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AN INVESTIGATION OF BARRIERS TO ADOPTING BUILDING INFORMATION MODELING (BIM) IN THE AEC INDUSTRY OF DEVELOPING COUNTRIES: A CRITICAL REVIEW

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Abstract
Nowadays, Building Information Modeling (BIM) is one of the most significant technologies for most firms in the construction industry of developing countries. Building information Modeling has become essential for facilitating all processes throughout the building lifecycle. However, a glance at the construction environment in developing countries shows that the implementation of BIM lags behind its potential due to various challenges at the project or organizational level. Therefore, this research aims to identify, classify, and compile the barriers associated with BIM implementation in the building industry of developing countries. The research methodology is content analysis, combining meta-analysis with qualitative and quantitative approaches to address the research question. Twenty-eight barriers were identified in two staged content analysis processes. The research outcomes form a comprehensive perspective for enhancing awareness among project stakeholders at different levels. The results highlight that most barriers were related to employee skills, a lack of standards, and software interoperability. The conclusion equips design and construction firms in developing countries with the strategies to effectively address challenges while developing their BIM implementation plans.

Keywords:
Building Information Modeling (BIM);
Barriers;
Implementation;
AEC Industry.

1 Introduction

The global architecture, engineering, and construction (AEC) industry has begun to take notice of Building Information Modeling (BIM) as a rapidly growing technology in demand. Building information modeling has been characterized in numerous ways, particularly regarding the functions and benefits it provides to companies [1]. As a result, BIM involves more than just a straightforward use of CAD and 3D presentation methods [2]. Additionally, BIM supports 3D modeling, 4D programming connected to the construction process, 5D modeling coupled with cost information, and even 6D modeling, as the idea of BIM has evolved [3]. In light of this, BIM is a method for successfully and efficiently bringing together the appropriate individuals and data [4]. In this regard, people, information, processes, technologies, and policies are the main elements of BIM [5], as shown in Fig. 1. Regarding different fields in engineering, BIM changes how projects are constructed and how business is conducted within the Architecture, Engineering, and Construction (AEC) Industry. In light of this, many firms around the globe seek professional employees who can effectively contribute to projects that involve BIM processes. Building information modeling is a foundational, intelligent, model-based business and industry transformation process in different engineering fields under BIM elements. Furthermore, during the building's lifecycle, all stakeholders follow the collaboration rules (owners, engineers, contractors, and facility managers). Moreover, building information modelling in engineering facilitates real-time sharing and access to project information, significantly reducing errors and conflicts between disciplines. BIM enhances design visualization, allowing engineers to create detailed 3D models of buildings or structures and improving the understanding and communication of complex systems.

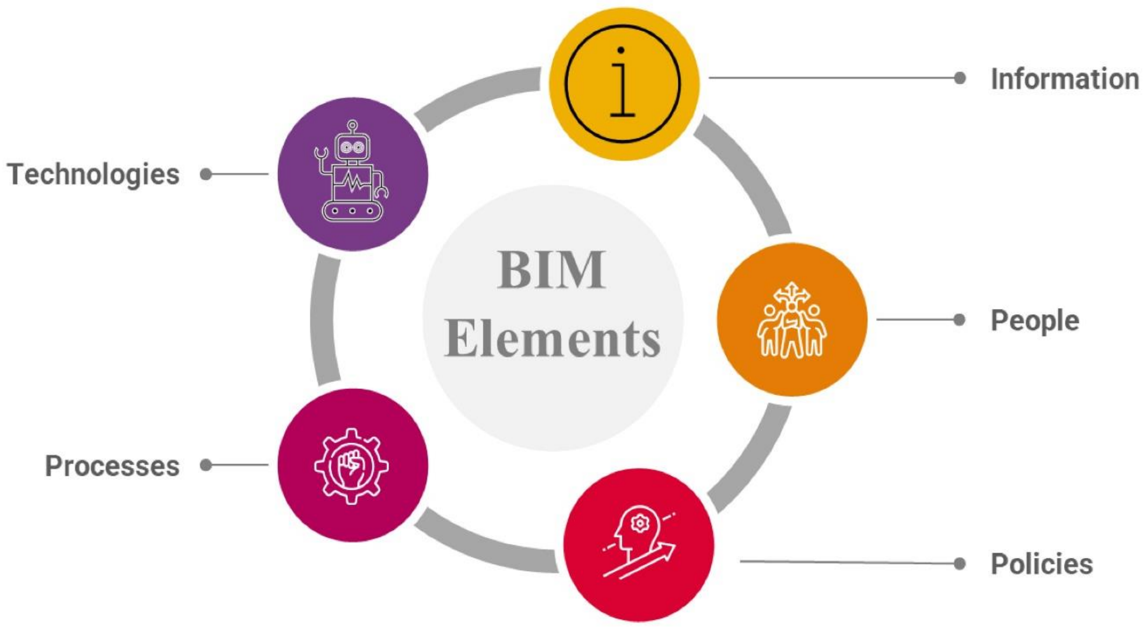

Fig. 1: The main elements of BIM.

Therefore, adopting BIM in developing countries can lead to the development of object-oriented, data-rich models useful for integrating the various phases of a construction project throughout its entire lifecycle [6]. Additionally, key stakeholders, including engineers, architects, contractors, and owners, can offer different direct and indirect benefits by applying BIM technology at multiple levels, such as project and organizational levels [7]. As a result, stakeholders related to the project in developing countries are encouraged to adopt and utilize BIM more frequently [8]. For instance, buildings can be constructed more rapidly and accurately through automated assembly when BIM is used, which reduces construction errors and enhances efficiency and quality [9]. Furthermore, BIM technology promotes cooperative working methods, enhances communication between project stakeholders, and improves the labor market [10,11]. Moreover, BIM software can enhance visualization, reduce waste, identify conflicts, and facilitate prefabrication and coordination of systems. In developing countries, BIM adoption broadens the search for solutions, improves project sustainability, achieves certification goals, and promotes informed decision-making [12,13]. Given the advantages, one might think that the BIM application should be a company's top priority; yet, many factors influence how well technology is implemented [14]. Although building information modeling (BIM) is a relatively new technology in the construction sector, numerous obstacles have hindered its widespread adoption, particularly in developing countries [15-17]. For these nations, these obstacles can be grouped into five main categories: the absence of a national standard, high application costs, a shortage of qualified staff, organizational problems, and legal problems [18]. For instance, most stakeholders are either unaware of the protocols for information transmission, software development, and interoperability, or they are unfamiliar with the advantages of BIM [19-20]. Early investments, such as the time and expense of hiring and training staff to utilize BIM and related software, are among the most significant obstacles [21-23]. BIM implementation has also been hampered by a shortage of personnel with the necessary training in developing countries [24]. Another commonly acknowledged obstacle to BIM implementation is the need for specialized software and data storage [25]. Organizational challenges associated with BIM implementation, such as trust issues, procedural concerns, and professional liability, represent another significant obstacle [26, 27]. Furthermore, ownership of BIM data, design documentation, and accountability for errors are among the legal concerns associated with BIM deployment in these nations [28]. Moreover, model management throughout the project may be problematic [29]. In developing countries, businesses' adoption of BIM may be passively influenced by the availability of resources, including money and time [30, 31]. Therefore, although BIM is an innovative concept in the AEC sector and offers a new paradigm for planning, building, operating, and maintaining facilities, stakeholders may encounter difficulties using it [32]. In developing countries, project stakeholders may not always be aware of the problems that may arise during implementation at the organizational or project level [33,34]. Here, it is worth mentioning that developing nations include countries such as Afghanistan, Angola, Bangladesh, Cambodia, the Central African Republic, Chad, Eritrea, Ethiopia, etc. Another instance is the obstacles to BIM implementation in post-war regions, such as the case of Syria. In this country, economic difficulties have prevented the diffusion of BIM usage within the construction industry [35]. According to the literature, the study's main objective is to identify and gather the primary obstacles to BIM implementation at both the project and organizational levels within the AEC Industry in developing countries.

2 Metodology

According to the literature, a thorough analysis of research papers, technical and review papers, books, articles, and websites was used to gather the significant issues affecting the adoption of BIM. Additionally, this initial search pool included more than 58 articles, 15 books, 23 conference papers, and 10 specified websites. In this context, keywords and the search engine were used to determine a pool of roughly thirty-five publications. Moreover, the terms "BIM barriers, challenges, and implementation" were used in this study. Here, the articles were examined to identify the hurdles that satisfied the study's goals, and extra points were awarded if an identified task was repeated. After reviewing every publication, a list of the difficulties in implementing BIM at various levels was created. Then, based on the recurrence of literature, a Rank (R) was determined among the obstacles to BIM deployment in the construction sector of developing countries. Additionally, each barrier's Relative Weight (RW) was determined using the following formula:

$$\textbf{Relative Weight, } RW = (F/H)$$

In the equation mentioned above, the barrier frequency is represented by (F), and the number of barriers in publications reviewed for this study is represented by (H). Here, it is worth mentioning that the main aim of this scoring system and the adopted formula is to extract the relative weight (RW) based on the repetition of each barrier listed from the targeted difficulties. As a result, the Rank (R), which indicates the effect of each barrier, will be determined for each difficulty in BIM deployment in the construction sector. Furthermore, the list of problems was categorized according to their relevance to the project, the organization, or both, and each obstacle was mapped accordingly. Figure 2 illustrates the research design and process employed in this study. Ultimately, the authors identified several barriers to adopting BIM in the AEC industry and associated each with previously defined categories.

Fig. 2: Research process.

3 Results and discussion

The study determined the primary obstacles to applying building information modelling in the construction sector of developing countries. The study also identified 28 barriers that affected the use of BIM in projects and organizations. Based on the current frequency of examining literature resources, Table 1 presents the relative ranking of the significant barriers that impact the effective adoption of BIM technology, along with its associated factors. In this regard, of the twenty-eight difficulties, 50% were related to an organization, 21.5% to a project, and 28.5% to both the project and the organization. Consequently, this highlights that, in the literature, most obstacles to implementing BIM are linked to organizational levels, as illustrated in Figure 3. Furthermore, Table 1 outlines the primary challenges to the adoption of BIM technology in the construction industry of developing countries, which include (1) social resistance to change, training costs, and the cost of hiring BIM experts (F=18); (2) traditional contracting methods (F=17); (3) software issues (compatibility, usability, and license) (F=16); (4) a lack of education and training on BIM use (F=15); (5) complexity of BIM (F=14); and (6). Additionally, the lack of legal or contract concerns (F=4), the lack of BIM risk insurance (F=3), technical issues (F=2), and a comparison of BIM to CAD (F=1) were the least significant obstacles to the adoption of BIM in developing countries.

Fig. 3 illustrates the 28 barriers to implementing BIM in developing countries, which are categorized into 14 organizational barriers, six project-specific barriers, and eight barriers that affect both the organization and the project.

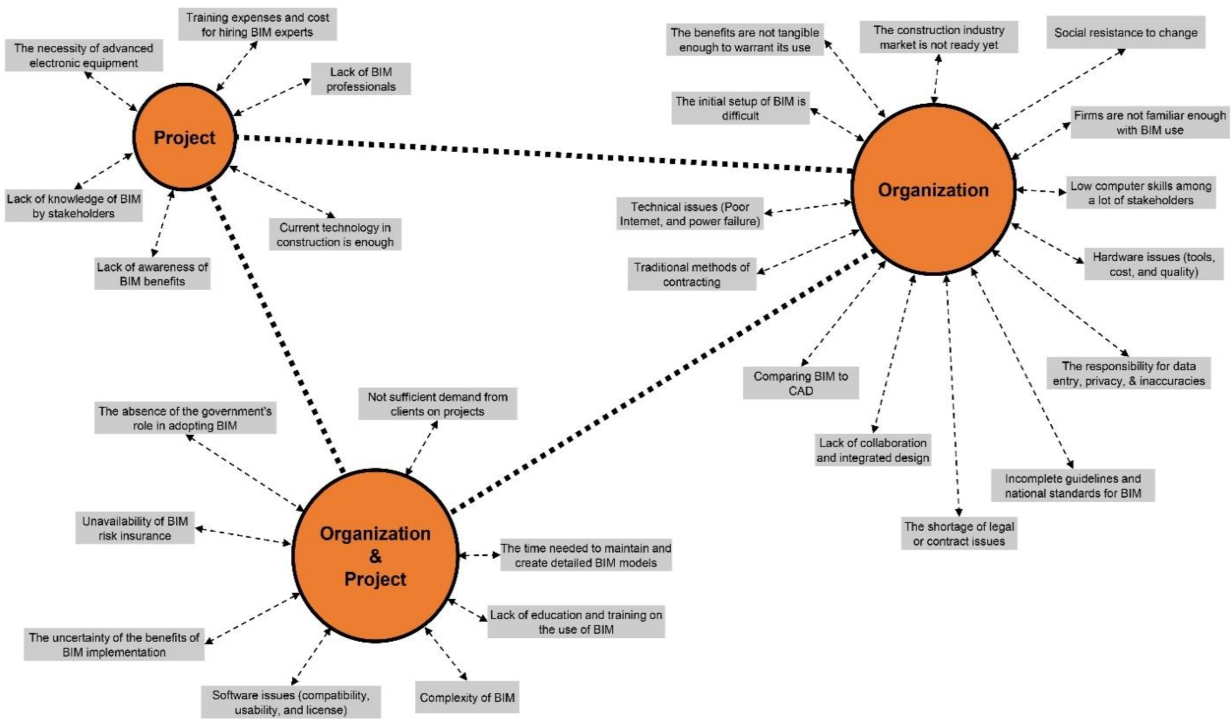

Fig. 3: The 28 barriers to implementing BIM.

Considering this, Fig. 4 represents the percentage of barriers to implementing BIM in terms of its association with project, organization, and project and organization in developing countries. Moreover, these percentages were determined based on the number of related barriers to each category among the 28 defined obstacles. Additionally, the pie chart indicates that barriers associated with projects account for 21.5%, obstacles associated with organizations for 50%, and barriers related to both organizations and projects for 28.5%.

Table 1: Rank of barriers to the implementation of BIM and its association.

ID	Barriers to the implementation of BIM	Importance		Rank	Barrier Applicability		
		(F)	(RW)	(R)	(P)	(O)	(P) & (O)
BA 1	Lack of knowledge of BIM by stakeholders	8	0.285	11	●		
BA 2	Lack of awareness of BIM benefits	9	0.321	10	●		
BA 3	The construction industry market is not ready yet	8	0.285	11		●	
BA 4	Lack of BIM professionals	13	0.464	6	●		
BA 5	Social resistance to change	18	0.642	1		●	
BA 6	Lack of education and training on the use of BIM	15	0.535	4			●
BA 7	Firms are not familiar enough with BIM use	7	0.25	12		●	
BA 8	Low computer skills among many stakeholders	11	0.392	8		●	
BA 9	Current technology in construction is enough	6	0.214	13	●		
BA 10	Training expenses and cost for hiring BIM experts	18	0.642	1	●		
BA 11	Software issues (compatibility, usability, and license)	16	0.571	3			●
BA 12	Hardware issues (tools, cost, and quality)	15	0.535	4		●	
BA 13	Complexity of BIM	14	0.5	5			●
BA 14	The responsibility for data entry, privacy, and inaccuracies	6	0.214	13		●	
BA 15	Incomplete guidelines and national standards for BIM	4	0.142	15		●	
BA 16	The necessity of advanced electronic equipment	5	0.178	14	●		
BA 17	The shortage of legal or contract issues	4	0.142	15		●	
BA 18	Not sufficient demand from clients on projects	13	0.464	6			●
BA 19	Lack of collaboration and integrated design	9	0.321	10		●	
BA 20	Unavailability of BIM risk insurance	3	0.107	16			●
BA 21	Comparing BIM to CAD	1	0.035	18		●	
BA 22	Technical issues (Poor Internet and power failure)	2	0.071	17		●	
BA 23	The absence of the government's role in adopting BIM	10	0.357	9			●
BA 24	Traditional methods of contracting	17	0.607	2		●	
BA 25	The time needed to maintain and create detailed BIM models	3	0.107	16			●
BA 26	The benefits are not tangible enough to warrant its use	12	0.428	7		●	
BA 27	The uncertainty of the benefits of BIM implementation	9	0.321	10			●
BA 28	The initial setup of BIM is difficult	11	0.392	8		●	
Percentage impacting a specific area					**21.5%**	**50%**	**28.5%**

Fig. 4: Percentage of barriers to BIM implementation by association.

Additionally, Fig. 5. represents the repetition against each barrier from the 28 to the implementation of BIM in the AEC industry.

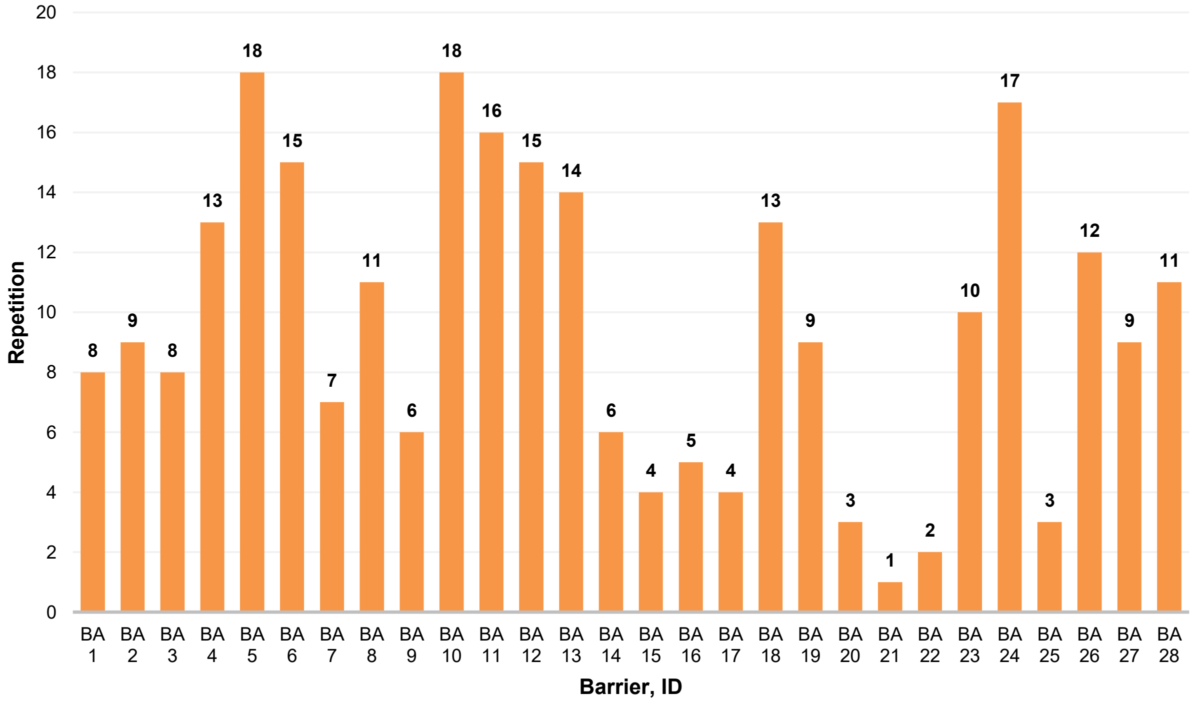

Fig. 5: Repetition against each barrier to the implementation of BIM.

Furthermore, Fig. 6 illustrates the critical ranking of barriers to adopting BIM technology in the construction sector of developing countries based on their relative weight value (RW). According to this study, the significant obstacle to the adoption of BIM is (BA 5) social resistance to change, (BA 10) training costs and the cost of hiring BIM specialists, (BA 24) conventional contracting methods, (BA 11) software problems, and (BA 6) a lack of knowledge and instruction on how to use BIM. Considering this, the primary obstacles that need to be addressed initially are these highly ranked ones. Furthermore, the low-rated obstacles to BIM deployment are (BA 21) the comparison of BIM to CAD, (BA 22) technical challenges, and (BA 20) the lack of BIM risk insurance. These low-ranked obstacles might be the last considered for mitigation.

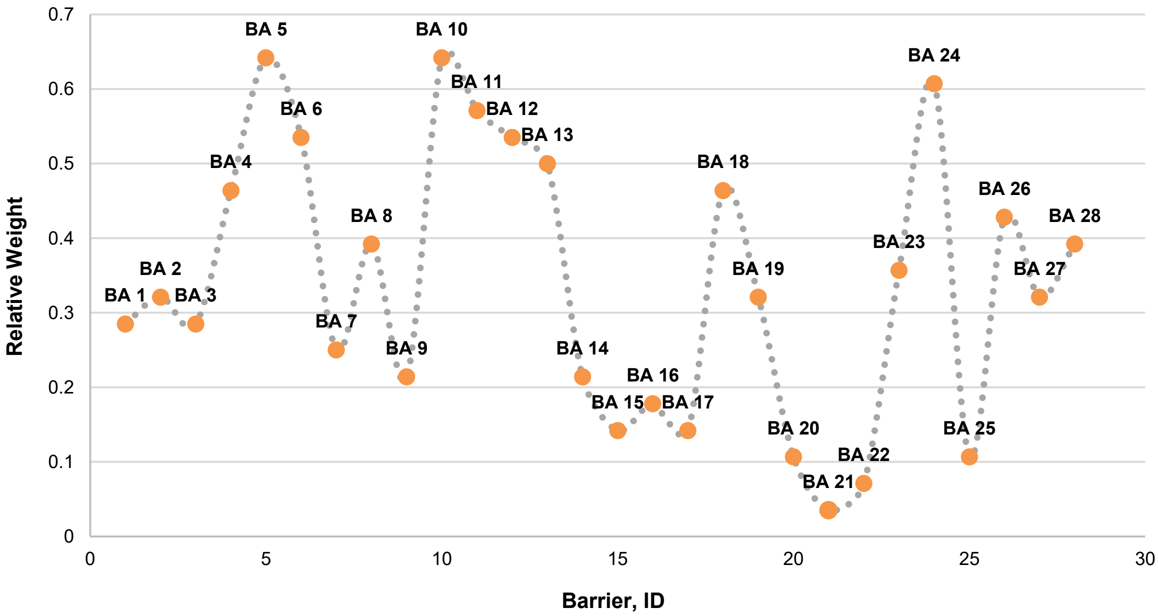

Fig. 6: Impact matrix (RW) of barriers to implementing BIM.

Furthermore, Fig. 7 illustrates the classification of BIM barriers associated with the main elements of BIM: people, information, processes, technologies, and policies.

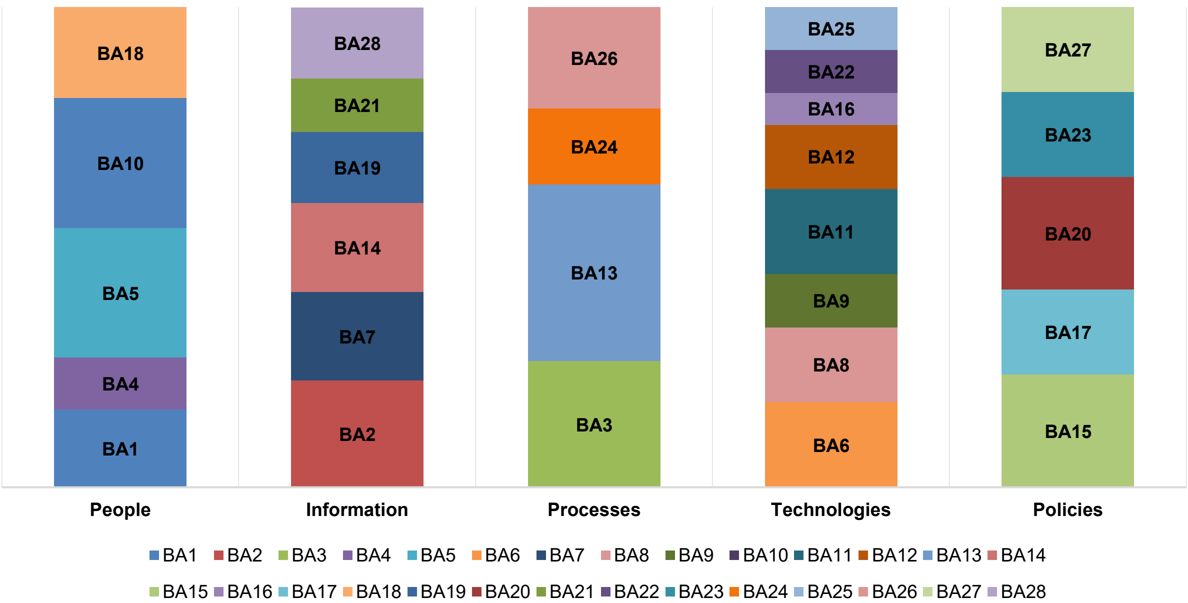

Fig. 7: The categories of BIM barriers related to the main elements of BIM.

4 Conclusions

The BIM concept and technologies have been widely adopted in practice worldwide, and the AEC industry has greatly benefited from their application. Nonetheless, the AEC sector relies heavily on the use of BIM, and obstacles to its adoption have garnered considerable attention. In this context, following a comprehensive literature review, the study aimed to identify implementation challenges associated with BIM in the AEC industry of developing countries. Most obstacles were identified at the organizational level 50%, including the ones most frequently mentioned in the literature. On the other hand, the barriers associated with projects account for 21.5%, and barriers related to both organizations and projects for 28.5%. This indicates that the construction sector faces greater challenges implementing Building Information Modeling (BIM) than individual projects. In developing countries, the main barriers to the AEC industry were social aversion to change, training costs, the cost of recruiting BIM specialists, conventional contracting techniques, the complexity of BIM, and a shortage of BIM professionals. Additionally, this study highlights that the main obstacles to this industry's continued use of BIM are interoperable hardware (including tools, cost, and quality) and software (such as compatibility, usability, and licensing). Furthermore, small and medium-sized design and construction firms in developing countries may find this list of obstacles essential. Therefore, the study's other primary goal is to give construction organizations the ability to recognize and rank the barriers to adopting BIM. By doing this, industries can effectively develop a BIM implementation strategy that addresses each identified issue. So, if design and construction firms in these developing nations wish to see the construction industry able to compete globally, these issues must be resolved. Moreover, this could be implemented by reducing the costs of BIM implementation, developing effective BIM implementation strategies, and enhancing BIM education and training. Additionally, the government, the AEC sector, educational institutions, and BIM suppliers should collaborate to raise awareness of BIM benefits and simplify BIM standards. Furthermore, facilitating contracting methods to support the construction sector could be considered an action plan. Government assistance significantly accelerates BIM adoption in the building industry in developing nations. Eventually, with the progressive involvement of government officials and other construction stakeholders, the AEC industry and building sector can overcome the obstacles to implementing BIM in developing countries. Finally, the authors anticipate that it will be crucial to continuously update the issues related to implementing BIM at the organizational and project levels.

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