facilities or platforms to perform at the stage where BIM demands? In this case, it can be seen that the Malawian construction industry has the minimum technological infrastructure to build upon and widen the adoption of BIM.

Figure 4 above shows the findings of the software available in different organizations in the Malawian construction industry. These organizations include consultants, contractors, government, developers, and universities/colleges. Table 5 below presents a breakdown of the software available within each organization.

Table 5. Software available in each organization.

Software	Software Available on Each Organization					Total
	Consultants	Contractor	Government	University/College	Developer/Real Estate	
AutoCAD	45	42	18	9	6	120
Revit	14	17	3	0	4	38
Microsoft Office and Project	10	13	3	2	0	28
Sketchup	11	4	3	1	2	21
Cost X	10	4	4	0	0	18
Sage	5	6	2	0	0	13
ArchiCAD	2	5	3	1	1	12
Rhino	3	2	1	1	1	8
Civil 3D	3	1	4	0	0	8
MathCAD	2	2	1	0	0	5
Tekla	0	0	0	1	4	5
Procore	2	0	1	0	1	4
Prokon	1	2	0	1	0	4
Lumion	3	0	0	0	0	3
Vectorworks	1	1	1	0	0	3
Solidworks	0	0	1	0	2	3

Starting with the consultants, the most available software by count is AutoCAD (45), followed by Revit (14), Sketchup (11), MS Office/Project (10), Cost X (10), Sage (5), etc. The software available to contractors is similar to those of consultants, starting with AutoCAD (42), Revit (17), MS Office/Project (13), Sage (6), ArchiCAD (5), Sketchup (4), Cost X (4), Tekla (4), etc. The available software in the government includes AutoCAD (18), Cost X (4), Civil 3D, MS Office/Project (3), Revit (3), Sketchup (3), ArchiCAD (3), etc. When looking at real estate/developers, the available software includes AutoCAD (6), Revit (4), Sketchup (2), etc. And lastly, the software available in educational institutions include AutoCAD (9), MS Office/Project (2), etc.

4.2.3. Ability to Use Software Available among Organizations

Furthermore, to determine and finalize the BIM competence level, the respondents were asked to rate their ability to use the software identified in Figure 4. The results are presented in Figure 5 below.

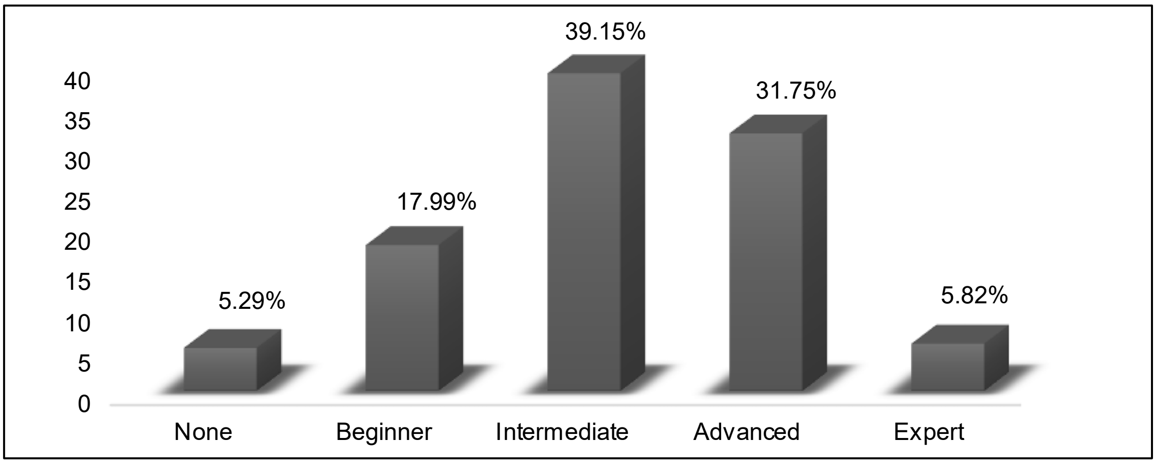

Figure 5. Ability to use the Software in Figure 4.

The ability was measured using a scale ranging from none, beginner, intermediate, advanced, and expert. The results revealed that most of the respondents have intermediate skills for the available software (39.15%), followed by advanced skills (31.74) and beginner (17.99%). A percentage of 5.29% of the respondents have no skills at all, and 5.82% are experts in the available software in their respective organizations. These findings revealed that the respondents had the average ability for the software available in their organization.

The ability of the respondents is almost evenly distributed across the measurement scale. This implies that, among organizations, there is a fair share of highly competent individuals and also low-competence individuals. There is still room for improvement, but this is a good start for the industry.

BIM transforms the construction industry by uniting diverse teams, boosting collaboration, minimizing waste, and increasing efficiency. However, implementing BIM requires tremendous effort, investments, changes in culture, and technological expertise [53]. A holistic approach incorporating people, processes, and technology is necessary to implement BIM effectively. Before BIM implementation, there are key challenges that need to be addressed. These challenges include but are not limited to a lack of BIM standards, cost, resistance to change, and skill gaps [54,55]. Therefore, it is essential to prepare thoroughly for BIM adoption. According to Chunduri et al. [56], establishing BIM goals/objectives, defining roles and responsibilities, assessing BIM readiness, and developing a BIM implementation framework are crucial for its adoption. Eastman et al. [47] add that, for successful BIM implementation, the team needs training to understand the fundamentals and benefits of BIM, BIM software and its capabilities, BIM workflows and how to integrate them into projects, and BIM standards and how to implement them.

Furthermore, adapting and using BIM technology in the construction industry requires a large initial investment in software, hardware, and staff training [57]. Saka and Chan [58] reported that large organizations face fewer challenges than smaller organizations in implementing BIM. This makes it seem as if smaller organizations do not want to use BIM, and the cause is a shortage of skills and expertise, which require massive investments in training and purchase of the technology. Most micro-, small-, and medium-sized enterprises (MSMEs) face financial constraints that limit their ability to invest in new technologies [59]. Organizations often seek funding from government sources or other investors to facilitate effective BIM implementation on a global scale. This financial support helps cover expenses related to consultation, training, and procuring the necessary software and hardware [60,61]. Considering this, the enforcement of the government in Malawi would be beneficial in increasing the industry's interest in using BIM tools. It should be specified as one of the conditions included in the contract tender documentation.

Europe, Oceania, and Asia, along with countries such as the United Kingdom (UK), China, France, Australia, and a few in other continents (such as the United States of America (USA)) have already mandated the use of BIM in public projects [62,63]. For successful implementation, Malawi can adopt this in public projects. However, there are no frameworks or standards for BIM implementation. A lack of training is one of the most critical obstacles that must be overcome to establish a satisfactory BIM implementation level. Many organizations in the construction industry believe implementing BIM would result in a decrease in efficiency. The reluctance to invest in BIM technology often stems from the complexity of mastering BIM authoring software and its disruption to established processes, such as traditional methods. Therefore, the successful adoption of new technology relies heavily on education and training [64]. Integrating BIM across higher education curricula and conducting trials of BIM-based tools are viable approaches to expand its applications.

A BIM introduction course for students in higher education institutions could serve as a potent incentive to educate and raise awareness regarding the significance and application of BIM [65,66]. Additionally, seminars or training could enhance the participants' theoretical knowledge, whereas hands-on experience with the technology would refine their abilities and knowledge. According to Manzoor et al. [67], free/low-cost seminars and workshops can stimulate active engagement and enhance understanding among professionals in the construction industry.

5. Conclusions

The findings show that, generally, there is a positive correlation between years of experience and BIM awareness, with organizations or individuals with more experience tending to have higher awareness levels. However, this relationship is only consistent across some types of organizations and varies depending on contextual factors. This is because BIM technologies are widely employed during the design and planning phases to generate 3D models, simulate building performance, and evaluate different design alternatives [68]. Therefore, consultants and contractors who usually play essential roles in the initial phases of a project typically have a better chance to possess extensive knowledge about the advantages and functionalities of BIM [69].

The level of BIM competence is mostly intermediate/moderate on the software that is available among organizations. Professionals possess a limited proficiency in BIM technical abilities, particularly in utilizing BIM-related technologies and executing BIM-related tasks. Linking the results with the demographic data, the findings align with Demirdoven's [30] findings, which revealed that BIM awareness and competency can be increased and measured through education, training, or development efforts. However, it is worth noting that the Malawian construction industry still has a long way to go before reaching full BIM maturity and widespread adoption. Furthermore, professionals in the industry are facing a growing demand from clients to adopt and utilize BIM in projects [14]. However, this differs in the Malawian construction industry due to minimal BIM adoption [58], hence the moderate BIM awareness and competence.

However, the Malawian construction industry has professionals who can help with the promotion of BIM awareness, providing support in the adoption processes, building the skills of local professionals, engaging with government bodies concerning the importance of BIM, encouraging a sense of community among BIM practitioners in the country, etc., to maximize adoption among construction organizations. Thus, construction organizations in Malawi should prepare for the adoption of BIM by addressing the insufficient technical skills and limited awareness of BIM among their workforce. Furthermore, engaging in collaborative efforts with the government, international organizations, and among themselves could serve as a good foundation for preparing for the widespread adoption of BIM.

The study faced limitations in time and budget, leading to a reliance on data that was not evenly representative in terms of qualifications, experience, and organizational types. Despite achieving a 56.4% response rate, considered adequate by research standards, the findings' generalizability may have been affected. The study highlighted the low awareness of BIM in Malawian educational institutions, indicating a deficiency in BIM education at the higher education level, which could impact industry readiness for BIM adoption. Furthermore, the study identified varying levels of BIM awareness among different groups, with consultants and contractors showing higher awareness compared to academic institutions, suggesting that exposure to BIM projects and training opportunities significantly influences awareness levels beyond years of experience alone.

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