



Building Information Model (BIM) Implementation in Perspective of Kazakhstan: Opportunities and Barriers

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Authors' contributions

This work was carried out in collaboration between both authors. Author DA designed the study, carried out literature search, performed data collection and analysis and wrote the first draft of the manuscript. Author MAH directed the study, managed the literature searches and analyses of the study and prepared the final draft. Both authors read and approved the final manuscript.

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ABSTRACT

The construction industry is characterized by low productivity with low technological advances, minimum automation and computerization. Building Information Modeling (BIM) as a means of technological innovation, has the great potentials to improve productivity, decrease project cost and shorten project delivery time. The initiative to implement BIM in Kazakhstan construction industry has sparked widespread interest recently. This study aims to identify the opportunities and barriers to implementing BIM in construction companies in Kazakhstan. A comprehensive literature search, interviews with leading construction companies and a survey among other construction companies in Kazakhstan were conducted to understand the barriers and opportunities of BIM adoption in Kazakhstan. The study reveals that the BIM adoption level in Kazakhstan is very low and there exists a number of challenges and lack of clear guidelines to implementing BIM. The study maps BIM implementation barriers in other countries with Kazakhstan by careful investigation of literature search, interviews and the survey results. The research also proposes a BIM implementation roadmap to be followed by the construction companies in Kazakhstan and other similar countries.

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1. INTRODUCTION

Construction is among the main industries that accounts for 9% GDP (gross domestic product) share [1]. The global spending in construction was \$11.4 trillion in 2018 and is expected to increase by \$14 trillion in 2025 [2]. Despite being one of the major contributors of country's economic development, the industry is characterized by low productivity with low technological advances and minimum computerization. The Architecture, Engineering and Construction (AEC) industry has been in continuous search for techniques to improve productivity, decrease project cost and shorten project delivery time. Building Information Model (BIM) has the potentials to achieve these goals [3].

BIM has been found to be the repository of information for buildings and infrastructure facilities starting from design, construction, operation and maintenance, and demolition. BIM is a digital version of a facility's physical and functional features [4] that forms a reliable basis for decision making during its lifecycle. As stated in [5], BIM use in the AEC industry encourages integration of the roles of all stakeholders in a project and hence it led to improved profitability, reduced costs, better time management and improved customer-client relationships. Realizing the enormous benefits offered by BIM, many countries have put mandates in place to use BIM for many of their construction projects, some countries have fixed their future mandates, some countries have planned specific BIM programs (e.g. BIM obligatory for government projects by 2020 and 2022 in Chile and Peru, respectively, Standards for BIM projects in Mexico, etc.), and some countries are planning on BIM adoption [6]. Kazakhstan falls among the last group. BIM implementation in Kazakhstan construction is still at its infancy.

The government of the Republic of Kazakhstan (RK) has taken the initiatives of BIM adoption in 2016 under the umbrella of Technology of Information Modeling of Construction Facilities (TIMCF) [7]. The primary goal of this initiative was set to implement the "Concept" which is a "Roadmap for information modeling technology implementation when designing construction facilities (BIM-technology)", between the time periods of 2018-2022. Nevertheless, project

stakeholders face many technology and process-related risks and barriers in implementing BIM [5] which are often country-specific. Accordingly, the aims of this study are as follows:

- Identify detrimental factors/implementation gaps and opportunities of BIM implementation in Kazakhstan; and
- Propose the methodology for BIM adoption in context of Kazakhstan and other similar countries.

2. LITERATURE REVIEW

The AEC industry these days serves an essential economic role. The construction sector is making considerable attempts to minimize project expenses, time and waste. For this purpose, various techniques of project management have been implemented which contribute to a greater perception of the project specific outcomes through effective collaboration and cooperation between project stakeholders [8]. BIM is largely recognized as a driving force for construction sector growth and performance. Thus, BIM is helping founders, planners, suppliers and business managers collaborate, envision and properly handle building projects from a stakeholder perspective [9].

BIM can be referred back to the early days of computers in the 1960s, while strong simulation systems began to appear in the 1970s and 1980s. Some consider the introduction of the ArchiCAD technology platform in 1982 in Hungary as a significant change in successful BIM adoption [10]. Although the technology underlying BIM has been available for more than two decades, adoption of a new technology in the construction industry is slow in comparison to industries such as manufacturing. Over the past few years, however, there has been a dramatic change as technology as well as implementation pace, and the construction sector recognizes the considerable benefits that can be derived from using this innovation. As evident by [11] who tracked the progression and application of BIM in the building industry via vast international surveys since 2007, there has been a substantial progress over the time, and in specific, very significant changes in adoption during the last few years. The BIM adoption was pioneered by countries such as the USA, the UK, Netherlands, Canada, and France. This adoption was strongly

driven by the state holders and the leading private organizations who wanted to legitimize their advantages by delivering quicker, reliable, efficient, and cost effective projects. Countries like Australia, Argentina, Japan, Korea and New Zealand started BIM adoption comparatively at a later stage, yet, gaining fast traction and outperforming some of the pioneered states [6, 11].

Based on the results of a research in the southeast of the US, 75% of construction firms used or suggested using BIM in their businesses [4]. In the UK, almost three-quarters construction companies are now using BIM [12]. In Japan, 80% of AECO industry professionals are aware of BIM [13]. According to a survey among 500 AEC professionals working on UAE construction projects, 87% had used BIM in their organizations [6].

BIM is viewed as both technology and process [5]. From the technological perspective, BIM is a data-rich, object-oriented, parametric and digital representation of a facility from which data and views appropriate to various stakeholders' needs can be extracted and analyzed for decision making and improving the delivery process of the facility [5,14,15]. Whereas, BIM can be viewed as a virtual process where all the stakeholders collaborate more accurately and efficiently than traditional processes [5]. Accordingly, different countries set different strategies to implement BIM considering the ability to technological adaptability, and rules and regulations requirements to manage the construction projects. For example, across the United States, BIM was developed by the US General Services Administration (GSA) back in 2003 [16] that established policy mandating BIM adoption for all Public Buildings Service projects. The regulatory directives from the USA, the UK and other countries demonstrated how knowledgeable companies will set realistic goals and enable businesses to utilize BIM technologies [11]. The UK implemented a BIM planning framework for the British building sector, which others view as the most comprehensive and innovative BIM implementation system of strategic significance in the world [17]. In the UK, BIM adoption has significantly increased since 2016 mandate. The Building and Construction Authority (BCA) in Singapore drafted a BIM Roadmap in 2010 with the aspiring objective that at least 80% of the construction industry would use BIM by 2015 [6]. The European Parliament proposed to amend Europe's rules to encourage, specify or mandate the use of BIM for publicly funded construction

and building projects in all 28 European Member States by 2016 [18].

Turning to the situation in Kazakhstan, it is among the countries that is planning to adopt BIM gradually in the construction industry [6], starting with the government's construction projects [7]. The Committee for Construction and Housing and Communal Services has taken steps to use this technology for government clients in order to reduce the costs of such projects and improve efficiency. Although, the BIM initiative was taken by the government of RK in 2016, there are some private construction companies who started to use this technology on their own [19,20]. Nevertheless, as surveyed by [19], a majority of the respondents (85%) mentioned that they never used BIM in their companies' practice for various reasons. These are: comfortable with the existing CAD systems that can fulfil the design and drafting needs; lack of technological expertise and unawareness of BIM benefits, concerned about extra cost that might be incurred by implementing new technology, unfamiliarity with BIM and client requirement factors and so on. Therefore, it is worth to investigate the barriers and opportunities to implementing BIM in Kazakhstan.

3. RESEARCH METHODOLOGY

To examine the barriers and opportunities of BIM implementation in Kazakhstan and the maturity level/capacity of BIM adoption by individual construction companies, a review of the past research was carried out followed by a survey and interviews within the construction companies. The literature review helped to identify current processes and detect specific barriers with an aim to propose a BIM implementation strategy/methodology in context of Kazakhstan and other similar countries. Interviews were performed to gain the insight of primary resources, practices and opinion of large companies who are using BIM for their construction projects. The survey was developed to gather an overall picture of BIM understanding and capacity levels of other national companies. The questionnaire was sent to professionals working in different areas of construction industry in Kazakhstan. Professionals from over 100 companies received the survey form and 46 of them participated in the survey. The survey results were analyzed and presented by descriptive statistics. Finally, a BIM adoption methodology is proposed based on the understanding of the interviews and survey

results and analyses of BIM implementation strategies in other countries around the world.

3.1 BIM Initiatives in Kazakhstan

The implementation of BIM is not only a sign of technological progress, it is a tool to minimize the risky investments for government by providing transparency in reports, improve quality of construction projects and enhance interaction of stakeholders during the project modeling. Realizing the importance of innovative technologies in construction, the Committee for Construction, Housing and Communal Services of the Ministry for Investments and Development of the RK, along with the “Kazakh scientific research and design institute of construction and architecture” (KazSRICA) JSC, started exploring implementation of BIM in 2016 [7]. As mentioned earlier, the primary goal of this initiative was to implement the “Concept” which is a “Roadmap for information modeling technology implementation when designing construction facilities (BIM-technology)”, between the time periods of 2018-2022. The “Concept” outlined three stages of BIM implementation.

- The first stage was initiated in 2017 with the objective to establish the requirements for the functional implementation of BIM at a standard equal to BIM Level 2 by 2019.
- The second phase is the time of realistic application and the compulsory usage of BIM at the design level for facilities financed by public funding with intended start from January 2020.
- The third stage is the phase of implementation of the BIM for planning the life cycle of building projects funded by regional and local budgets. This phase is planned to begin in 2022.

The governmental support for technological novelties is evident from approval of “Action Plan” by the Ministry of Investment and Development in April 2017 [21]. To date, 11 paragraphs out of 43 were realized, and one of them is converting BIM in the building industry of the RK with accompanying regulatory and technical attestation.

Beside the government initiatives, a very few leading construction companies in Kazakhstan have started using BIM for many of their construction projects to capitalize the competitive advantages [19,20]. Moreover, there are few consulting/ training centers in Kazakhstan who provide training and consultation services on BIM software and BIM use.

3.2 BIM Opportunities and Challenges in Kazakhstan

According to the government initiative as mentioned above and listed in [21], information modelling technology will be put into practice in the construction industry in three stages:

- In 2017-2019, voluntary application and development of standards is expected,
- In 2020-2021, the design of technologically complex facilities, and
- From 2022, the transfer of executive models to operations will begin.

Although a few leading construction companies in Kazakhstan have started adopting BIM for their construction projects including buildings and oil and gas transport facilities, majority of the construction companies, particularly small and medium size companies have not started to use BIM for various reasons [19]. The full potentials of BIM can be attained when all the companies will build BIM capabilities within their organizations along with the government initiatives. At this moment, the government initiatives are limited to developing standards and specifications for information modeling in the construction industry by analyzing the national documents and coding systems of the advanced countries that have implemented BIM-technologies. The specific initiatives to help capacity building for the private construction companies are yet to come.

To gain the insight on the strategies used and challenges faced by the companies who are using BIM, interviews were conducted with two leading companies. Unfortunately, the authors could not reach all the BIM practicing companies. Moreover, a survey was also carried out to know the opinion and understanding of BIM by the other companies including small and medium sized companies.

3.2.1 Interviews

Only two companies based in Nur-Sultan agreed to take part in the interview session. The name of these companies is not revealed here to keep the company-specific information confidential. The head of the BIM department and a BIM specialist from one company and the BIM manager from another company attended the interview sessions. A semi-structured interview was designed with the blend of closed- and open-ended questions which is suitable when

information is to be gathered with few follow-up queries [22]. They were asked questions on different aspects of BIM implementation including knowledge/BIM expertise, difficulties/challenges faced, observed benefits, future plans, and suggestions for others who want to adopt BIM in their organizations.

3.2.2 Survey

The survey was conducted to know the understanding and maturity level of BIM by other companies including small and medium sized companies. The survey was sent to over 100 companies and the recipients were the key personnel in the company (e.g. directors, chief executive officers, managers and so on). Among them, 46 companies participated in the survey. The questionnaire include general information about the company (nature of business), problem faced, familiarity of BIM and BIM practice within the organizations.

4. RESULTS AND DISCUSSION

4.1 Interviews and Survey Results

4.1.1 BIM adoption in large construction companies in Kazakhstan

Both the companies started using BIM in 2017. No personnel in either company had prior educational background or training on BIM technologies. The company started to train some of their employees by specialists from Russia and one company hired a Russian consultant for their initial project to be done using BIM. Since then, they are providing training to other employees through their own internal training programs. Both the companies are using Autodesk tools (Revit, Naviswork, BIM 360, Dynamo etc.) as their BIM platform. In terms of challenges faced, the biggest difficulties was lack of expertise within the organization followed by lack of desire by the employees to adopt new technologies since the traditional methods were more credible to them. At the beginning, many errors occurred in developing the BIM model due to unfamiliarity with the program aroused from the adjustment and transition to new platform issues. Problem is also faced due to limited coverage of HVAC families in Revit as required for the project. Many of these problems were overcome with time and expertise gained by doing more projects with BIM.

Both the companies observed some significant benefits by adopting BIM that include accurate

and fast estimation, early detection of collisions and resolve them immediately before commencing for physical installation, and better communication among design teams and management personnel with better visualization. The companies are mainly using BIM for the design phase and preconstruction and are planning to expand to use it for construction and operation of the facility. They are building BIM capabilities within the organization with regular training program and acquiring necessary BIM compliant software and hardware. One company urged for well-established rules and regulations from the government as they are currently using BIM for their internal projects within the company setup. A standard BIM specification is necessary when they want to implement BIM for the whole lifecycle of the construction projects involving all the stakeholders outside of the organization. And, it is important to build the BIM capabilities by all the relevant companies, particularly small and medium sized organizations. As mentioned by one of the companies, financial difficulties could be a major hindrance to adopt BIM for small companies. A significant expense is involved in the purchase of hardware and software required to run the program and the necessary training for the employees. The government support is necessary in this regard.

4.1.2 BIM maturity level in other companies in Kazakhstan

The survey results reveal that most of the companies are involved in building construction (50%), followed by road construction (17%), façade and other installation works (13%), operations and maintenance (10%), only one engineering company, and remaining 6% from other disciplines.

In response to question on the satisfaction level of construction works in Kazakhstan, the average value obtained was 5.5 on a scale of 10, where 1 = unsatisfactory and 10 = fully satisfactory. Based on the participants' opinions, problem faced by construction companies in Kazakhstan are presented in Fig. 1. As can be seen, problems such as poor management, bureaucracy, design issues, quality of works etc. can be improved by implementing BIM as evident by literatures. On the other hand, there are problems like lack of expertise/competence, financing, and poor IT development, the companies and the government should work together to enhance the BIM implementation program.

The survey results also depict that 41% of participants are familiar with BIM technology whereas the remaining 59% are not. Moreover, about half of the companies who are familiar, used BIM at their works, as can be seen in Fig. 2. Regarding the level of effectiveness of BIM in the construction industry, the average score was 8.1 (out of 10) by the participants who used BIM at their works. The perception is almost the same by the companies who have not used BIM yet, with a score of 7.6. This agreement shows that BIM has high potentials in the Kazakhstan's construction industry.

Finally, an open response was asked to know their opinion on how BIM can constructively influence the construction. The responses can be summarized as follows:

- It will help to manage the costs
- It will accelerate the project
- There will minimum errors
- Better planning (time saving)
- Avoid failures in design
- Avoid errors and inconsistencies in the estimates

- It will be very helpful (undefined)
- Do not know (who are not familiar with BIM)

4.2 BIM Implementation Barriers in Other Countries

The study further explored BIM implementation barriers with possible recommendation to enhance BIM use in different countries. As can be seen in Table 1, the barriers are tabulated based on various case studies that are found in literatures. These case studies can be a possible exemplar for the Kazakhstan construction industry. Accordingly, the Table also maps if these barriers are in line with the construction projects/companies in Kazakhstan. The suggested recommendations are also listed so that construction companies in Kazakhstan as well as other countries who are in the process of adopting BIM. It is evident from the Table that most of the barriers are common with Kazakhstan's context. This mapping is done based on the findings from the literature and current BIM status in Kazakhstan, interviews and the survey results discussed above.

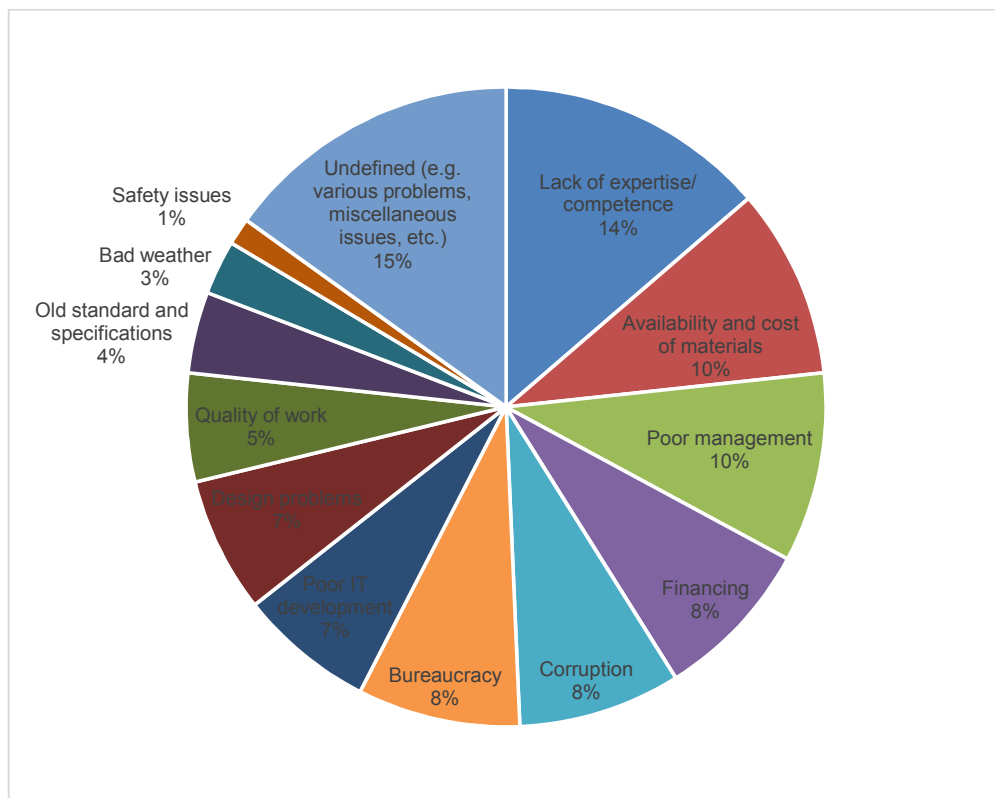


Fig. 1. Problem faced/weakness of the construction sector in Kazakhstan

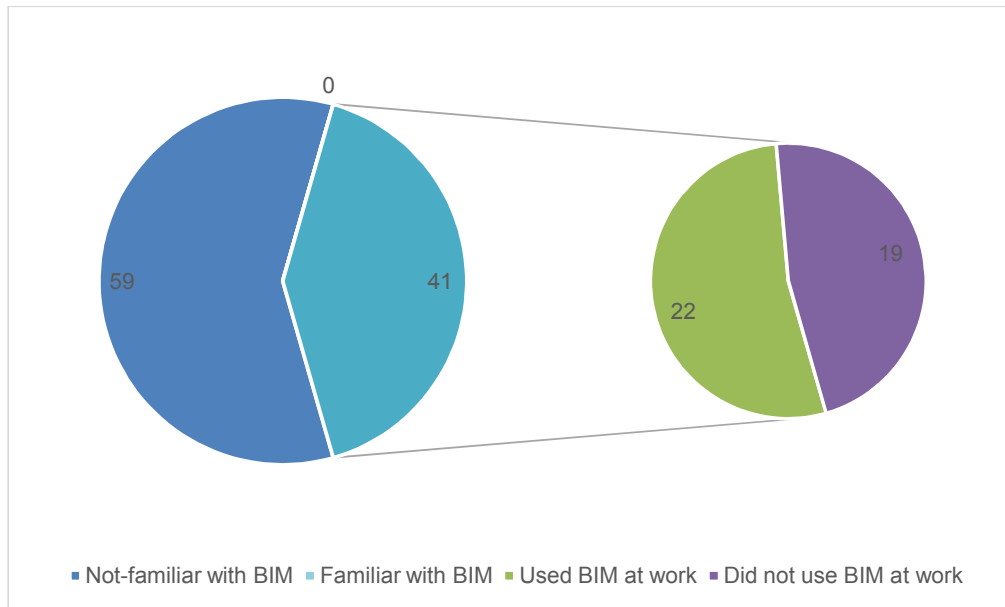


Fig. 2. Familiarity and use of BIM by the construction companies in Kazakhstan

Table 1. BIM implementation barriers in other countries and mapping for Kazakhstan

Countries	Barriers	Kazakhstan barriers	Recommendations
Iran and North Cyprus [4]	No supply and demand for BIM	√	Overcome the resistance to change, and get people to understand the potential and the value of BIM over conventional programs (2D drafting).
	Architects and engineers are not trained properly / Owners are not aware of the benefits of BIM	√	
	No organization to follow and motivate construction companies to implement BIM	√	
	Convenient to apply traditional software (AutoCAD) => lack of interest	√	
Malaysia [23]	Issues of interoperability	√	Factors such as collaboration, communications, workflows, and work processes should be assessed.
	Contractual relationships in construction agreements		
	Policy formation	√	
	The lack of determination of BIM ownership		
Georgia [24]	Data (Licensing issues)		Improve functionality and accuracy, interoperability and information exchange, BIM objects/libraries, software attributes/qualities, and other software selection criteria such as transaction-related issues and indicators related to technology vendors.
	Financial support	√	
	Responsibility for any inaccuracies	√	
	Interoperability	√	
	Data management		
United Kingdom [17,25]	Happy to continue using traditional CAD	√	Present BIM financial benefits and ROI at higher organizational levels.
	Firms are not familiar enough with BIM use	√	
	Reluctance to initiate new workflows or	√	

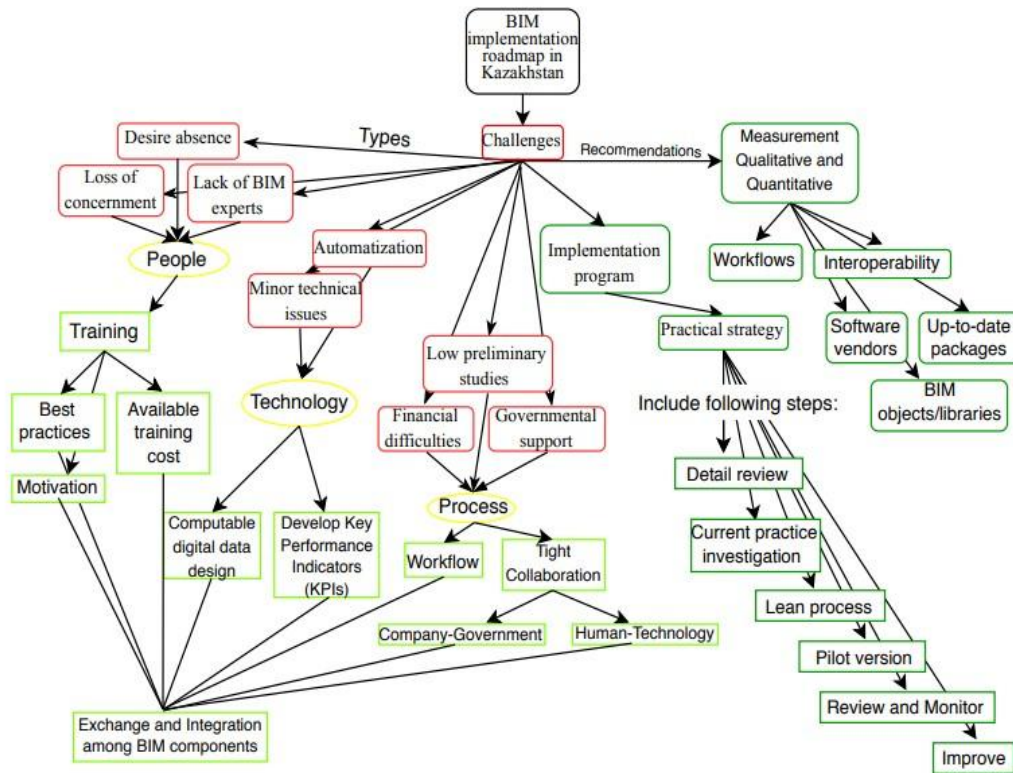


Fig. 3. BIM implementation Road Map in Kazakhstan

Generally the strategic path to BIM implementation integrated people, processes and technology and resulted in capacity building through process changes, technical infrastructure and staff competence to achieve productivity growth and competitive advantages. The Table also depicts that few issues can be omitted as those will not be a problem in Kazakhstan's context. For example, barriers such as "contractual relationships in construction agreements", "the lack of determination of BIM ownership", "licensing problems" etc. will not be a big concern since the government of the RK is working on BIM specifications with necessary rules and regulations. Moreover, issues such as "benefits from BIM implementation do not outweigh the implementation costs" and "learning curve" etc. are not relevant as evident from the survey results.

4.3 Methodology for Successful BIM Implementation in Kazakhstan

Based on the findings from the literatures, interviews and survey results, a "Roadmap" is developed as shown in Fig. 3. It reflects in a personalized and streamlined version of a

roadmap that shows the step-by-step methodology to implementing BIM in Kazakhstan, and possibly in other developing countries who want to adopt BIM in their construction companies.

The roadmap reveals the way BIM can be introduced in Kazakhstan based on issues and opportunities they have. It includes determinant factors of technology acceptance and highlights significant issues that exist in Kazakhstan. In addition, there is a borrowed strategy that is formed based on international experience. It covers process adoption, detail review, practice investigation, action planning and evaluation.

Findings from the interviews, survey and literature review emphasize the issues and challenges in the implementation of BIM in Kazakhstan construction and are listed below:

- Absence of desire to change from the use of traditional technologies to BIM
- Lack of BIM experts who can work on this platform and in particular share knowledge with others

- Loss of concernment due to failures and errors
- Automatization
- Minor technical issues
- Low preliminary studies
- Financial difficulties
- Governmental support

Productively BIM Implementation involves major changes in the way the business in the construction industry operates and its processes at each stage. It covers three main categories: people, technology and process.

4.3.1 People

As can be seen in Fig. 1, lack of expertise/competency (that also include lack of qualified specialists and field engineers) was one of the major problems in Kazakhstan's construction sector. Adopting BIM obviously entails qualifying experts and education and is unlikely to be availed easily for every company who are not familiar with this technology. There is a need for well-prepared training with available costs. Awareness and education are critical to tackling the resistance to change, not just about BIM tools but about BIM process in particular. This often parallels process improvement and quite often changes the organizational setup and also how responsibilities should be assigned. Understanding of international practices in turn may generate interest and motivation among workers.

4.3.2 Technology

The interviewed companies and the most survey respondents pointed out that BIM implementation requires not only learning new program applications, but also acquiring the technology within the organization and trying to learn how to develop key performance indicators in order to demonstrate a set of targets that aims to deliver improvements in terms of technology performance. Depending on the company's business needs, a set of key performance indices (e.g. productivity improvement, time saving, cost savings, estimation accuracy, clash detection, improved communication, safety, sustainability etc.) should be established against the BIM use [27,28].

4.3.3 Process

The process is also an important basis for BIM adoption. It includes adaptation of workflow with BIM process. It also requires tight collaboration

and cooperation between various project parties including the stakeholders outside of the organization and the government authority for an optimization of workflow. Business Process Model and Notation (BPMN) or other widely used techniques can be adopted by the companies [29].

5. CONCLUSION

The construction industry in Kazakhstan is now on the verge of entering a tremendous technological progress pathway. Implementation of BIM in Kazakhstan as a means of technological advance, gives a wide range of benefits starting from the optimization of the construction process to correspondence of company development to global levels of technological progress. Some specific requirements for successful BIM implementation need to be overcome to initiate this transition. This study conducted a comprehensive literature search, interviews and a survey to investigate the understanding, barriers and opportunities of BIM implementation in Kazakhstan. It was found that a majority of the companies (59%) are not familiar with the BIM technology and only a limited number of private leading construction companies started exploring and using BIM for their projects. Although there is a positive attitude among the companies regarding BIM use, this research demonstrates that there is no clear guideline on how to properly implement BIM in the workplace. The analysis of readiness of the construction companies to use BIM technology in other countries helped to identify possible barriers in Kazakhstan in the prospective future. Accordingly, the study mapped implementation challenges in other countries with possible recommendations and proposed a roadmap to be followed by the construction companies in Kazakhstan and other similar countries. Hence, the study makes some noteworthy contributions to the existing body of knowledge.

It is to be mentioned that although 22% (out of 46 responses) of the surveyed companies used BIM for their projects, only two leading companies agreed to participate in the interviews. This is an indication that the lack of familiarity could be one of the critical factors in implementing BIM which demands further investigations with more comprehensive surveys and interviews.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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