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Barriers in Adoption and Implementation Strategies for Building Information Modeling In Pakistan Construction Industry

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Abstract

Building Information Modeling (BIM) is one of the most recent developments in the construction industry. In Pakistan, research on BIM in academia and construction industry is relatively a new phenomenon. This paper has tried to find out the barriers and implementation strategies for BIM adoption in Pakistan construction industry. The main objective of this research is to investigate the barriers in BIM adoption and its implementing strategies in construction industry in Pakistan for coordinating and managing construction projects. The methodology for this research was based on a questionnaire survey to collect data. The questionnaire was designed comprising on research variables for barriers in BIM adoption and BIM implementation strategies. This survey was conducted among Architects, Designers, Engineers, Contractors, Sub-contractor, MEP consultants, Academia, Developers, and Facility Owners. The collected data were analyzed by conducting different statistical procedures to make inferences.
Results of this survey indicated that the barriers for implementing BIM were lack of awareness, lack of support from consultants and contractors, lack of industry motivation, and lack of knowledge by owners. The main BIM implementation strategy was the dissemination of BIM knowledge to government departments, academia and the industry. Workshops on BIM benefits are required to be conducted to create more awareness among all stakeholders. This research work recommends that BIM need to be implemented in the local context apart from some adoption barriers.

Keywords

Building Information Modeling (BIM), Virtual Building Construction, Object-Oriented CAD Systems, Virtual Design and Constriction

1. Introduction

With BIM technology, one or more accurate virtual models of a building can be constructed digitally. They support design through its phases, allowing better analysis and control than manual processes. When completed, these computer generated models contain precise geometry and data needed to support the construction, fabrication, and procurement activities through which the building is realized (Eastman, Teicholz et al. 2011). Building information modeling is emerging as an innovative way to virtually design and manage projects. Research indicates that predictability of building performance and operation is greatly improved by adopting BIM (Azhar 2011).

In Pakistan, Building Information Modeling (BIM) is a new concept in the construction industry. Very little work has been carried out to explore its potential in the industry. This research has tried to find out barriers in the way of its adoption and to formulate strategies for implementing BIM for coordinating and managing construction projects through a research survey based on a questionnaire. The objective of this research is to explore barriers in BIM adoption and to discuss implementing strategies for its applications in designing, coordinating, managing and execution of construction projects in the construction industry of Pakistan.

2. Literature Review

BIM is an emerging tool for designing that is used to design and document a project and is also used as a vehicle to enhance communication among all project stakeholders (Krygiel and Nies 2008). BIM is a revolutionary technology and a process that has quickly transformed the way buildings are conceived, designed, constructed and operated (Hardin 2009).

The ability to utilize BIM to virtually construct a building prior to construction of the actual building provides an effective means to check its constructability in the real world and to resolve any uncertainties during the process. This allows for more efficient and better design structures that limit waste of resources, optimize energy usage, and promote passive design strategies (Bynum, Issa et al. 2012).

The project's design performance can also be better developed with the help of a model. The improved ability to visualize the design proposals in the early project phases greatly aids in the assessment of the spaces and aesthetic finishes of the project. The intent of the designers is more easily and accurately communicated to the other project team members, and adjustments can be made until the design meets the desired goals (Kymmell 2008).

The deployment of BIM within the construction industry poses many significant problems. BIM is a disruptive technology, unlike the adoption of 2D CAD which simply automated a traditional process; BIM requires a whole paradigm shift and a new way of working (Davidson 2009). Most obstacles in the learning process can be related to like lack of understanding of the process and inability to use the required tools (Kymmell 2008). The barriers to implementation of BIM as found in US were lack of skilled personnel, lack of company investment, lack of collaborative work processes and modeling standards, interoperability, lack of legal and contractual agreements (Ku and Taiebat 2011). Primary reasons and barriers for not to implement BIM in many UK construction companies and firms were found to be not familiar enough with BIM use, reluctance to initiate new workflows or train staff, firms do not have enough opportunity for BIM implementation, benefits from BIM implementation do not outweigh the costs to implement it, and benefits are not tangible enough to warrant its use (Arayici, Khosrowshahi et al. 2009).

3. Research Methodology

This research was conducted as an exploratory study to measure the perception of the construction industry stakeholders about the barriers in BIM adoption and to formulate implementing strategies for its applications in the local context**.** After the preliminary study, a detailed literature review was carried out and a number of already developed questionnaire were examined. After this review, the research variables for barriers for BIM use and to adopt BIM were grouped in a separate section; and research variables for BIM implementing strategies were grouped in a separate section.

The online questionnaire form was designed using Google documents. The link of the questionnaire was sent to Architects, Designers, Engineers, MEP (Mechanical, Electrical, and Plumbing) Consultants, Contractors, Developers, Facility Owners, Academia and Construction Industry related members via email and by hand where it was required. The emails were acquired from the websites of Pakistan Engineering Council (PEC), Pakistan Council of Architect and Town Planners (PCATP), Institute of Architects Pakistan (IAP) and personal contacts and relations.

Out of 175 questionnaires sent out, 157 were received. Twenty three (23) incomplete questionnaires were excluded and analysis was carried out on 134 questionnaires. The collected data were analyzed using MS Excel and SPSS. Cronbach's Coefficient Alpha was measured to check the reliability of the collected data and to examine the internal consistency of the items of the questionnaire when research variables were on Likert scale. The Shapiro-Wilk Normality Test was performed to check whether data is parametric or non-parametric i.e. whether the data were normally distributed or otherwise. Kruskal-Wallis test was performed to check the differences or similarities in the perception of stakeholders about the research variables. A 5% level of significance was considered to represent statistically significant relationships in the collected data. The perception level of the respondents to the research variables was assessed by using the mean score (MS) computed by the following formula (Chan and Kumaraswamy 1996):

$$MS = \frac{\sum(f x s)}{N} \quad (1 \leq MS \geq 5) \qquad \text{(Eq 1)}$$

Where 's' is score given to each research variable by the respondents and ranges from 1 to 5 when 1 is "Strongly disagree" and 5 is "Strongly agree"; "f" is frequency of responses to each rating (ranges from l to 5) for each research variable; and N is total number of responses (134). In addition to the mean score, the five-point scale was transformed to relative importance indices using the relative index ranking technique (Chan and Kumaraswamy 1997; Sambasivan and Soon 2007) to determine the rankings of the research variables and verify the evaluation by mean score.

$$\text{Relative Importance Index (RII)} = \sum w / (A*N) \quad (0 \leq RII \geq 1) \qquad (3\text{-}2)$$

$$RII = \left(\frac{1n1+2n2+3n3+4n4+5n5}{(A*N)}\right)$$

Where
w = weighting assigned to each research variable by the respondents having range from 1 to 5
n1 = number of respondents for Strongly disagree
n2 = number of respondents for Disagree
n3 = number of respondents for Not sure
n4 = number of respondents for Agree
n5 = number of respondents for Strongly agree
A= highest weight is 5
N = sample size taken as 134

A random sample for this study was selected from a population of more than 30,000 construction industry establishments registered with Pakistan Engineering Council (PEC 2012). It was fairly a large population and the sample is representative of various construction experts.

4. Findings and Discussion

This research survey was one of the first steps towards assessing the barriers in BIM adoption and to formulate the implementing strategies for its use and applications in the local context for coordinating, communicating and managing the construction projects.

4.1. Respondent's Profile

The respondents to this survey as indicated in Table 1 were Architects / Designers, Engineers / MEP Consultants, Contractors / Specialty Contractors, Academicians and Developers / Facility Owners with the varied professional experience from 1 to more than 20 years and they were holding positions in their organizations as Managing Director, Project Director / Manager, Project Architect / Engineer / Planner, Contract Manager, Site Manager, Site Supervisor, Facility Manager, and Professor / Lecturer in Academia.

Table 1: Respondent’s grouping

CI Stakeholders	Frequency	Percent	Cumulative Percent
Architects / Designers	30	22.4	22.4
Engineers /MEP Consultants	48	35.8	58.2
General / Specialty Contractors	25	18.7	76.9
Academician	20	14.9	91.8
Developers / Facility owners	11	8.2	100.0
Total	**134**	**100.0**	

Table 2 shows that there is an increasing level of awareness about BIM technology and its processes when 88.1% of the respondents were having either little or general knowledge and 11.2% were with working knowledge of BIM. Most of them (64.9%) have no working experience with BIM (see Figure 1) but quite a number of them (35.1%) were having varied experience with this technology. All of them were having the knowledge of BIM technology and its processes when the recorded level of knowledge about BIM was 44% for little, 44% for general and 11.2% for working.

Table 2: Respondent's level of knowledge about BIM

Respondent's level of knowledge about BIM	Frequency	Percent	Cumulative Percent
Little	59	44.0	44.0
General	59	44.0	88.1
Working	15	11.2	99.3
Expert	0	0.0	99.3
No answer	1	.7	100.0
Total	**134**	**100.0**	

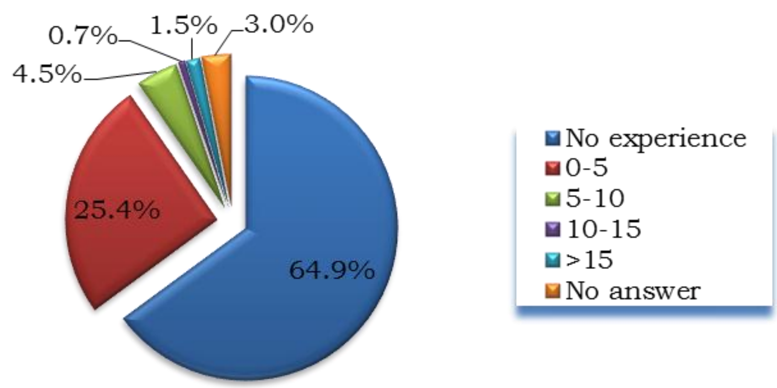

Figure 1: Respondent's experience with BIM

4.2. Respondent’s Organization Profile

Randomly selected 87 organizations participated to the survey across the country in which there were 26 Architecture / Designers, 26 Engineers / MEP Consultants, 16 General / Specialty Contractors, 9 Academic Institutions and 10 Developers / Facility Owners. The geographical location of the projects was across the country (31% Punjab, 15.1% Khyber Pakhtunkhwa, 17% Sind, 10.1% Balochistan, 9.9% Kashmir, and 8.5% Gilgit-Baltistan, whereas 8.5% respondents were also working in abroad). The average number of employees working in the organizations was from 25 to 500. The size of the projects were 100 to 500 million rupees and they were residential, commercial, educational, healthcare, institutional, civil, cultural, industrial, entertainment, sports and transportation. The respondents were working in well-established organizations working in different parts of the country on different kind of projects.

4.3. Nature of the collected data and Statistical Tests

The validity of the collected data was measured and it was found the *p*-values for each research variable was less than 0.05 or 0.01. The correlation coefficient of each research variable was positive and significant at $\alpha = 0.01$ or $\alpha = 0.05$. Cronbach's Coefficient Alpha value was 0.879 and this value reflected a higher degree of internal consistency of the collected data. After conducting the normality test, the significance values were found 0.000 which were less than 0.05 indicating that the collected data was not normally distributed and the data were non-parametric in nature. Non-parametric tests were required for further analysis. A Kruskal-Wallis test was conducted to compare the outcome of the research variables. No significant difference (as $p > 0.05$) was found among the construction industry stakeholders indicating that all the stakeholders had similar perception about the barriers in BIM adoption and BIM implementation strategies.

4.4. Frequency Analysis

Descriptive statistics were used for frequency analysis of the research variables to draw results. The findings of the responses to these variables have been shown in in Table 3 and Table 4. Table 3 shows the Mean Score (MS) values of the research variables for barriers in BIM adoption that the respondents to this survey were agreed that 'BIM technology, its software, hardware and its training is expensive', 'Hesitation to learn new technology, and unwillingness to change the traditional way of practice are barriers in BIM adoption', 'Lack of awareness, support from consultants and contractors, industry motivation and clients, knowledge on owner's side, are also the barriers in the way of BIM adoption', 'The common practice of design and drafting separately is one of the barriers in BIM adoption', 'Multiple BIM models for AEC stakeholders and their reliability is one of the concerns in BIM adoption', 'Current contractual system does not adequately addresses issues of control of entry of data to BIM model, the liability for errors, mistakes, omissions and model ownership', 'Licensing, copyright and insurance obligation issues are not resolved adequately for BIM adoption', and 'Lack of software interoperability / compatibility and standardization of BIM process is one of the barriers in its adoption'.

Table 3: Frequency Analysis for Barriers in BIM Adoption

Research Variables	MS	1	2	3	4	5	No. of Respondents
		Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree	
BIM technology, its software, hardware and its training is expensive.	3.61	2	12	42	58	20	134
Hesitation to learn new technology, and unwillingness to change the traditional way of practice are barriers in BIM adoption.	3.80	1	16	19	71	27	134
Lack of awareness, support from consultants and contractors, industry motivation and clients, knowledge on owner's side, are also the barriers in the way of BIM adoption.	3.98	0	5	21	80	28	134

The common practice of design and drafting separately is one of the barriers in BIM adoption.	3.63	1	17	36	56	24	134
Multiple BIM models for AEC stakeholders and their reliability is one of the concerns in BIM adoption.	3.50	1	9	57	56	11	134
Current contractual system does not adequately addresses issues of control of entry of data to BIM model, the liability for errors, mistakes, omissions and model ownership.	3.76	0	4	40	74	16	134
Licensing, copyright and insurance obligation issues are not resolved adequately for BIM adoption.	3.57	1	7	53	61	12	134
Lack of software interoperability / compatibility and standardization of BIM process is also one of the barriers in its adoption.	3.63	2	14	33	67	18	134
Mean	**3.69**						

Table 4 indicates the mean score (MS) values of the research variables for BIM implementation strategies that the respondents to the survey were agreed that 'BIM should be integrated into education courses across all AEC disciplines', 'Workshops on BIM benefits to create awareness among all the stakeholders should be conducted', 'Pilot projects should be undertaken to validate and demonstrate the BIM outcomes', 'Lessons learned from the pilot projects need to be disseminated to government, academia and industry', 'Government departments should be educated on 'model-based' deliverables and its benefits', 'Governments should encourage adopting of BIM as a collaborative working tool in the built environment sector', 'Academia, Pakistan Engineering Council (PEC) and Pakistan Council for Architect and Town Planning (PCATP) should develop BIM project execution guides and manuals for AEC and MEP professionals', 'PEC and PCATP should develop new forms of contract for architects, engineers, consultants, and contractors for intellectual property, insurance and warranty requirements for the use of BIM technology/processes', 'BIM requirements should be incorporated into consultant, contractor, subcontractor and vendor agreements for scope, schedule of delivery and file / data formats of the model', 'Adoption of best practices in BIM process may be taken as a guide for BIM implementation', 'The early involvement of all key disciplines in the BIM design process is essential' and 'Change of business model / process can lead the way of BIM adoption'.

Table 4: Frequency Analysis for BIM Implementation Strategies

Research Variables	**MS**	**1**	**2**	**3**	**4**	**5**	**No. of Respondents**
		Strongly Disagree	**Disagree**	**Not sure**	**Agree**	**Strongly Agree**	
BIM should be integrated into education courses across all AEC disciplines.	4.10	1	4	15	74	40	134
Workshops on BIM benefits to create awareness among all the stakeholders should also be conducted.	4.17	1	1	15	74	43	134
Pilot projects should be undertaken to validate and demonstrate the BIM outcomes.	4.12	1	3	13	79	38	134
Lessons learned from the pilot projects need to be disseminated to government, academia and industry.	4.19	1	2	13	72	46	134
Government departments should be educated on 'model-based' deliverables and its benefits.	4.04	1	2	17	84	30	134
Governments should encourage adopting of BIM as a collaborative working tool in the built environment sector.	4.06	2	1	13	89	29	134
Academia, PEC and PCATP should develop the BIM project execution guides and manuals for AEC and MEP professionals.	4.09	2	1	13	89	29	134

PEC and PCATP should develop new forms of contract for architects, engineers, consultants, and contractors for intellectual property, insurance and warranty requirements for the use of BIM technology/processes.	3.93	2	9	19	71	33	134
BIM requirements should be incorporated into consultant, contractor, subcontractor and vendor agreements for scope, schedule of delivery and file / data formats of the model.	3.81	2	10	23	75	24	134
Adoption of best practices in BIM process may be taken as a guide for BIM implementation.	3.98	0	2	22	87	23	134
The early involvement of all key disciplines in the BIM design process is essential.	4.04	0	6	16	79	33	134
Change of business model / process can lead the way of BIM adoption.	3.84	0	6	25	88	15	134
Mean	**4.03**						

4.5. Ranking for Barriers in BIM Adoption

Table 5 indicates the ranking of Barriers in BIM adoption in the industry in which 'Lack of awareness, support from consultants and contractors, industry motivation, knowledge on owner's side, are the barriers in the way of BIM adoption' was ranked at the top with the highest value of RII (0.7955) and followed by 'Hesitation to learn new technology, and unwillingness to change the traditional way of practice are barriers in BIM adoption', whereas 'Multiple BIM models for AEC stakeholders and their reliability is one of the concerns in BIM adoption' and was ranked at the lowest with the value of RII (0.7000) and followed by 'Licensing, copyright and insurance obligation issues are not resolved adequately for BIM adoption'.

The construction industry stakeholders have the perception for Barriers in BIM adoption that the lack of awareness, lack of support from consultants and contractors, lack of industry motivation, lack of knowledge on owner's side, are the barriers in the way of BIM adoption. They also perceived that hesitation to learn new technology, and unwillingness to change the traditional way of practice are also barriers in BIM adoption.

Table 5: Ranking for Barriers in BIM Adoption

Research Variables	Mean Score	RII	Overall Rank
BIM technology, its software, hardware and its training is expensive.	3.6119	0.7224	5
Hesitation to learn new technology, and unwillingness to change the traditional way of practice are barriers in BIM adoption.	3.7985	0.7597	2
Lack of awareness, support from consultants and contractors, industry motivation and clients, knowledge on owner's side, are also the barriers in the way of BIM adoption.	3.9776	0.7955	1
The common practice of design and drafting separately is one of the barriers in BIM adoption.	3.6343	0.7269	4
Multiple BIM models for AEC stakeholders and their reliability is one of the concerns in BIM adoption.	3.5000	0.7000	7
Current contractual system does not adequately addresses issues of control of entry of data to BIM model, the liability for errors, mistakes, omissions and model ownership.	3.7612	0.7522	3
Licensing, copyright and insurance obligation issues are not resolved adequately for BIM adoption.	3.5672	0.7134	6
Lack of software interoperability / compatibility and standardization of BIM process is also one of the barriers in its adoption.	3.6343	0.7269	4
Mean	**3.6856**	**0.7371**	

4.6. Ranking for BIM Implementation Strategies

Table 6 shows the ranking for BIM Implementation Strategies in the construction industry in which 'Lessons learned from the pilot projects need to be disseminated to government, academia and industry' is ranked at the top with the highest value of RII (0.8388) and followed by 'Workshops on BIM benefits to create awareness among all the stakeholders should also be conducted' whereas 'BIM requirements should be incorporated into consultant, contractor, subcontractor and vendor agreements for scope, schedule of delivery and file / data formats of the model, is ranked at the lowest with the value of RII (0.7627) and followed by 'Change of business model / process can lead the way of BIM adoption.

The construction industry stakeholders have the perception for BIM Implementation Strategies that this could be implemented by disseminating the lessons learned from the pilot projects to government departments, academia and the industry. They perceived for its implementation that workshops on BIM benefits should be conducted to create awareness among all the stakeholders.

Table 6: Ranking for BIM Implementation Strategies

Research Variables	Mean	RII	Overall Rank
BIM should be integrated into education courses across all AEC disciplines.	4.1045	0.8209	4
Workshops on BIM benefits to create awareness among all the stakeholders should also be conducted.	4.1716	0.8343	2
Pilot projects should be undertaken to validate and demonstrate the BIM outcomes.	4.1194	0.8239	3
Lessons learned from the pilot projects need to be disseminated to government, academia and industry.	4.1940	0.8388	1
Government departments should be educated and lobbied on 'model-based' deliverables and its benefits.	4.0448	0.8090	7
Governments should also encourage adopting of BIM as a collaborative working tool in the built environment sector.	4.0597	0.8119	6
Academia, PEC and PCATP should develop the BIM project execution guides and manuals for AEC and MEP professionals.	4.0896	0.8179	5
PEC and PCATP should develop new forms of contract for architects, engineers, consultants, and contractors for intellectual property, insurance and warranty requirements for the use of BIM technology/processes	3.9254	0.7851	10
BIM requirements should be incorporated into consultant, contractor, subcontractor and vendor agreements for scope, schedule of delivery and file / data formats of the model.	3.8134	0.7627	12
Adoption of best practices in BIM process may be taken as a guide for BIM implementation.	3.9776	0.7955	9
The early involvement of all key disciplines in the BIM design process is essential.	4.0373	0.8075	8
Change of business model / process can lead the way of BIM adoption.	3.8358	0.7672	11
Mean	**4.0311**	**0.8062**	

The construction industry stakeholders perceived that BIM implementation strategies can be adopted first and the barriers in BIM adoption are to be addressed keeping in view the local context.

4.7. Implementation Comments

Many respondents to this survey have provided some suggestions for the implementation of BIM in last part of the questionnaire in which they suggested awareness workshops for BIM in the construction industry and education to the academia should be provided with training to apply BIM to their curriculum and practice. Clients should be made aware of the BIM benefits for its use and applications and they may make it as a contractual requirement of delivery process. PCATP & IAP platforms should be fully utilized to educate professionals, academicians and students regarding the advantages of BIM.

5. Conclusions

There is an increasing level of awareness about BIM technology and its processes as 88.1 % of the respondents were having either little or general knowledge and 11.2% were with working knowledge of BIM. Majority of the respondents (64.9%) have no working experience with BIM because of various adoption barriers but quite a number of them (35.1%) were having varied experience with this technology. The major barriers in the way BIM adoption were lack of awareness, lack of support from consultants and contractors, lack of industry motivation, and lack of knowledge on owner's side. Also the hesitation to learn new technology, and unwillingness to change the traditional way of practice are also barriers in the way of BIM adoption. Implementation Strategies for BIM adoption were the disseminating of BIM knowledge to government departments, academia and the industry. The study suggested that workshops on BIM benefits should be conducted to create more awareness among all stakeholders. The ranking indicates that BIM implementation strategies should be adopted first and followed by addressing the barriers in BIM adoption.

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