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The individual perceptions of BIM practice in Algeria between practitioners and academics: Implementation barriers and strategic solutions

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Abstract: Few efforts have been conducted to compare the opinions of academics and practitioners regarding the Building Information Modelling (BIM) perceptions. This research was conducted to fill this gap and to explore the different understanding of BIM implementation between academics and practitioners in terms of BIM critical barriers, and strategic solutions in Algeria. The research approach is based on literature review and empirical analysis of academics and practitioners' perception. This research utilized a questionnaire survey, which was followed by statistical analysis. The entire survey sample was categorized into subgroups based on respondents' profile type, graduation, work type, and CAD and BIM knowledge. A subgroup analysis using a statistical approach was conducted to examine the differences in individual perceptions among the various groups mentioned. The subgroup analysis revealed that there was a gap in the BIM awareness between the academics and the practitioners. It was inferred that the top BIM implementation barriers were within people and policy factors. The ranking of BIM strategic solutions revealed that the implementation of BIM in Algeria is only possible through the involvement of local authorities, and the engagement of the academic sector in professional training. Scholarly, this research will contribute to the body of knowledge in BIM implementation by extending BIM adoption research, previously limited to practitioners, by proposing multiple factors. Practically, it illustrates the gap between academics and practitioners' perception in BIM implementation, and provides suggestions for Construction Industry-Academics-Partnership as an influential key for promoting the BIM adoption in Algeria.

Keywords: BIM, perspectives, questionnaire survey, implementation barriers, strategic solutions, Algeria

INTRODUCTION

Discussing the integration of Building Information Modelling (BIM) into Algeria's construction industry has become a necessity as Algeria's construction sector continues to expand. This is a new cycle that the construction industry is undergoing all over the world. Not long ago, from the 1980s to the late 1990s the construction industry assisted in the computerisation of architectural drawing with the introduction of the computer as artificial intelligence that saves time in performing calculation tasks. It must be remembered that there was a reluctance to introduce Computer-aided design (CAD) software into architecture, especially in design education (Brown, 2009; Burleson and Selker, 2002; Lawson, 2002). This reluctance is due to the fact that many design educators consider that CAD is merely a tool for enhancing good design (Unver, 2006), and discourages further exploration of design ideas by creating the illusion of completeness and precision (Robertson et al., 2007). At the beginning of the 2000s, the computerisation of drawing tools was inevitable due to the increased complexity of buildings. Hence, everyone was obliged to adhere to this evolution in order to be able to exist.

In Algeria, interest in BIM has only recently emerged. The first significant event to promote BIM, the CityCAD 1st edition, was organized in 2015 to discuss the need for BIM implementation in Algeria. After that, various institutions have been established to advance BIM by offering training programs for both individuals and organizations. In 2018, BIM was introduced into the architectural curriculum as a course titled "Modelling and Simulation BIM" for third-year students. Otherwise, a number of private training institutions in Algeria have started encouraging the adoption of BIM, with the backing of various organizations working to establish a BIM framework. Despite these efforts, it seems that, apart from a few initiatives, the majority of construction industry professionals in Algeria have not yet shown much interest in embracing BIM for their design and construction processes.

Various studies have been carried out on the adoption of BIM and explored either the point of view of practitioners—architects and engineers (Abubakar et al., 2014; Van Roy and Firdaus, 2020; Ahmed, 2018; Arunkumar et al., 2018; Azhar, 2011; Baba, 2010; Bender, 2010; Bouguerra et al., 2020; Cao et al., 2017; Chan et al., 2019; Chileshe et al., 2015; Eadie et al., 2013; Gerges et al., 2017; Gu and London, 2010; Hosseini et al., 2015; Hosseini et al., 2016;

Jin et al., 2015; Jin et al., 2017; Khairool Aizat et al., 2019; Kim et al., 2016; Latiffi et al., 2015; Liu et al., 2015; Liu et al., 2019; Marzouk et al., 2021; Mehran, 2016; Memon et al., 2014; Monko and Roider, 2014; Nanajkar, 2014; Olawumi and Chan, 2018; Smith and Tardif, 2009; Yan and Damian, 2008; Zahrizan et al., 2013) or academics—students— (Zou et al., 2019; Jin et al., 2018; Sah and Cory, 2008; Adhikari et al., 2020; Jin et al., 2019; Salman, 2013). However, few efforts have been conducted to compare the opinions of academics and practitioners regarding the BIM perceptions (Wu and Issa, 2013; Dib et al., 2012, Chen et al., 2017; Zou et al., 2019). The existing researches have tried either to investigate the gap between BIM education and industry requirements (Wu and Issa, 2013; Zou et al., 2019), or to investigate the comparison between academics and practitioners' perceptions of BIM maturity indicators (Dib et al., 2012, Chen et al., 2017).

This research was conducted to fill this gap and to explore the different understanding of BIM implementation between academics and practitioners. It examines several multi-influence factors, including profile type (practitioners vs. academics), graduation (architect, engineer, student), work type (project owner, design firm, contractor), and CAD and BIM knowledge. Specifically, this paper seeks to: (1) identify and evaluate the perceptions of BIM practices among practitioners (such as project managers, project owners, and contractors) and academics (including university educators and students) regarding critical barriers and strategic solutions in Algeria; (2) explore differences in perceptions of these factors based on the profiles of construction sector participants; (3) assess the level of BIM awareness among both practitioners and academics; and (4) propose strategies to enhance BIM implementation in Algeria.

This study extends previous research (Tehami and Seddiki, 2023) regarding the implementation of BIM in Algeria from architects' perspective. It explores the differences in opinions between academics and practitioners. Additionally, the study expands the existing understanding of BIM perception and encourages further discussion on how academics and professionals from less mature BIM countries view BIM practices compared to those from more BIM mature countries.

LITERATURE REVIEW

BIM, which originated in the 1970s through the work of Charles M. Eastman (Eastman et al., 2011), is regarded as a significant transformation in the construction industry (Shelden, 2009). Due to its capacity to improve efficiency, reduce costs, and decrease delays in construction, BIM is acknowledged as the most promising advancement within the Architecture, Engineering and Construction (AEC) industry (Azhar, 2011). The adoption of BIM varies between countries and is shaped by a range of factors (Gu and London, 2010). Thus, numerous studies have examined BIM adoption in both developed and developing nations. Tab. 1 from previous research by Tehami and Seddiki (2023) highlights the key obstacles identified after a thorough review of existing studies on barriers to BIM implementation.

Tab. 1. Overview of BIM implementation barriers. (Source: Tehami and Seddiki, 2023)

BIM Barriers	References
Cultural transformation and attitude challenges	Abubakar et al. (2014), Ahmed (2018), Arunkumar et al. (2018), Chan et al. (2019), Denzer and Hedges (2008), Eadie et al. (2013), Gerges et al. (2017), Marzouk et al. (2021), Nanajkar (2014), Saka and Chan (2019).
Shortage of experienced and qualified BIM specialists	Arunkumar et al. (2018), Gerges et al. (2017), Jamal et al. (2019), Kumar and Mukherjee (2009), Liu et al. (2015), Memon et al. (2014), Nanajkar (2014), NBS (2013), Van Roy and Firdaus (2020), Saka and Chan (2019).
Clients do not demand the use of BIM in their projects	Baba (2010), Birkeland (2009), Bouguerra et al. (2019), Chan et al. (2014), Gerges et al. (2017), Marzouk et al. (2021), Monko and Roider (2014), NBS (2014; 2018; 2019), Nanajkar (2014), Van Roy and Firdaus (2020), Saka and Chan (2019)
High expenses for BIM-related hardware and software	Abanda et al. (2014), Abubakar et al. (2014), Ahmed (2018), Van Roy and Firdaus, 2020; Arunkumar et al. (2018), Bouguerra et al. (2019), Chiponde et al. (2017), Denzer and Hedges (2008), Eadie et al. (2013), Gerges et al. (2017), Hosseini et al. (2016), Jamal et al. (2019), Liu et al. (2015), NBS (2013; 2014; 2018; 2019), Saka and Chan (2019).
Interoperability issues	Chan et al. (2019), Saka and Chan (2019).
Inadequate support and lack of incentives from decision-makers for encouraging BIM adoption	Abubakar et al. (2014), Hosseini et al. (2015; 2016), Zahrizan et al. (2013).
No legal or contractual agreement on BIM	Van Roy and Firdaus, 2020; Bouguerra et al. (2019), Chan et al. (2019), Hosseini et al. (2016), Liu et al. (2015), Marzouk et al. (2021), Mehran (2016), NBS (2013; 2018; 2019), Smith and Tardif (2009), Zahrizan et al. (2013).
Lack of BIM data library and standards	Bouguerra et al. (2020), Saka and Chan (2019).
Resistance from project stakeholders to adopt new working practices	Chan et al. (2014), Gerges et al. (2017), Yan and Damian (2008).

As part of a precedent research study on the adoption of BIM in Algeria from the perspective of architects (Tehami and Seddiki, 2023), survey questionnaires (see translation in Appendix) were distributed to 100 Algerian architects with diverse profiles. The results indicated that the key barriers to BIM implementation were related to people and policy factors. Furthermore, the study found differences in BIM maturity levels between large and small organizations in Algeria. It emphasized that, at the current maturity level, the BIM implementation would not advance without the active involvement of local authorities and policymakers, whose role is crucial in promoting and accelerating the BIM adoption in the country.

Academics' and practitioners' perception of BIM practice

With the expansion of ICTs in the AEC industry worldwide, the BIM implementation is becoming unavoidable. Many industry stakeholders are still searching for the best methods to teach or learn about BIM (Christopher and Daniel, 2023). Enhancing this implementation must necessarily involve the academics. The academic community responded to this demand by integrating BIM courses in their curricula (Wu and Issa, 2013). A great number of universities are developing BIM training courses in the form of "master degrees" for practitioners to reinforce the BIM adoption in AEC industry. In the other hand, BIM is integrated in the curriculum at undergraduate and graduate levels as a full-fledged university course (Wu and Issa, 2013). Both academia and AEC industry agree that BIM education is crucial for quickening the BIM adoption in response to the AEC current transition.

However, contrary to the BIM adoption in USA and Europe, it seems like there is a differentiation in the understanding of the skills needed, the content and the method of BIM education in the Middle East and Africa (Nawari and Alsaffar, 2016). It is believed that this difference in BIM practice perception is one of the reasons that delayed the BIM adoption in this region. Thus, the present paper tries to fill this gap and investigates the individual perceptions of BIM practice in Algeria by soliciting the viewpoint of both the practitioners and the academics. The study considers various multi-influencing factors, namely profile type (practitioners, academics), graduation (architect, engineer, student), work type (design firm, project owner, contractor), and knowledge of CAD and BIM.

RESEARCH METHODOLOGY

To explore individual perceptions of BIM implementation in Algeria from the perspectives of both practitioners and academics, this research employed a questionnaire survey followed by statistical analysis. The data collection was part of the previous study by Tehami and Seddiki (2023) and followed the procedures outlined by Cao et al. (2017) and Jin et al. (2017). Various methods were used to reach potential survey participants, including events, seminars, and an online questionnaire distributed via Google Forms. The questionnaire survey was distributed to potential participants with diverse profiles. The study population included architects, engineers, and architecture students from across the country. A non-probability sampling technique was utilized to select a representative sample for this research. The sample size was calculated using the following formulas (1) and (2) for determining sample size (Daniel and Cross, 2018; Naing et al., 2006):

(1) n (1) = N*X / (X + N – 1), where,

(2) X (2) = Zα/22 *p*(1-p) / d2,

Zα/2 is the critical value of the Normal distribution at α/2. With α 0.1 and a 90% of confidence level, the critical value is 1.645. d is the margin of error—MOE (7% used for this study), p is the sample proportion (0.5 is used for a larger sample size), and N is the population size. The population size of this research was estimated at 16,000. This estimation included: around 10,000 certified architects in Algeria (According to the National Council of the Order of Architects, CNOA), 1,994 engineers (according to the Algerian Ministry of Housing, Town Planning and the City), and around 4,000 architecture students. For the estimation of the share of students, only those students who have already taken BIM courses were considered, which excluded students from the 1st and 2nd year. Then:

X = (1.645)2 * 0.5 * (1-0.5) / (0.07)2 = 138.1

n = 16,000 * 138.1/ (138.1+ 16,000 – 1) = 137.6

A total of 150 respondents completed the survey. The survey paper included guidelines that outlined the purpose of the study, emphasized the anonymous nature of the survey, and explained how the survey results would be utilized. The questionnaire (in French) was structured into three sections: the background information of participants, barriers for the BIM implementation, and the strategic solutions for the BIM adoption in Algeria. The strategic solutions were adopted from the study conducted by Liu et al. (2019). The questionnaire demonstrated consistent content, adequate sampling, and compelling findings (Tehami and Seddiki, 2023).

Analytical procedure

Reliability analysis was conducted to assess the internal consistency of the factors using Cronbach's alpha (Kim et al., 2016; Chileshe et al., 2016). The ranking of implementation barriers in Algeria was carried out, as described in Chileshe et al. (2015), by analyzing the descriptive statistics, including mean score values and standard deviations. Multivariate Analysis of Variance (MANOVA) was utilized to examine the differences in perceptions of critical barriers and strategic solutions for BIM adoption in Algeria across various groups segmented by profile type, educational background, work type, and knowledge of CAD and BIM, as noted in Chileshe et al. (2016). When MANOVA identified an overall difference among the respondent groups, univariate ANOVA tests were conducted to determine the sources of these differences, as described in Yuksel et al. (2000).

ANALYSIS AND DISCUSSION

Background information of respondents

A summary of the demographic characteristics of the respondents is presented in Tab. 2. The set of respondents was divided into two profiles: the majority were practitioners constituting more than 72%, and academics more than 27%. This gap can be considered adequate and representative of the difference between practitioners and academics in Algeria. In this study, the academic profile refers to university profiles, namely professors and students.

The most of respondents were architects constituting more than 79%, 13.97% were students, and 6.7% were engineers. The respondents were mainly working in a design firm, i. e. 44.70%. 17.30% of the respondents worked for a project owner, 10.70% worked for a contractor, then 13.30% worked as a university teacher, and 14% were students. This diversity in respondents' profiles allowed to have different viewpoints of participants, between theoretical and practical knowledge which enhanced the quality of data collected. Regarding the mastery of CAD and BIM software among the respondents, the results showed that 38.70% were experts in CAD software (2D/3D modelling), while 36.70% used BIM software such as Revit and ArchiCAD. Additionally, 18% only utilized 2D modelling with CAD software, 4.70% were experts in BIM (demonstrating proficiency in a collaborative platform that has facilitated BIM coordination in a construction project), and only 2% reported having no mastery of CAD (computer-aided design) software like AutoCAD.

Tab. 2. Respondents' personal and contextual characteristics. (Source: Authors, 2023)

Profile type	Frequency (N)	Percentage (%)
Academic	41	27.30
Practitioner	109	72.70
Graduation		
Architect	120	79.33
Engineer	9	6.70
Student	21	13.97
Work type		
Design firm	67	44.70
Project owner	26	17.30
Contractor	16	10.70
University Professor	20	13.30
Student	21	14.00
Knowledge of CAD and BIM		
Lack of expertise in CAD software like AutoCAD	3	2.00

Skilled in CAD software for 2D modelling only	27	18.00
Skilled in CAD software for modelling in both 2D and 3D	58	38.70
Application of BIM tools like Revit, ArchiCAD, and similar programs	55	36.70
A BIM expert	7	4.70

Reliability analysis

The five-point scale demonstrated reliability, with a Cronbach's alpha of 0.87 for BIM barriers and 0.93 for BIM adoption solutions, both exceeding the acceptable lower limit of 0.7 for Cronbach's alpha.

Barriers to the BIM implementation

Ranking analysis

This analysis ranked individual perceptions of BIM barriers according to their mean values and standard deviations. According to Tab. 3, the three most significant barriers to BIM implementation in Algeria were associated with the people factor. Overall, respondents agreed that the two primary barriers were P2, "Shortage of experienced and skilled professionals in BIM", and P4, "The lack of involvement from local authorities in the implementation of BIM", both having the same mean value of 4.25 and a standard deviation of 1.09. The third barrier was P3, "Clients do not mandate the implementation of BIM in their projects", which had a mean value of 4.19. This agrees with the previous study's results on BIM implementation barriers in Algeria from architects' perspective conducted by the authors (Tehami and Seddiki, 2023). Similarly, it was found that the People factor (P2 and P4) was the most prominent challenge of BIM implementation.

In other studies, conducted in developing countries like Malaysia (Zahrizan et al., 2013), Nigeria (Abubakar et al., 2014; Amuda-Yusuf et al., 2017), Egypt (Marzouk et al., 2021), and in Iran (Hosseini et al., 2015), the first barrier of BIM implementation was related to policy factor. The policy aspect was identified as the second key factor, encompassing the fourth, fifth, sixth, and seventh most significant barriers. Respondents indicated that there were "Insufficient training and awareness programs" (Y2) with a mean value of 4.10, followed by a "The absence of support and incentives from policymakers for promoting BIM" (Y1) with a mean value of 4.07. Additionally, respondents noted "Insufficient best practices for BIM within the construction industry" (Y5) with a mean value of 3.95.

Another barrier highlighted by the respondents was Y3, "No legal or contractual agreement on BIM," which had a mean value of 3.87. This is consistent with the results of the previous study conducted by the authors (Tehami and Seddiki, 2023) except that the ranking order was reversed, Y1 fourth and Y2 fifth. Similar to other developing countries like Malaysia and Iran, the Algerian state plays a vital role in shaping the economy and business environment. Since the business strategies of construction companies in Algeria rely heavily on the budget allocated by policymakers for construction projects, these decision-makers have the potential to be a key driving force in encouraging the adoption of BIM in the industry (Tehami and Seddiki, 2023).

Barriers ranked from eighth to twenty were primarily associated with process and technology factors. In terms of process, respondents noted a resistance from project stakeholders to adopt new working practices (S4), which received a mean value of 3.61. This result is consistent with the findings of previous research by Tehami and Seddiki (2023), as well as those of Abubakar et al. (2014) in Nigeria and Hosseini et al. (2015) in Iran. The construction industry in Algeria continues to be largely dominated by traditional project delivery methods, highlighting the need for a fundamental shift in the working approach of construction companies. However, this transition encounters strong resistance from project stakeholders.

Tab. 3. Ranking of the barriers to the BIM implementation. (Source: Authors, 2023)

Factors	ID	Barriers	Mean	Standard Deviation	Rank
People	P2	Shortage of experienced and skilled professionals in BIM	4.25	1.09	1
People	P4	The lack of involvement from local authorities in the implementation of BIM	4.25	1.09	1
People	P3	Clients do not mandate the implementation of BIM in their projects	4.19	1.02	3
Policy	Y2	Insufficient training and awareness programs	4.10	1.08	4
Policy	Y1	The absence of support and incentives from policymakers for promoting BIM	4.07	1.13	5
Policy	Y5	Insufficient best practices for BIM within the construction industry	3.95	1.11	6
Policy	Y3	No legal or contractual agreement on BIM	3.87	1.09	7
Process	S4	Resistance from project stakeholders to adopt new working practices	3.61	1.19	8
People	P1	Resistance to changes in working methods within design offices	3.61	1.28	9
Policy	Y4	Unclear scope and ownership between within project team	3.56	0.98	10
Process	S2	Insufficient active involvement from consultants	3.40	1.18	11
Process	S5	Lack of BIM standard, guideline and protocols	3.52	1.15	12
Technology	T1	High expenses for BIM-related hardware and software	3.35	1.35	13
Process	S3	Lack of BIM data library and standards	3.14	1.19	14
People	P5	Difficulty in learning for those unfamiliar with BIM	3.33	1.41	15
Technology	T4	Interoperability issues	2.85	1.16	16
Technology	T5	BIM coordination is challenging to implement in complex designs	2.79	1.27	17
Technology	T3	BIM software is challenging and complex to learn and utilize	2.60	1.33	18
Technology	T2	BIM lacks the necessary features or flexibility	2.53	1.23	19

		to generate a 3D model			
Process	S1	BIM does not decrease the time spent planning	2.17	1.14	20

This reluctance is understandable, given the ongoing challenges related to the internet speed and infrastructure, which remain major obstacles to BIM adoption due to delays in the implementation of ICT solutions by the Algerian state. Additionally, the most significant technology barrier identified was T1, "High expenses for BIM-related hardware and software", which had a mean value of 3.35. As the adoption of BIM requires specific hardware and software, it affects the cost. It is important to point out that in other studies (Arunkumar et al. (2018) in India, Van Roy and Firdaus (2020) in Indonesia, Khairool Aizat et al. (2019) in Malaysia, NBS Reports (NBS, 2019) in the UK, this barrier was ranked as the main factor. It appears that this is related to the maturity of BIM in these countries (Tehami and Seddiki, 2023).

Multivariate Analysis of Variance (MANOVA)

To examine the differences in perceptions of BIM barriers among various groups segmented by profile variables, a one-way MANOVA was conducted.

BIM Barriers: People factor

According to Tab. 4, the result of MANOVA analysis indicates that the "graduation" has a significate effect (p = 0.006) on the respondents' perceptions of the people barriers to the BIM adoption in Algeria. To identify the source of the differences, univariate ANOVA tests were conducted (see Tab. 5). The results indicate a statistically significant difference in perceptions of the barriers P2, "Shortage of experienced and skilled professionals in BIM" (p = 0.037), and P5, "Difficulty in learning for those unfamiliar with BIM" (p = 0.037), among groups of respondents segmented by "graduation."

Tab. 4. Wilks' Lambda Result (MANOVA Tests). (Source: Authors, 2023)

Variables	BIM Barriers				BIM Solutions
	People factor	**Technology factor**	**Policy factor**	**Process factor**	
Profile type	P = 0.591 Lambda 0.975 No significant differences	**P = 0.006 Lambda 0.842**	P = 0.131 Lambda 0.919 No significant differences	P = 0.716 Lambda 0.980 No significant differences	P = 0.166 Lambda 0.906 No significant differences
Graduation	**P = 0.006 Lambda 0.843**	**P = 0.006 Lambda 0.844**	P = 0.125 Lambda 0.868 No significant differences	P = 0.602 Lambda 0.945 No significant differences	P = 0.183 Lambda 0.836 No significant differences
Work type	P = 0.291 Lambda 0.853 No significant differences	**P = 0.001 Lambda 0.770**	P = 0.172 Lambda 0.836 No significant differences	P = 0.258 Lambda 0.849 No significant differences	P = 0.350 Lambda 0.739 No significant differences
CAD and BIM knowledge	P = 0.636 Lambda 0.887 No significant differences	**P < 0.001 Lambda 0.724**	P = 0.587 Lambda 0.882 No significant differences	P = 0.490 Lambda 0.873 No significant differences	P = 0.140 Lambda 0.704 No significant differences

Tab. 5. ANOVA analysis of subgroup differences towards BIM-barriers-related items. (Source: Authors, 2023)

Item	Overall mean	SD	ANOVA according to Profile type		ANOVA according to Graduation		ANOVA according to Work type		ANOVA according to CAD and BIM knowledge	
			F-value	*p*-value	*F*-value	*p*-value	*F*-value	*p*-value	*F*-value	*p*-value
P1	3.61	1.28			1.30	0.275				
P2	4.25	1.09			3.36	**0.037***				
P3	4.19	1.02			1.32	0.270				
P4	4.25	1.09			2.50	0.086				
P5	3.33	1.41			3.37	**0.037***				
T1	3.35	1.35	4.5435	**0.035***	2.82	0.063	3.283	**0.013***	1.33	0.261
T2	2.53	1.23	0.7627	0.384	3.96	**0.021***	2.110	0.083	6.20	**<.001***
T3	2.60	1.33	0.2178	0.641	6.09	**0.003***	4.163	**0.003***	7.16	**<.001***
T4	2.85	1.16	0.0731	0.787	6.25	**0.002***	2.085	0.086	1.63	0.171
T5	2.79	1.27	0.2183	0.641	1.43	0.242	0.929	0.449	4.36	**0.002***

Note: A *p-value lower than 0.05 indicates significant differences among subgroups regarding BIM barriers.

Fig. 1 shows that respondents who identified as architects and students were more likely to view P2, "Shortage of experienced and skilled professionals in BIM", as the primary barrier to the BIM implementation, compared to respondents who were engineers. This could be explained by the fact that engineers, by the nature of their work, are required to use IT tools, which means that they are more able and used to working with software than architects. So, it seems that P2 does not represent important BIM barrier for them. Additionally, student respondents were less likely than their architect and engineer counterparts to consider P5, "Difficulty in learning for those unfamiliar with BIM," as a significant barrier to BIM adoption in Algeria. This perspective may be attributed to their academic experience, as they had already been exposed to BIM courses at the university. As a result, they do not perceive learning difficulties as a critical obstacle to BIM adoption in Algeria. Monko and Roider (2014) emphasized the role of the Public-Private-Academia Partnership (PPAP) as the most influential driver of BIM adoption in Tanzania. Similarly, Marzouk et al. (2021) highlighted that while government initiatives can play a crucial role in technology implementation, educational institutions are key influencers in accelerating BIM adoption in the Egyptian construction industry.

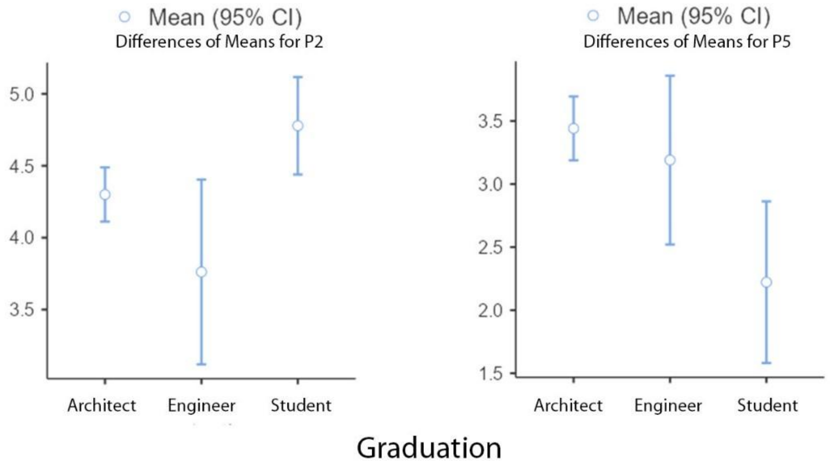

Fig. 1. Characteristics of respondents' graduation and relationships with BIM People Barriers P2 and P5. (Source: Authors, 2023)

BIM Barriers: Technology factor

Tab. 4 reveals significant effects of the following factors on respondents' perceptions of the technological barriers impeding BIM adoption in Algeria: "profile type" (p = 0.006), "graduation" (p = 0.006), "work type" (p = 0.001), and "CAD and BIM knowledge" (p < 0.001). The results of the univariate tests show a statistically significant difference in perceptions of the barrier T1, "High expenses for BIM-related hardware and software" (p = 0.035), among groups of respondents segmented by profile type (see Tab. 5). Fig. 2 illustrates that academic respondents were more likely to dismiss T1 as a critical barrier to BIM adoption in Algeria compared to their practitioner counterparts. This result seems coherent and can be explained by the fact that the practitioners' respondents tend to have more knowledge about the real cost of the BIM software and hardware.

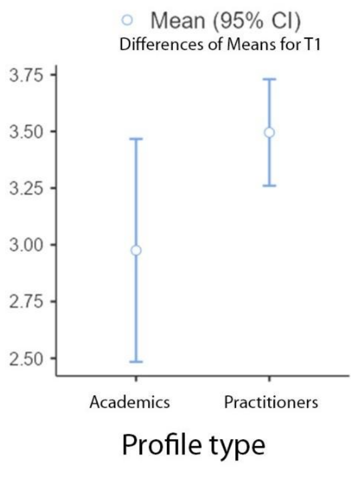

Fig. 2. Characteristics of respondents' profile type and relationships with BIM Technology Barrier T1. (Source: Authors, 2023)

Besides, the univariate tests results' reveal statistically significant differences in perceptions of the barriers T2, "BIM lacks the necessary features or flexibility to generate a 3D model" (p = 0.021), T3, "BIM software is challenging and complex to learn and utilize" (p = 0.003), and T4, "Interoperability issues" (p = 0.002) among groups of respondents segmented by graduation (see Tab. 5). Fig. 3 shows that student respondents were more inclined to dismiss T2, "BIM lacks the necessary features or flexibility to generate a 3D model", as a critical barrier to BIM adoption in Algeria compared to architects and engineers. This can be explained by the fact that since students had BIM courses in university, they had sufficient knowledge of the BIM functions to judge that T2 cannot be in any way a BIM critical barrier. Additionally, students were also more likely to reject T3, "BIM software is challenging and complex to learn and utilize", as a significant barrier to BIM implementation in Algeria than their architect and engineer counterparts.

Additionally, respondents who identified as engineers and students were more likely to dismiss T4, "Interoperability issues", as a significant barrier to BIM adoption in Algeria. In contrast, architect respondents exhibited a somewhat neutral attitude toward this barrier. This agrees with the previous findings and suggests that the respondents who were engineers and students have enough knowledge of the BIM functions than respondents who are architect. Moreover, the results of the univariate tests indicate statistically significant differences in perceptions of T1, "High expenses for BIM-related hardware and software" (p = 0.013), and T3, "BIM software is challenging and complex to learn and utilize" (p = 0.003) among groups of respondents segmented by work type (see Tab. 5).

Fig. 4 shows that student respondents were more inclined to dismiss T1 as a critical barrier to BIM adoption compared to other respondents. This agrees with the aforementioned findings and allows to identify that, from among the academic respondents, it was the students who were more likely to reject T1 as a critical BIM barrier. Additionally, both students and contractors were more likely to reject T3 as a significant barrier than their counterparts. This agrees with the aforementioned findings and suggests that the respondents who were students and contractors (who are mostly engineers) have enough knowledge of the BIM functions than respondents who are architects.

Furthermore, the results of the univariate tests indicate statistically significant differences in perceptions regarding T2, "BIM lacks the necessary features or flexibility to generate a 3D model" (p < 0.001), T3, "BIM software is difficult and complex to learn and utilize" (p < 0.001), and T5, "BIM coordination is difficult to adapt in a complex design" (p = 0.002) among groups of respondents segmented by CAD and BIM knowledge (see Tab. 5). Fig. 5 shows that respondents who were BIM experts were more likely to dismiss T2 as a critical barrier compared to those who primarily mastered CAD software in 2D/3D modelling and those who used BIM software like Revit and ArchiCAD. Likewise, respondents mastering CAD software in 2D modelling only had a somewhat neutral attitude. This can be explained by the fact that respondents who were BIM experts were more familiar with BIM software than the other groups of respondents.

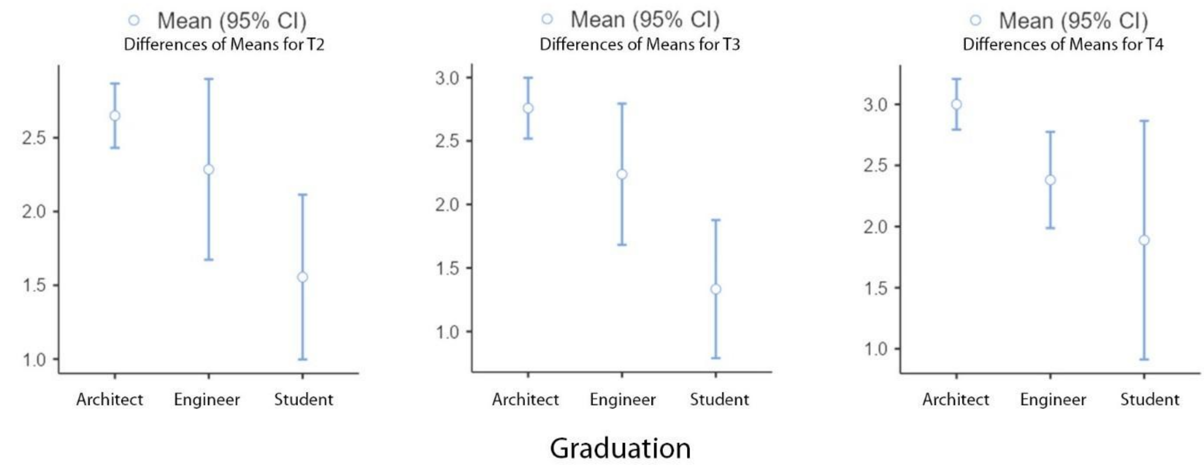

Fig. 3. Characteristics of respondents' graduation and relationships with BIM Technology Barriers T2, T3, and T4. (Source: Authors, 2023)

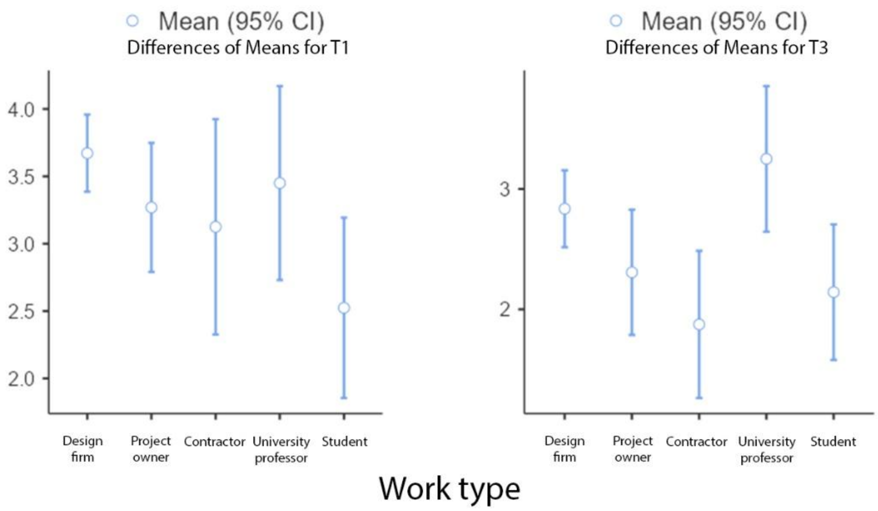

Fig. 4. Characteristics of respondents' Work type and relationships with BIM Technology Barriers T1 and T3. (Source: Authors, 2023)

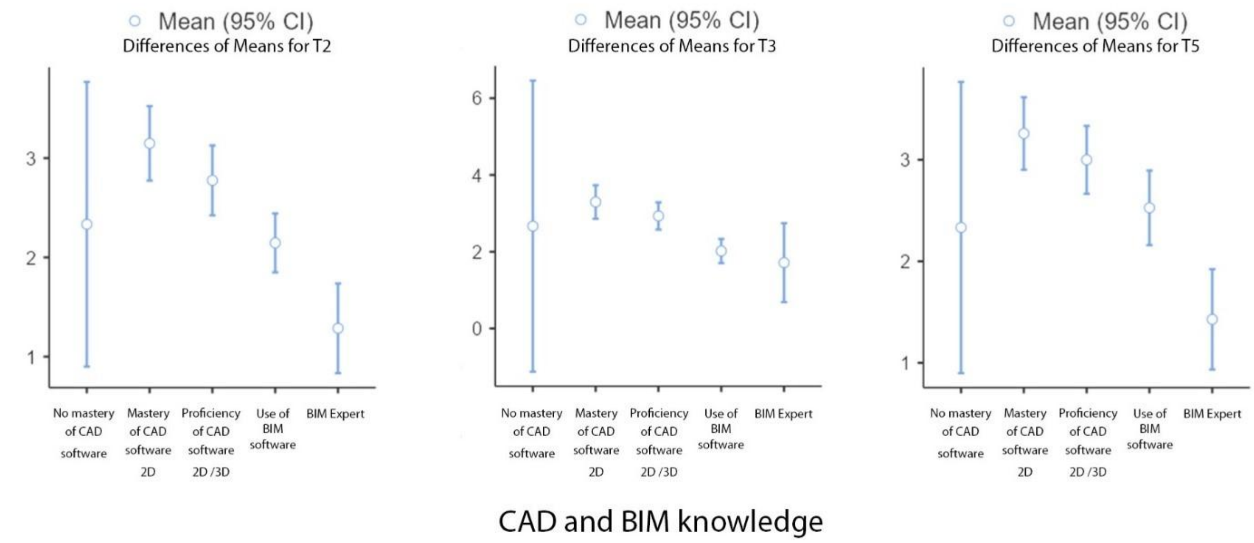

Fig. 5. Characteristics of respondents' CAD and BIM knowledge and relationships with BIM Technology Barriers T2, T3, and T5. (Source: Authors, 2023)

Additionally, respondents who were BIM experts were more inclined to dismiss T3 as a critical barrier compared to those who primarily mastered CAD software in 2D/3D modelling and those using BIM software like Revit and ArchiCAD. This result seems to be coherent as long as it is quite normal that respondents who are more familiar with BIM reject T3 as a critical BIM barrier. Moreover, respondents who mastered CAD software in 2D modelling and those proficient in CAD software for 2D/3D modelling expressed significantly less concern about T5 as a critical barrier compared to respondents using BIM software like Revit and ArchiCAD, as well as BIM experts. This can be explained by the fact that these two groups of respondents were unfamiliar with BIM functionalities.

BIM Barriers: Policy factor

Regarding the BIM policy barriers, no statistically significant differences were identified among any groups of respondents. This suggests that perceptions of "BIM policy barriers" are consistent across all groups within our sample (see Tab. 4).

BIM Barriers: Process factor

Concerning the BIM process barriers, no statistically significant differences were observed among any groups of respondents. This indicates that perceptions of "BIM process barriers" are relatively uniform across all groups within our sample (see Tab. 4).

Strategical solutions for BIM adoption in Algeria

This part aims to investigate the most impactful solutions for BIM adoption in Algeria. 10 factors of BIM strategic solutions, adopted from the study conducted by Liu et al. (2019), had been listed in the questionnaire to be ranked by the respondents.

Ranking analysis

Tab. 6. Ranking of BIM strategic solutions. (Source: Authors, 2023)

ID	Strategic Solutions	Mean	Standard Deviation	Rank
SU1	Launch BIM training and certifications	4.44	0.96	1
SU2	Promotion and awareness of stakeholders in the construction industry	4.41	0.96	2
SU4	Government support and application of BIM	4.21	1.07	3
SU10	Employing BIM specialists	4.18	0.99	4
SU9	Investment of BIM software and hardware	4.12	1.04	5
SU8	Define the responsibilities of the various stakeholders in a BIM project	4.11	0.99	6
SU3	Development of a standard BIM legal or contractual agreement	4.07	1.14	7
SU6	Development of BIM Standards	4.01	1.07	8
SU5	Technical progress in computing and information technology (IT)	3.97	1.11	9
SU7	Improvement and simplification of BIM tools	3.95	1.10	10

This analysis ranked individual perceptions of BIM strategic solutions according to their mean values and standard deviations. Tab. 6 provides the statistical means, standard deviations, and ranks of these factors. According to Tab. 6, the most important BIM strategic solution identified is SU1, "Launch BIM training and certifications," with a mean value of 4.44. This result is in line with the findings of past studies. For Khairool Aizat et al. (2019) and Latiffi et al. (2015), BIM training was the 2nd most important strategic solution for the BIM implementation in Malaysia. The other highly ranked BIM strategic solutions include SU2, "Promotion and awareness of stakeholders in the construction industry," with a mean value of 4.41, SU4, "Government support and application of BIM," with a mean value of 4.21, and SU10, "Employing BIM specialists," with a mean value of 4.18. Providing incentives and spreading awareness was also considered as the best strategies for promoting BIM in Egypt (Marzouk et al., 2021). The importance of the government implication for the enforcement of BIM was also identified by Marzouk et al. (2021) in Egypt, and by Latiffi et al. (2015) and Khairool Aizat et al. (2019) in Malaysia as an important strategic solution for the BIM implementation.

Multivariate Analysis of Variance (MANOVA)

For the BIM strategic solutions, no statistically significant differences were found among any groups of respondents. This suggests that perceptions of "BIM strategic solutions" are consistent across all groups within our sample (see Tab. 4).

CONCLUSION

Different from previous BIM implementation studies conducted in developed and developing countries, this study collected a large volume of data from the viewpoints of both practitioners (project managers, project owners, contractors) and academics (university teachers and students). This dual approach provides a scholarly contribution to the body of knowledge on BIM implementation by extending the BIM adoption research beyond practitioners to include academics. By incorporating multiple influencing factors (e.g., profile type, graduation, etc.), this study builds upon and expands previous research on individual perceptions of BIM adoption. Additionally, it offers valuable insights into the current state of the BIM implementation in Algeria, helping to bridge existing knowledge gaps in the field. Furthermore, this paper extends previous research on the BIM implementation in Algeria (Tehami and Seddiki, 2023) by examining individual perceptions of the BIM practice among practitioners and academics, particularly in relation to BIM critical barriers and strategic solutions.

The ranking analysis of BIM implementation barriers revealed that construction stakeholders in Algeria view people and policy factors as the most significant barriers to effective BIM implementation. People and policy factors included the non-involvement of local authorities in the BIM application, BIM knowledgeable professionals and clients' BIM knowledge. On the other hand, technology, and process factors such as the high cost of BIM hardware and software, and reluctance to change the working method by project stakeholders were considered less important barriers. Multivariate Analysis of Variance (MANOVA) revealed that the academics' respondents, precisely the student, were more aware and had a sensitive perception toward certain BIM critical barriers. Compared to practitioners' respondents (architects and engineers), students held more confirmatory views, such as for the BIM people and technology barriers.

Therefore, there was a gap in the BIM awareness between the academics (student) and the practitioner's (architect and engineer). Thus, and according to the survey findings of this study, Construction Industry-Academics-Partnership could be suggested as an influential key for promoting the BIM adoption in Algeria. This could reinforce the engagement of the academic sector in vocational training. It is worth mentioning that the authors have collaborated for the elaboration of a canvas for professional master's training on "energy efficiency in the building" by using BIM. This training is part of a partnership between GIZ (Gesellschaft für Internationale Zusammenarbeit) and the Algerian universities (USTO-Oran, Blida, Constantine) to strengthen the professional integration of graduates from the academic sector.

However, it is crucial to note that these significant differences between groups of respondents did not affect the overall ranking of the most important BIM barriers.

The ranking of strategic solutions was in line with the findings of the critical barriers' analysis. The top BIM strategic solutions were the launch of BIM training and certifications, promotion and awareness of stakeholders in the construction industry, and government support and application of BIM. Therefore, the government should first consider providing incentives to accelerate BIM training courses in both private and public institutions by promoting partnerships between the construction industry and academia. This initiative would encourage large construction companies to incorporate the BIM learning as part of internal training for their employees, thereby facilitating the BIM implementation in their projects. Secondly, Algerian authorities should gradually mandate the BIM implementation for large public projects through regulation.

Although this research covered the BIM practice perception of both practitioners and academics in Algeria, a limitation of this study is related to the sample size and the multi-influence factors. As part of future studies, it will be interesting to have a more representative population for both the construction industry and the educational institutions in the country. Furthermore, other multi-influence factors could be considered in further research as the compatibility issues at the organizational level of the construction industry in Algeria for facilitating the BIM adoption. Finally, recommended future investigations also include developing an interrelation framework for the BIM implementation among BIM pedagogy and BIM industry practice to address gaps between the educational institutions and the construction industry.

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