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An investigation of the challenges for BIM implementation

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Abstract: *This research investigates the difficulties encountered while implementing Building Information Modeling (BIM) and examines the impact of demographic and professional characteristics on individuals' perceptions of these issues. The article outlines five primary obstacles: knowledge-related limitations, cost-related restraints, willingness concerns, technology restrictions, and legal obstructions. Contractors have a high degree of predictability when it comes to identifying these difficulties, which can be attributed to their active engagement in the execution of projects. There is a positive correlation between job experience and knowledge of legal obstacles. The age of persons is a crucial factor in determining the presence of barriers to willingness, as older individuals frequently exhibit resistance towards BIM. The study suggests that providing specialist BIM training to experienced professionals, fostering clear communication, and offering leadership support can be successful strategies for managing organisational change. Additional research is necessary to understand the impact of demographic characteristics on the application of BIM.*

Keywords: *Building Information Modelling (BIM), Adoption Barriers, Construction Industry*

1. Introduction

BIM has become a transformative tool in the architecture, engineering, and construction industry. Its efficiency in process management has significantly changed the conception, design, construction, operation, and maintenance of building projects (Omar et al., 2023; Srikanth et al., 2023). As a high-efficiency information tool, building information modelling (BIM) supports the design and execution stages of engineering projects and promotes effective interface management. By digitizing data, BIM has enhanced collaboration and interoperability between project phases, marking a considerable improvement over the traditional two-dimensional paper format (Rani et al., 2023). This technology symbolizes national pride and productivity, underscoring its profound significance in the industry.

Traditionally characterized by lagging productivity, cost overruns, and project delays, the AEC industry has undergone significant transformations due to technological advancements. These innovations, including BIM, automation, prefabrication, novel manufacturing concepts, artificial intelligence, and 3D printing, have addressed the industry's inefficiencies and reputation as a major global waste producer (Likita et al., 2022). Despite the absorption in various countries, its uptake needs further improvement. Implementing BIM presents a complex process requiring extensive awareness and collaboration among construction participants, which entails overcoming the challenges associated with the shift from traditional processes to BIM-based ones. The preparedness and maturity level for BIM implementation within organizations hinges on understanding available tools, techniques, information levels, and the collaborative framework, thus emphasizing the critical role of knowledge in harnessing this technology (Kapogiannis et al., 2019).

Although BIM has been proven to enhance project performance and quality, significant barriers to its adoption persist, including resistance to change, legal and contractual limitations, high training costs, lack of a conducive environment, and lack of well-trained professionals to manage the tools. This report explores these challenges and the impact of respondent characteristics and demographics on their perception of BIM implementation difficulties as captured in survey data.

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2. Methodology

2.1 Sample Descriptive Analysis

The study employed a sample size of 149 individuals, encompassing several demographic factors such as gender, age, role, education, job experience, and barriers. To mitigate inconsistencies, a process of data cleansing was undertaken, followed by a comprehensive descriptive analysis to assure the accuracy of the obtained results.

Table 1: Sample Descriptive Analysis

Variable	Value	Frequency	Percent (%)
Gender	Male	99	71.20
	Female	40	28.80
	18-30	20	14.39
Age	30-40	94	67.62
	>40	25	17.99
	Consultant	63	45.32
Role	Contractor	49	35.25
	Other	25	17.99
	Master or PhD	38	27.74
Education	Bachelor	73	53.28
	Diploma	26	18.98
	1-5 years	25	17.98
Working experience	6-10 years	71	51.07
	10 years	38	27.34
BIM experiences	Yes	74	53.20
	No	65	46.80

Table 1 shows a sample of 139 participants, exhibiting a heterogeneous demographic composition with 71.20% male and 28.80% female individuals. The age distribution exhibited variability, with 14.39% falling within the 18-30 age bracket, 67.62% falling within the 30-40 age bracket, and 17.99% falling within the over 40 age brackets. The responsibilities of the participants exhibited variation, with 45.32% serving as consultants, 35.25% as contractors, and 17.99% occupying various positions. The distribution of education levels among the participants was diverse, with 53.28% possessing a bachelor's degree, 18.98% holding a diploma, and 27.34% having accumulated more than a decade of professional experience.

2.2 Data analysis

The study employs the Kolmogorov-Smirnov Test to validate the assumption of normal distribution. Subsequently, it does a difference analysis using Independent-Samples. The Mann-Whitney U Test, Kruskal-Wallis Test, multiple linear regression analysis, K cluster analysis, and R's Pairwise Comparisons are utilized to conduct data analysis and get insights into the correlations between variables.

This study aims to acquire the anticipated outcomes by collecting data through the process of sampling, as outlined below:

● This study examines the impact of respondents' features and demographics on their perception of problems related to the deployment of BIM by an experimental methodology.

● Experienced professionals may be more familiar with traditional working methods and whether there is more resistance to adopting BIM.

● Different professional roles may face other challenges. What challenges are they paying more attention.

● Other audience groups of BIM have different corresponding strategies, so there are several types of groups in implementing BIM. Then different strategies are implemented for these types of groups to promote BIM better.

● Whether young professionals or professionals new to the profession are more open to new technologies and methods.

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3. Results

Table 2: Kruskal-Wallis Test

Ranks				
	A	N	Mean Rank	Asymp. Sig.
Average Knowledge score	1	26	74.10	0.535
	2	88	70.98	
	3	25	62.28	
	Total	139		
Average Cost score	1	26	62.62	0.552
	2	88	72.36	
	3	25	69.38	
	Total	139		
Average Willing Score	1	26	76.60	0.650
	2	88	68.47	
	3	25	68.52	
	Total	139		
Average Technology Score	1	26	69.65	0.968
	2	88	69.58	
	3	25	71.84	
	Total	139		
Average Legal Score	1	26	74.85	0.609
	2	88	67.43	
	3	25	74.02	
	Total	139		

A Kruskal-Wallis Test (see Table 2) was conducted to examine the differences in average knowledge score, average cost score, average willingness score, average technology score, and average legal score across different age groups. The sample consisted of 21 participants in the 18-30 age group, 94 participants in the 30-40 age group, and 24 participants in the >40 age group, totaling 139 participants. These findings suggest no significant differences in the examined variables ($p > 0.05$).

3.1 Analysis of the differences in knowledge, cost, willingness, technology, and legal barriers at the level of experience with BIM

Table 3: Coefficientsa

	BIM experience	N	Mean	Std. Deviation	Mean Rank	p
Average Knowlge score	No	65	1.378	1.216	64.5	0.398
	Yes	74			70.16	
Average Cost score	No	65	1.293	1.083	65.94	0.661
	Yes	74			68.88	
Average Willing Score	No	65	0.893	1.191	62.40	0.152
	Yes	74			72.02	
Average Technology Score	No	65	0.737	1.191	69.84	0.510
	Yes	74			65.42	
Average Legal Score	No	65	1.241	1.101	57.94	0.007*
	Yes	74			75.99	

The study employed an independent sample Mann-Whitney U test as shown in **Table 3** to examine potential disparities in average knowledge scores, cost scores, willingness scores, technical scores, and legal scores between participants with and without BIM experience. The sample comprised 65 participants who had no prior experience with BIM, and 74 participants who had previous expertise with BIM. The findings of the study revealed a statistically significant difference in the average legal score ($p = 0.027$*). This suggests that individuals with prior expertise in BIM achieved significantly higher scores (mean rank = 75.99) compared to those without BIM experience (mean rank = 57.94).

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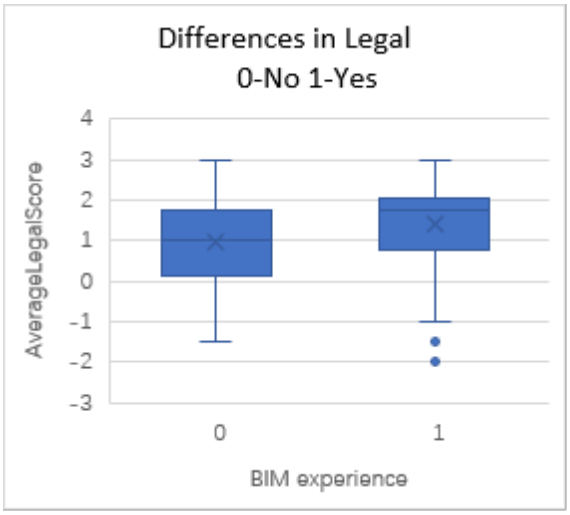

Figure 1: U-test

Figure 1 presents the outcomes of the independent samples U-test (p>0.05), indicating a statistically significant disparity in the degree of legal obstacles between individuals with and without BIM expertise.

3.2 Regression analysis

Table 4: Kruskal-Wallis Test for Willing Score

Coefficients[a]								
		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
Model		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	2.199	1.362		1.615	0.109		
	Age	0.381	0.166	0.182	2.261	0.025*	0.053	17.049
	Role Consultant	-2.595	0.827	-1.083	-3.139	0.002*	0.054	18.397
	Role Contractor	-2.102	0.828	-0.842	-2.540	0.012*	0.059	16.989
a. Dependent Variable: Average Willing Score								

The research findings indicate that presence of role characteristics such as consultant and contractor was found to be linked to obstacles in willingness, indicating a greater degree of impairment in terms of volition. There was a positive association between age and willingness barriers, indicating that older persons tended to have lower levels of willingness barriers as shown in Table 4.

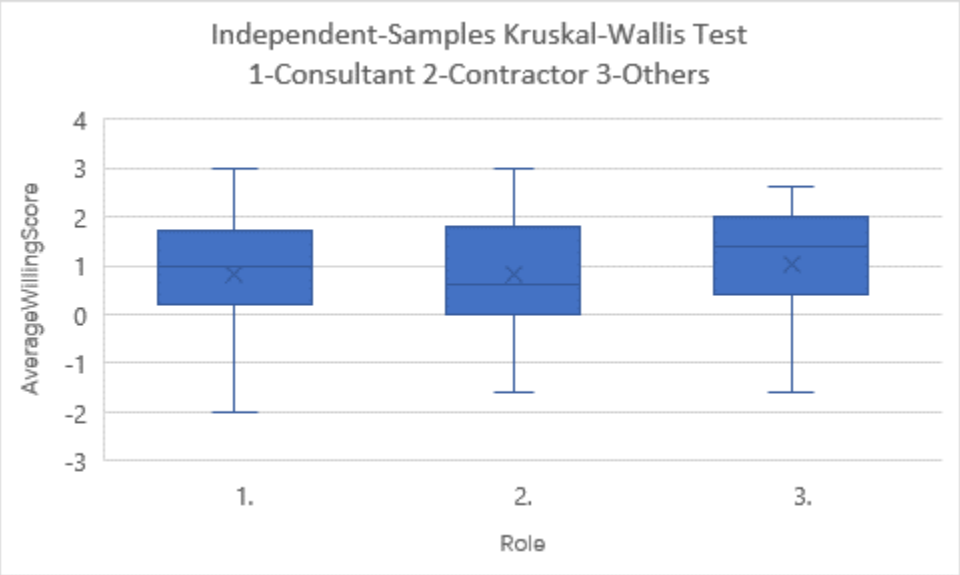

Figure 2: Kruskal-Wallis Test for Willing Score

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The study demonstrates a noteworthy positive correlation between the presence of barriers to willingness and professional roles, including contractors, consultants, and other relevant positions. Nevertheless, it is important to note that there exists a notable disparity in the extent to which these barriers are affected by different entities. Contractors exert the most substantial influence, followed by others and consultants as shown in Figure 2.

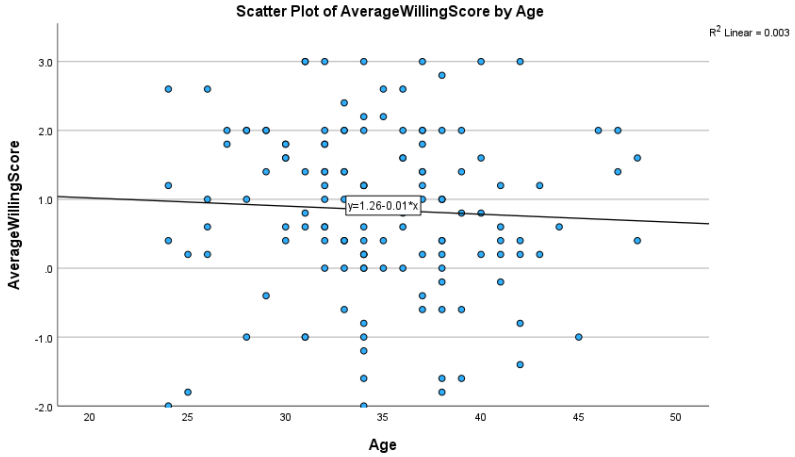

Figure 3：Multiple linear regression analysis for willingness score

The results depicted in Figure 3 indicate a substantial relationship between age and the extent of willingness impairment, whereas older persons tend to exhibit lower levels of impairment. The regression equation provides confirmation, indicating that the willingness score may be predicted by the equation 1.26-0.01 multiplied by the individual's age.

Table 5: Multiple linear regression analysis for Average Technology Score

Model		Unstandardized Coefficients		Standardized Coefficients	t	p
		B	Std. error	Beta		
1	(Constant)	-1.479	1.430		-1.035	0.303
	Role Consultant	1.785	0.860	0.759	2.076	0.040*
	Role Contractor	1.961	0.856	0.800	2.292	0.024*
	Role Others	1.600	0.889	0.525	1.800	0.074
a. Dependent: Average Technology Score						

Table 5 found that P=0.040<0.05 and P=0.024<0.05 between roles and technical barriers, indicating that consultants and contractors in roles can significantly and positively predict technical barriers, gender, education, work experience, and BIM experience.

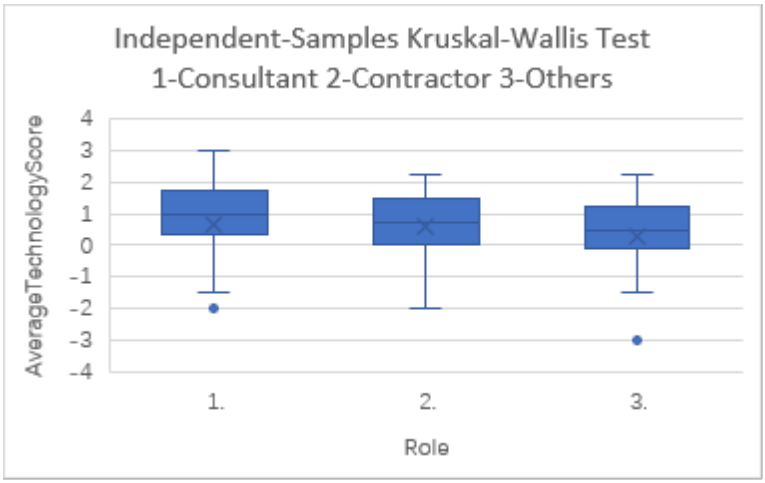

Figure 4: Kruskal-Wallis Test for Average Technology Score

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The findings in Figure 4 of the study indicate that the positions of contractors and consultants have a substantial influence on technical barriers, with contractor roles exerting a more pronounced effect compared to consultant roles. These findings are substantiated by P-values of 0.040 and 0.024, respectively, which are both statistically significant at the conventional alpha level of 0.05.

Table 6: Kruskal-Wallis Test for Average Legal Score

Coefficients[a]								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	0.857	1.302		0.658	0.512		
	Role Consultant	-1.772	0.790	-0.797	-2.242	0.027*	0.054	18.397
	Role Contractor	-1.824	0.791	-0.788	-2.305	0.023*	0.059	16.989
	Experience1-5years	1.134	0.532	0.394	2.133	0.035*	0.202	4.960
	Experience5-10years	1.255	0.502	0.567	2.499	0.014*	0.133	7.492
	Experienceabove10years	1.299	0.521	0.523	2.494	0.014*	0.156	6.414
a. Dependent Variable: Average Legal Score								

Through Table 6**,** the study revealed that those with expertise in consulting and contracting, as well as those with professional experience, demonstrated a higher likelihood of accurately predicting legal obstacles.

3.3 K-means clustering

Table 7: K-means clustering

Final Cluster Centers			
	Cluster		
	1	2	3
Average Knowledge score	1.6	2.0	-2
Average Cost score	1.35	1.82	0.31
Average Willing Score	0.3	1.8	0.2
Average Technology Score	0.12	1.48	0.47
Average Legal Score	1.24	1.89	0.04
N	51	54	34

The data, as shown in Table 7**,** illustrates three distinct groups according to the respondents' assessments of barriers to BIM implementation. Specifically, 36.7% of the respondents agree, 38.8% strongly agree, and 24.5% disagree with these restrictions. These insights can provide guidance for implementing strategic initiatives aimed at addressing the identified hurdles, thereby facilitating a seamless adoption of BIM throughout the construction industry.

4. Discussion

This research aims to identify the primary obstacles encountered during the implementation of BIM. These hurdles encompass knowledge-related limitations, cost-related constraints, issues pertaining to willingness, technological restrictions, and legal impediments. This study examines the impact of distinct traits and demographic factors on individuals' comprehension and perception of certain obstacles. The findings indicate that the presence of contractors, consultants, and other professional roles is a strong predictor of constraints related to willingness, technology, and legal aspects in the application of BIM. Contractors exhibit the highest level of predictive capacity in terms of willingness, with consultants ranking second in this regard. Contractors are likely to have a more hands-on role in the execution of projects and hence may meet a range of concerns, which in turn enhances their awareness and understanding of the obstacles associated with implementing BIM. There is a notable correlation between job experience and the anticipation of legal obstacles, as those with lengthier professional backgrounds tend to exhibit a higher propensity for predicting such barriers. The research separates the sample into three distinct categories, with the primary objective of boosting comprehension regarding the potential value and obstacles associated with BIM. Additionally, the study aims to address issues pertaining to willingness and legal aspects, while also offering a cost-benefit analysis and legal training to mitigate apprehensions related to legal matters.

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The findings of this study indicate a negative association between age and willingness, implying that older individuals may exhibit a preference for conventional approaches as opposed to emerging technologies such as BIM. This resistance could be attributed to fear of the unknown, a perceived lack of benefits, or mistrust of new technologies.

To address this matter, it is imperative to implement a complete approach that encompasses the provision of specialized BIM training to seasoned experts. This training aims to augment their comprehension and competence in utilizing this technological tool (Tulubas et al., 2017). According to Zhou et al. (2019), the successful implementation of change management techniques may be achieved through the incorporation of transparent communication and strong leadership support, which can effectively address and overcome resistance. The user's text is already academic and does not need to be rewritten. The facilitation of knowledge transfer, fostering familiarity with BIM, and mitigating resistance to change can be achieved through the promotion of mentorship programs and the adoption of a progressive approach to BIM deployment (Abbasnejad, 2022). However, it is imperative to customize these suggestions according to the unique circumstances of a company and its members to ensure successful execution.

My empirical comparative analysis reveals certain similarities and differences in barriers to BIM implementation.

The scholarly literature and empirical research have identified five distinct hurdles that impede progress in diverse domains: knowledge, cost, willingness, technology, and legal considerations. These barriers have been observed to have a pervasive presence across different sectors, but with varying degrees of focus, as evidenced by studies conducted by Liu et al. (2015), Hosseini et al. Existing literature indicates that the presence of knowledge and cost barriers poses considerable obstacles in the application of BIM. However, additional research is required to comprehensively comprehend the influence of demography on this matter. The findings of the research indicate that the importance of cost diminishes for employees with more expertise and in certain job positions. This phenomenon may be attributed to corporate budgeting procedures or variations in technology literacy among different demographic groups.

Regarding willingness barriers, the literature largely focused on organizational culture and the reluctance to change. The findings of the study indicate that the impression of barriers related to technology is influenced by the specific roles individuals have, with a particular emphasis on contractors and consultants. This observation underscores the presence of human and subjective elements in these barriers, as opposed to attributing them only to structural factors.

Legal barriers present in the literature **(Azhar, 2011)** were confirmed by my findings, emphasizing the role of work experience. This correlation implies that understanding of legal barriers may increase with work experience due to an increased understanding of the law, legal environment, and practical legal issues.

The results emphasize the necessity for continued investigation and a tailored strategy to tackle obstacles in the deployment of BIM, emphasizing the impact of individual traits on perception.

5. Conclusions

This study examines the difficulties associated with the implementation of BIM and assesses the influence of demographic features and professional jobs on this process. The findings indicate that contractors anticipate encountering obstacles pertaining to factors such as willingness, technology, and legality. The role of work experience is also essential in forecasting legal hurdles. Age is a substantial determinant of barriers to willingness. This study highlights the necessity of implementing focused interventions tailored to certain professional groups, as well as the significance of comprehending the requirements of the intended audience when formulating strategies for BIM adoption. This study offers significant insights that can inform future research endeavours and industrial practices.

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