

Awareness, Adoption, and implementation of Building Information Modelling in Small and Medium Enterprises in the Moroccan AEC Industry

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Abstract: Building Information Modelling (BIM) has gained widespread popularity over the past decade, mainly in the Architecture, Engineering, and Construction (AEC) industry. The adoption of BIM in developed countries is already regulated as opposed to developing and underdeveloped countries. This study aims at filling the knowledge gap as to the adoption and implementation of BIM practices in small and medium enterprises (SMEs), with a focus on the Moroccan AEC industry. The main goals of this study are 1. to determine the BIM awareness level and adoption rate, 2. to assess the familiarity level, 3. to establish the benefits, challenges, and prospects of BIM. The results of this study have shown that BIM awareness is high, but its adoption and implementation are not, though promising as it is exponentially gaining the attention of AEC practitioners.

Keywords: Building Information Modelling (BIM), AEC, Awareness, Adoption, Implementation.

1. Introduction

The construction industry contributes greatly to the GDP and economic growth and development of countries. In fact, "GDP from Construction in Morocco averaged 10665.96 MAD Million from 2006 until 2021, reaching an all-time high of 12844 MAD Million in the second quarter of 2021 and a record low of 5702 MAD Million in the first quarter of 2006" (Trading Economics, 2021). The AEC industry, in general, faces however several challenges from different aspects like costs, workplace diversity, waste, technology adoption, and knowledge sharing.

With all the technological advances that the world has witnessed, it comes with no surprise that the AEC industry was positively affected as well. One of the biggest technology advancements for AEC is BIM. The concept of BIM has, in fact, been around since the 1970s, but has evolved into standards and practices in the last 2 decades. Some countries, like the UK, have regulated its use and made it mandatory for all projects surpassing a certain amount of money. Taking the UK as an example, BIM has been mandated for all public sector projects costing over £50,000, with the minimum level of BIM to be adopted and implemented set at Level 2. This means that public sector projects are to follow BIM standards such as ISO 19650 and PAS1192-2 from the initial stages of their projects. Similar to the UK, a number of countries have a fairly high BIM adoption rate. Table 1 presents some of them. This is, however, not the case for the majority of countries.

Table 1: BIM Adoption Rates

Country	Adoption Rate	Reference
United States	79%	Gerges et al., 2017
United Kingdom	74%	Malleson, 2018
Canada	78%	MaCabe et al., 2018
Australia	67%	Red Stack BIM services, 2016
China	48.8%	Tu et al, 2021

There are 3 BIM levels. Level 0 is the starting point where investigation, feasibility, and planning are carried out. It is also called the scratch point. Then, level 1 is about the design and the start of the construction process. In this phase, 2D and 3D designs are used for vectoring and sharing respectively. Level 2 is what is referred to as the BIM maturity level. In this level, the scheduling and cost estimation of the construction project is done using 4D and 5D. Level 3, the advanced level, is all about sustainability and applications. Figure 1 presents the BIM levels, uses, and maturity level.

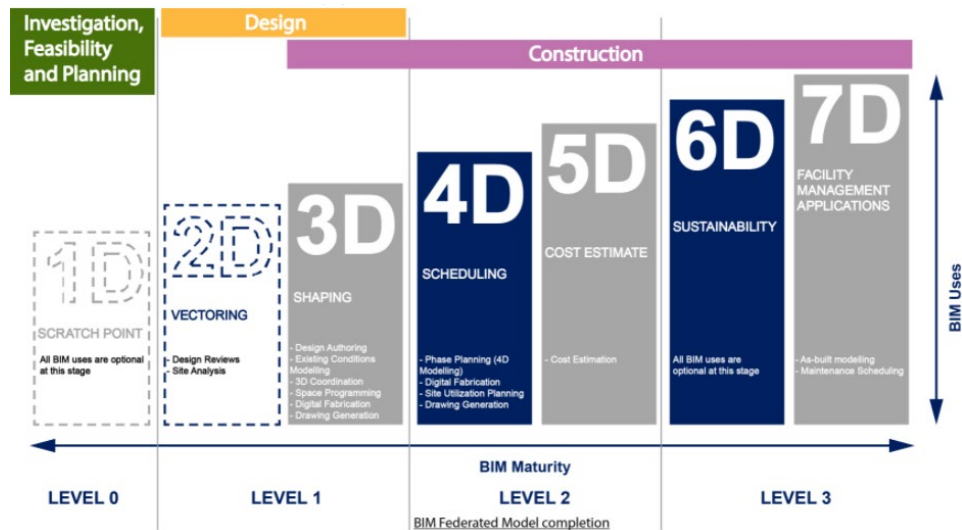


Figure 1: BIM levels and uses (from: AIM, 2019)

The aim of this paper is to showcase the implementation level and adoption rate of BIM practices within SMEs in the Moroccan AEC industry. This paper is structured as follows. Section II presents a review of the literature focused on the adoption and use of BIM in SMEs. Section III discusses the research methodology. Section IV presents the results and discussion. Section V presents the research limitations.

2. BIM Adoption in SMEs: A Review of the Literature

The adoption of BIM has been regulated in some countries, as opposed to others. When it comes to SMEs, their adoption of BIM relies heavily on the required investment and the risk of losing it (Abanda et al., 2014). There are a few studies that explored the implementation of BIM in SMEs.

To start off, Vidalakis et al. (2019) explored the adoption and implementation of BIM in the British AEC industry, focusing on SMEs located in South-East England. The main objectives of the study were to 1. assess the level of expertise in BIM related tools; 2. assess the level of familiarity with BIM implementation support tools; 3. assess the level of familiarity with BIM concepts; 4. Perceive the main barriers to the adoption of BIM; and 5. Perceive the enabling factors to the adoption of BIM. The study has found that 85.8% of the respondents had no knowledge at all of BIM software packages. In addition, the main barriers identified are the high cost of software, licensing fee, and set up, the software interoperability issues, and the lack of in-house skills. From another perspective, the main enablers identified are the knowledge exchange with other businesses, industry initiatives, further guidance and leadership, and further CDP training. The findings of this research indicated that the interviewed SMEs' knowledge in existing BIM support systems is at a particularly low level. It is, however, a continuous and on-going process, and more companies will adopt it in the future.

Similarly, Newton and Chileshe (2012) investigated the awareness, usage, and benefits of BIM in South Australia. The main objectives of the study were to 1. assess the current awareness and determine the BIM adoption rate, and 2. establish the advocated BIM benefits and its impact on project outcomes. A field study was conducted where 29 organizations were randomly selected, and asked to fill in a questionnaire. This latter was made of four main sections: 1. The general demographics of the respondents and awareness and issues, 2. BIM enablers, 3. the barriers and challenges, and 4. the benefits of adopting BIM. This study revealed that only a minority of the interviewed firms, about 17%, use some level of BIM. The top benefits of using BIM, according to the survey results, are improved constructability, improved visualization, improved productivity, and reduced clashes. A few companies have also mentioned: improved quality and accuracy, improved client satisfaction, increased competitiveness, and improved information sharing. The most significant implication arising from this study is that the benefits surrounding BIM significantly outweigh its negative aspects.

It should be noted that, to the best of our knowledge, no published / publicized study has investigated the adoption and implementation of BIM practices in SMEs in Morocco.

3. Methodology

3.1 Design Method

This project used a descriptive design method in which a structured survey questionnaire was developed and shared with a large number of managers of AEC SMEs in Morocco. Furthermore, interviews were conducted with 7 top-management executives from 7 randomly-chosen companies that responded to the questionnaire. The purpose of the questionnaire and interviews were to get answers related to both the awareness, the implementation, the prospects, and the challenges of the use and implementation of BIM.

The survey questionnaire was run over a period of 3 months, and was written in 2 languages: French and English, to be sure that the respondents pick the language they prefer and understand the questions thoroughly since the working language in Morocco is French. In addition, the survey was divided into several parts. In addition, filter questions were used to differentiate between BIM and non-BIM users, and therefore allow respondents to get appropriate questions. BIM users, for example, were asked about their proficiency level in BIM, the number of years since the company started using it, the level of BIM used, the number of projects carried out using BIM, and so on, while non-BIM users were rather asked about the barriers to the adoption of BIM, the alternatives used, and the software currently in use.

In addition, and as previously mentioned, the interviews were held with top-management executives only. The goal of these interviews were to get a more in-depth view of what it entails to use BIM from a managerial perspective, how it helped the organization, what concessions had to be made, and what challenges had to be overcome.

3.2 Primary Data Collection

The main source of data in this research is the responses to the survey questionnaire and interviews. This is the link to the questionnaire was sent to a large number of SMEs in Morocco. These latter specialize in the following areas: architecture, contractors, engineering, consultancy, and project owners.

4. Results and Discussion

The results are presented in this section, in addition to a thorough discussion. This section is divided into four parts. The first part discusses the companies' line and field of business, their size, the number of projects carried out using BIM, and so on, along with the companies' awareness, adoption, and use of BIM practices. The second part focuses on the challenges that companies encounter and factors that influence that. The third part focuses on the advantages of BIM. Last but not least, the fourth part discusses the reasons and factors that influence the awareness, adoption, and implementation of BIM in the Moroccan AEC industry.

4.1 BIM Awareness, Adoption, and Use

To start off, 105 respondents have completed the survey and submitted their answers. Nonetheless, post data cleaning, only 82 responses were considered, and the others were disregarded. The purpose of data cleaning is to only consider reliable and accurate responses. As previously mentioned, the majority of the respondents' companies operate in the architecture or civil engineering industry.

The companies exact field of work varies, but the majority operate in building and public works or architecture. To be more specific, 38% operate in building and public works, 34% in architecture, 11% in civil engineering, and the rest is divided between consultancy, construction logistics, construction materials, and interior and landscape design. Furthermore, the majority of the interviewed companies are small, consisting of 1 to 50 employees. 11, however, can be considered medium large companies with an employee range of 100-250.

Furthermore, the average number of projects carried out with and without BIM differs from one category of companies to the other. The graph below presents the overall number of project and the projects carried out using BIM and the ones without BIM.

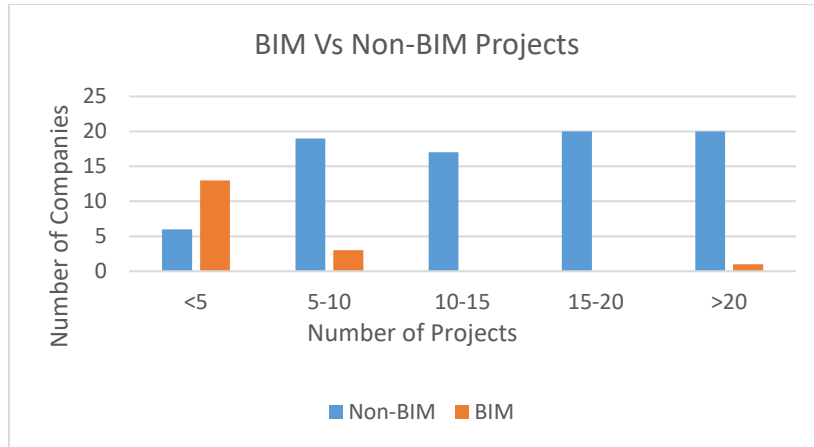


Figure 2: Number of BIM projects per year

It can be noticed that there is a major difference in the annual number of projects carried out using BIM as opposed to the ones carried out without BIM. In fact, 6 companies have carried out less than 5 projects per year without using BIM as opposed to 13 that are carried out annually using BIM. However, all the companies that have voted for this option mentioned that they have only carried out 1 BIM project. Therefore, the 13 projects refer to 13 companies, each carrying 1 project. Likewise, only 1 company has carried out more than 20 projects using BIM.

Regarding the used software, the majority of companies use Autocad, Archicad, and Revit. Table 2 presents the results.

Table 2: Software used

Revit	Autocad	Archicad	Navisworks	Robot	Bluebeam Revu	3D Max	Primavera	Rhino	DIALux	ProDesign	MS Office	BIM360
12	17	12	2	3	1	1	1	1	1	1	1	1

There are a few companies that use a combination of software. A popular software combination is Revit with Autocad, and Revit with Archicad. There are, however, other software in use like Robot and BIM 360, but not popular among the investigated organizations.

In addition, 55% of the respondents believe that their employees are not familiar with BIM at all. Even for the BIM-users, the companies' proficiency level was mostly limited or general. In fact, only 2 companies have significant expertise in BIM, as shown in figure 4.

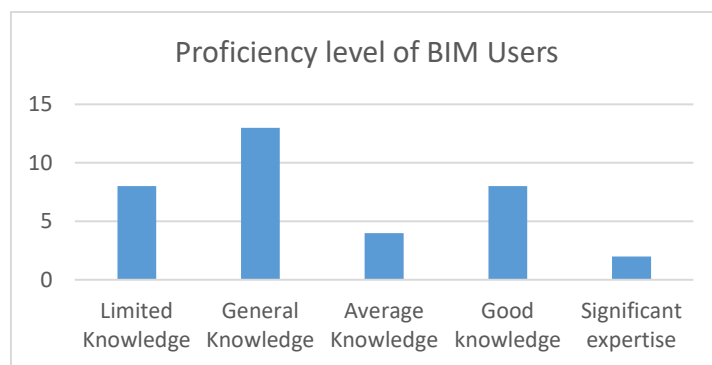


Figure 3: Proficiency level of BIM users

As a follow up to the proficiency level of BIM users, the companies' general level of BIM leaned towards the low side. In fact, 48% are beginners and 39% are intermediate as opposed to 9.7% who believe they are advanced and the 3% that consider themselves experts. The fact that several companies have just started adopting BIM explains why their level is not advanced. In addition, 3D modelling is the level used by most companies, while not a single company uses 5D and 6D so far. Still, only 6.5% of the companies use BIM systematically while 93.5%

use it for specific projects, and only when asked to by the clients. Figure 5 presents the BIM adoption timeline, the company’s BIM level, and the modelling level used.

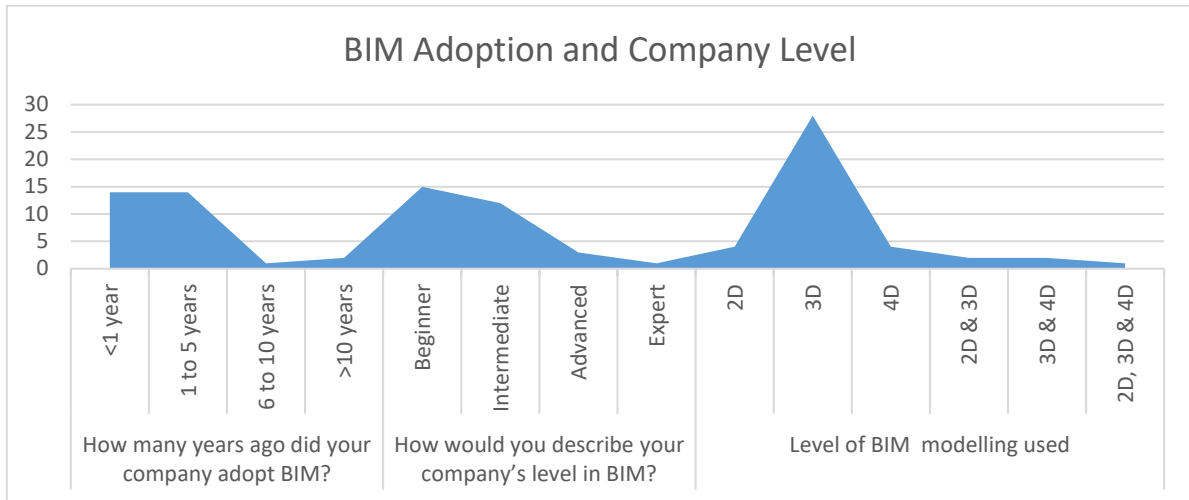


Figure 5: BIM Adoption

Regarding the uses of BIM within organizations, the majority have selected: building system analysis, construction system design, engineering analysis, and structural analysis. Very few are the ones who have selected programming, mechanical analysis, and cost estimation. Figure 6 presents the BIM features, the enabling intra-corporate collaboration features, and the support tools used.

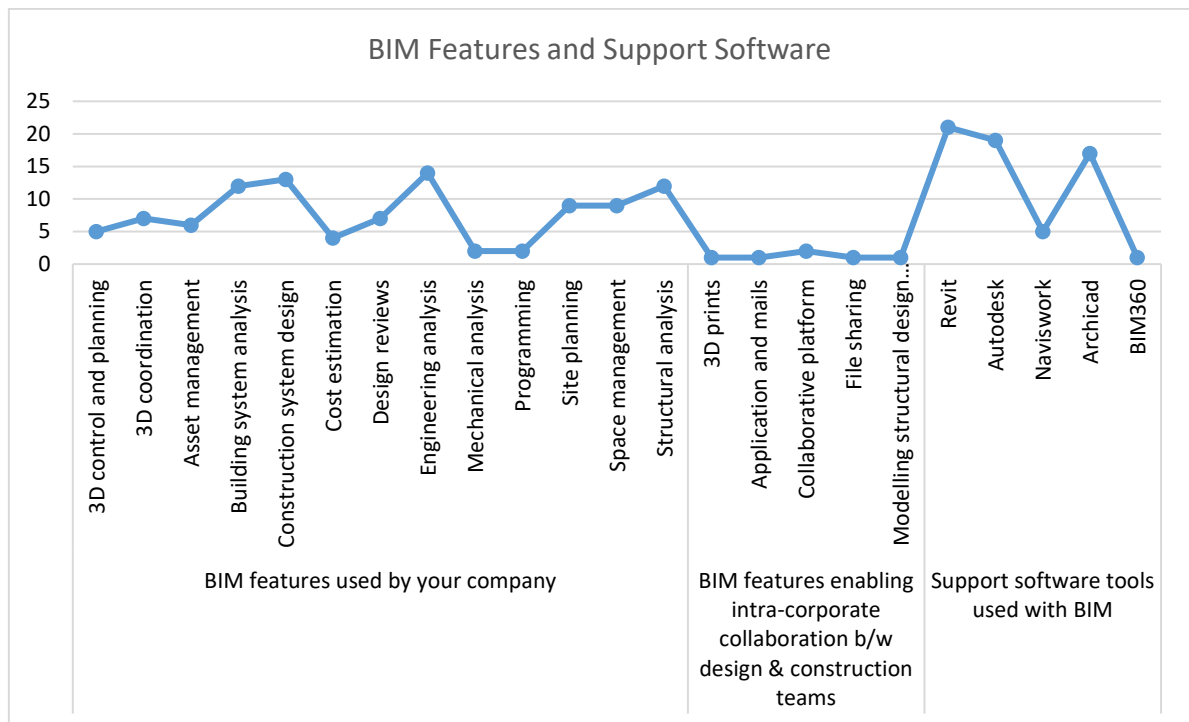


Figure 6: BIM Features and Support Software Tools Used

The most used BIM features are engineering analysis, building system analysis, and construction system analysis, while the least used ones are mechanical engineering and programming. The features for enabling intra-corporate collaboration between the design and the construction team within the same organization are mostly not used. The vast majority of companies do not use any of these features. Last but not least, the most popular software used with BIM are Revit, Autodesk, and Archicad, while only 1 company uses BIM 360.

Regarding whether or not the implementation of BIM lead to some change in management, 80% do have a BIM champion in top management, but only 29% have made some type of change in management to allow for the adoption of this latter.

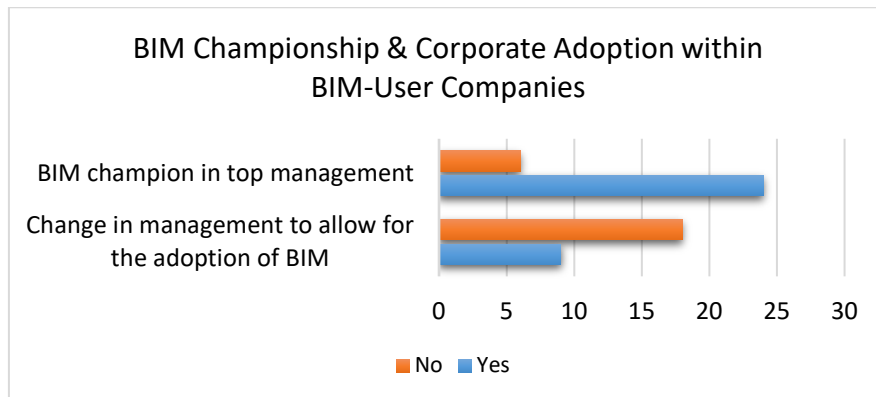


Figure 4: BIM Championship & Corporate Adoption

To conclude this section, we can say that these results are not surprising given the fact that 45% of the companies that have adopted BIM have done so less than a year ago, 45% have adopted it in the last 5 years, 3.5% have adopted it between 5 and 10 years ago, and 6.5% have adopted it over 10 years ago.

4.2 Challenges and Influencing Factors

Several challenges hinder the use of BIM within SMEs in the Moroccan AEC industry. In fact, the most feared challenge with regards to the use of BIM is the need for training. According to some of the comments left by respondents, this is particularly challenging because it is hard to find trainers. In addition, companies also fear the cost of training, mainly if they are required to have all their employees certified. Many companies have actually opted for free BIM lessons available online. The graph below presents the main challenges of using BIM according to the respondents.



Figure 5: BIM Challenges

60% of the respondents believe that the need for training is a major challenge. Likewise, 55% believe that the cost of software is high, and 43% believe that it is too complicated to use. In fact, the majority of SMEs believe that the software they currently use is enough and that they do not need to upgrade and use BIM. From the comments left by the respondents, and from the interview responses, 70% of the non-BIM respondents believe that BIM is unnecessary for SMEs and should only be adopted by big companies. Another major challenge encountered by many SMEs is the non-conformity in the use of BIM. For a project to be successfully carried out with BIM, all stakeholders must use BIM, which, at this point, is hard to achieve. Nonetheless, 11 of the BIM-

users believe that BIM does not have any drawbacks and that they can see its benefits though not used for a long time.

Furthermore, another major influential factor is the lack of BIM qualified professionals in top-management. In fact, only 6 organizations have a BIM champion in top management. Another important challenge mentioned during an interview with a top manager is the clients' lack of understanding. In fact, many clients do not wish for the company to use BIM as they believe it leads to a waste of time and resources. This may be due to the lack of exposure and lack of awareness of BIM and the benefits it can offer.

4.3 Potential Advantages of BIM

Several advantages can be linked to the adoption of BIM within organizations. The most popular advantages of BIM according to the survey results and interviews are the fact that it improves communication between the different stakeholders, improves creativity, reduces conflicts and errors, and improves productivity. Figure 7 presents the survey results as to the advantages of BIM.

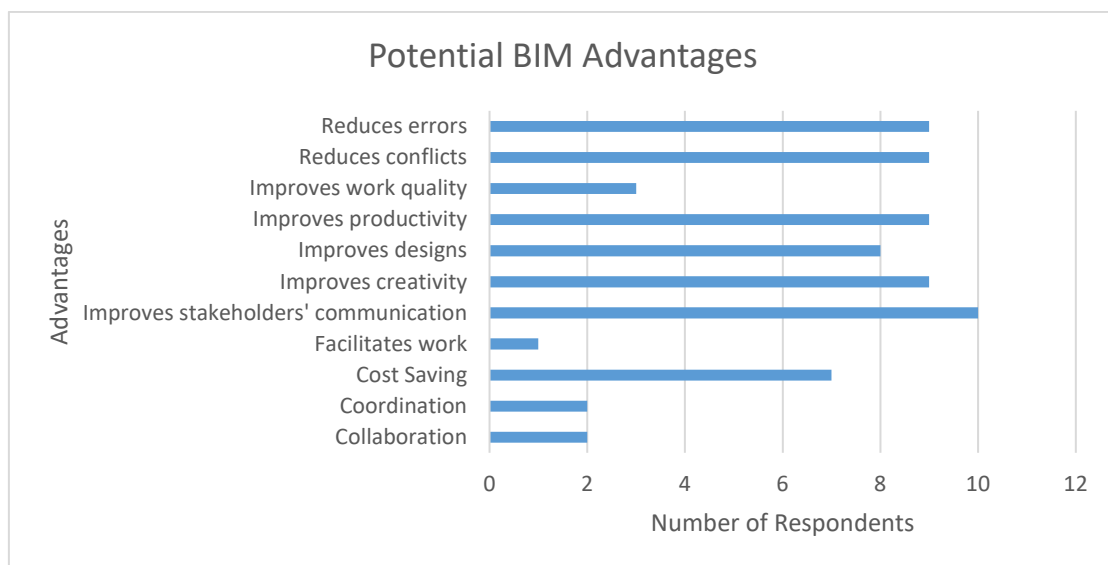


Figure 6: Potential BIM advantages

From the 82 respondents, only 1 company believes that BIM facilitates work, 2 believe that it helps with coordination and collaboration, and 3 believe that it improves work quality. This may be due to several reasons, the main one being that BIM is not regulated in Morocco and is therefore not widely used. This makes it hard for BIM users to successfully carry out a project using BIM practices from start to end. A common struggle is having one stakeholder use BIM, but not the others. This leads to lack of coordination, complications with regards to collaboration between the different stakeholders, among other issues.

BIM has, nonetheless, several advantages during all the stages of the construction process. In the pre-construction phase, BIM helps with several aspects including but not limited to conceptualization (Eastman et al., 2011), site analysis (Azhar et al., 2011), design reviews and cost estimation (Khosrowshahi, 2017). During the construction phase, some of the important advantages that BIM offers include construction evaluation and resource planning (Kjartansdottir et al., 2017) and procurement management (Eastman et al., 2011). Last but not least, during the post-construction phase, BIM provides maintenance assistance (Enshassi et al., 2018), among other benefits. From the survey, however, 50% of the responding companies are not aware of the benefits that come with using BIM.

4.4 Reasons and factors that influence the awareness, adoption, and implementation of BIM

Most respondents did not know what tasks and/or information are not taken into account by BIM processes. However, some have mentioned the adaption to local regulations in Morocco, clarity of tools, and the cost of materials among others.

In fact, responding companies believe that the following are not taken into account by BIM processes:

- Adaptation to local regulations in Morocco

- Clarity of tools
- Lack of adaptability
- Material costs
- Lack of experience
- Trainings

The majority of respondents that do use BIM did not know how BIM can enable collaboration between the design team and the construction team within the organization. Very few respondents, nonetheless, have mentioned 3D prints, mails, collaborative platforms, and file sharing.

Figure 8 presents the uses of BIM that would potentially be needed in the future.

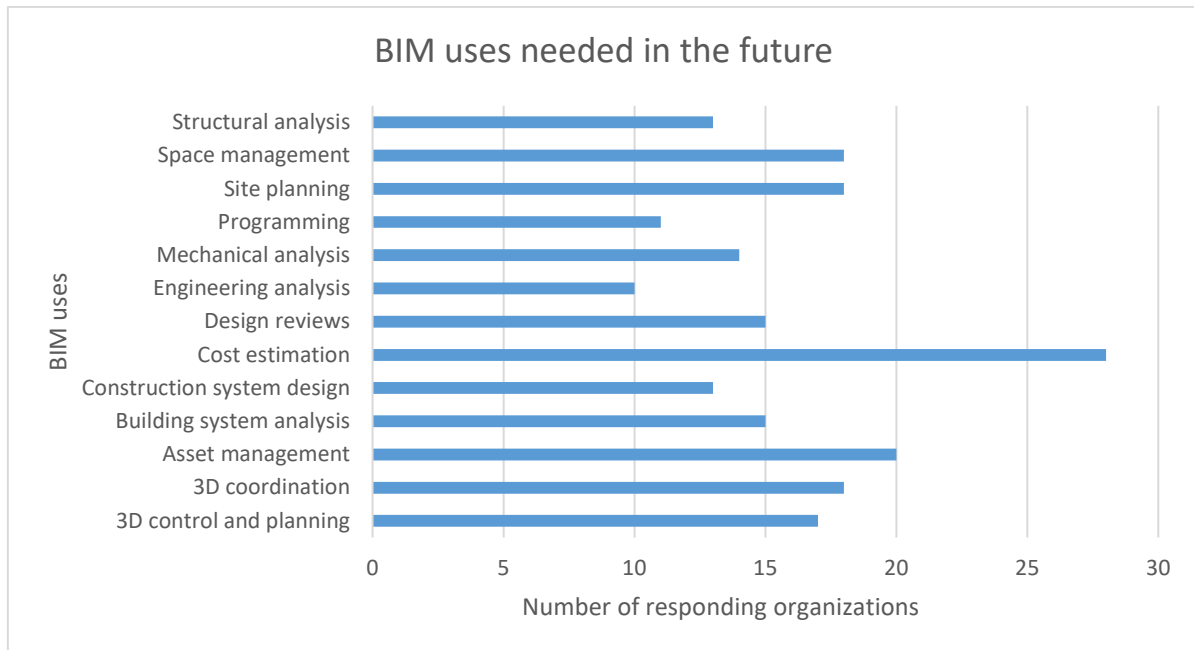


Figure 7: Potential BIM uses needed in the future

All companies believe that using BIM in the future will become crucial, mainly if it gets regulated by the government. It should be noted that, at this time, the majority of the interviewed companies do not have an alternative to BIM and are using what they call the “classical method”.

From another perspective, there are of course some factors that do encourage the use of BIM. During the interviews carried out, the factors mentioned were:

- Government support in acquiring the material and offering staff trainings;
- Experience sharing between BIM users and non-BIM users. This will encourage the non-BIM users to get first hand insight into the advantages that come with using BIM.

5. Limitations

The main limitations of this work is that, although this study provides a general overview of the awareness, adoption, and implementation of BIM practices in Morocco, the results cannot be generalized to all AEC SMEs.

6. Conclusion

BIM has gained popularity in Western countries over the last decade. However, it seems that it is just starting to take off in the majority of developing countries like Morocco. There are several challenges that hinder the acceptance and implementation of BIM practices like the cost of software and the need for training.

Future works include a further study, to be conducted in a couple of years, to determine whether or not more companies have adopted and implemented BIM processes.

References

- Abanda, F. H., & Tah, J. H. M. (2014). Free and open source Building Information Modelling for developing countries. In the International Conference on ICT for Africa, 1-4 October, ICT University, Yaoundé, Cameroon.
- Aimgrp.com. (2019). AIM Newsletter Q2 (2019). [online] Available at: <<https://www.aimgrp.com/Newsletter%20Q2/Newsletter1902web.html>>
- Azhar, S., Carlton, W. A., Olsen, D. and Ahmad, I. (2011), "Building information modeling for sustainable design and LEED®rating analysis", *Automation in Construction*, Vol. 20, No. 2, pp. 217–224.
- CFI, 2015. Diffusion of Innovation. [online] Corporate Finance Institute. Available at: <<https://corporatefinanceinstitute.com/resources/knowledge/other/diffusion-of-innovation/>>.
- Eastman, C., Teicholz, P., Sacks, R. and Liston, K. (2011) "BIM handbook: a guide to Building Information Modeling for owners, managers, designers, engineers, and contractors", New Jersey, Wiley.
- Eastman, C., Teicholz, P., Sacks, R. and Liston, K. (2011) "BIM handbook: a guide to Building Information Modeling for owners, managers, designers, engineers, and contractors", New Jersey, Wiley.
- Enshassi, A., AbuHamra, L. A. and Alkilani, S. (2018) "Studying the benefits of building information modeling (BIM) in architecture, engineering and construction (AEC) industry in the Gaza strip", *Jordan Journal of Civil Engineering*, Vol. 12, No. 1, pp. 87–98.
- Gerges, M., Austin, S., Mayouf, M., Ahiakwo, O., Jaeger, M., Saad, A. and Gohary, T. (2017) "An investigation into the implementation of building information modelling in the Middle East", *Journal of Information Technology in Construction*, Vol. 22, pp. 1–15.
- Khosrowshahi, F. (2017) Building Information Modelling (BIM) a Paradigm Shift in Construction. In: Dastbaz, M., Gorse, C. and Moncaster, A. (eds.) *Building Information Modelling, Building Performance, Design and Smart Construction*, Springer, Cham
- Kjartansdottir, I. B., Mordue, S., Nowak, P., Philp, D. and Snæbjörnsson, J. T. (2017) "Building Information Modelling - BIM". Warsaw: Civil Engineering Faculty of Warsaw University of Technology.
- LaMorte, W. (2019). Diffusion of Innovation Theory. [online] Sphweb.bumc.bu.edu. Available at: <https://sphweb.bumc.bu.edu/otit/mph-modules/sb/behavioralchangetheories/behavioralchangetheories4.html>.
- MaCabe, B., Shahi, A. and Zhang, L. H., (2018) "1ST Annual BIM report for greater Toronto area" University of Toronto.
- Malleson, A. (2018) "National BIM Survey: summary of findings", National BIM Report 2018. RIBA Enterprises Ltd.
- Newton, K. and Chileshe, N. (2012) Awareness, usage and benefits of Building Information Modelling (BIM) adoption – the case of the South Australian construction organisations In: Smith, S.D (Ed) Procs 28th Annual ARCOM Conference, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, pp 3-12.
- Red Stack BIM services (2016) "Is BIM a growing trend in Australia?", available at <https://www.redstackbim.com/sites/bim/media/pdfs/bim-report-april-2016.pdf>.
- Tradingeconomics.com. (2021). Morocco GDP from Construction and Public Works | 2021 Data | 2022 Forecast. [online] Available at: <https://tradingeconomics.com/morocco/gdp-from-construction#:~:text=GDP%20From%20Construction%20in%20Morocco%20averaged%2010665.96%20MAD%20Million%20from,the%20first%20quarter%20of%202006.>
- Tu, B., Zuo, J., Chang, R.-D., Webber, R.J., Xiong, F. and Dong, N. (2021), "A system dynamic model for assessing the level of BIM implementation in construction phase: a China case study", *Engineering, Construction and Architectural Management*, Vol. ahead-of-print
- Vidalakis, C., Abanda, F. H., & Oti, A. H. (2020). « BIM adoption and implementation: focusing on SMEs." *Construction Innovation*, 20(1), pp 128–147.