CME LIVE OPEN ACCESS

Journal of
Petroleum Gas & Chemical Engineering

Research Article

Challenges in the Adoption of BIM by Construc tion Professionals Over 50 Years of Age Cognitive, Technical and Pedagogical Barriers

Jorge Pablo Aguilar Zavaleta*

Department of Engineering and Architecture, Cesar Vallejo University, Peru.

***Correspond Author:** Jorge Pablo Aguilar Zavaleta, Department of Engineering and Architecture, Cesar Vallejo University, Peru.

Received: 2025 June 04 **Accepted:** 2025 June 23 **Published:** 2025 July 07

Abstract

The adoption of Building Information Modeling (BIM) technologies in the construction industry faces significant challenges, particularly among professionals over the age of 50. This demographic often encounters cognitive, technical, and pedagogical bar riers that hinder their ability to effectively integrate BIM into their workflows. Cognitive limitations such as reduced information processing, memory retention issues, and a lack of familiarity with digital tools can lead to resistance to new technology. These challenges are compounded by technical obstacles, including software interoperabil ity problems and a general lack of user-friendly design in BIM applications, which can create frustration and deter adoption among older professionals [1-3]. Moreover, pedagogical approaches in training programs often do not adequately ad- dress the unique learning needs of older construction workers. Traditional educational methodologies may reinforce existing barriers, failing to promote critical thinking and adaptability—skills increasingly required in modern construction practices. Innovative pedagogical strategies, such as formative analytics and context-based learning, are crucial for fostering an engaging and supportive educational environment that aligns with the rapidly evolving demands of the industry [4,5]. Despite the notable successes in BIM implementation across various projects, many older professionals still grapple with the underlying issues that inhibit their technological transition. Financial constraints, digital literacy challenges, and the need for ongoing technical support further complicate the landscape, creating a disparity between younger and older workers in technology adoption [6-8]. Recognizing and addressing these barriers is essential not only for individual growth but also for the broader evolution of the construction industry as it increasingly relies on digital solutions for project management and execution. As the construction sector continues to embrace digital transformation, there is an urgent need for tailored strategies to empower older professionals to navigate BIM technologies effectively. By fostering an inclusive environment that supports continuous learning, collaboration, and innovation, the industry can ensure that all professionals, regardless of age, can contribute to and benefit from the advancements in building technology [9-11].

Keywords: BIM, 50-year-old professionals, Changes

1. Introduction

1.1. Cognitive Barriers

Cognitive barriers play a significant role in the adoption of Building Information Modeling (BIM) technologies among construction professionals over the age of 50. As individuals age, various cognitive changes can influence their ability to learn and adapt to new technologies. These changes often manifest as difficulties in processing information, reduced cognitive flexibility, and challenges in learning new systems and processes [1,2].

1.2. Awareness and Understanding

One of the primary cognitive barriers identified is a lack of awareness regarding the capabilities and features of BIM technologies. Many older professionals may be familiar with traditional construction methods but may struggle to grasp the full potential of BIM. This knowledge gap can result in resistance to adopting new technologies, as users may feel overwhelmed or intimidated by the complexity of BIM systems [1].

1.3. Memory and Retention

Memory retention is another critical aspect affecting older professionals' ability to adopt BIM. Cognitive decline can lead to difficulties in remembering instructions or procedures, making it challenging to effectively use BIM software. As noted, older adults often express frustration over their inability to recall information necessary for the setup and operation of such technologies [1,2]. This cognitive challenge can deter them from engaging with BIM tools, further hindering their technology adoption.

1.4. Learning Adaptability

The adaptability to learn new technologies can vary significantly among older adults. While some may exhibit a willingness and motivation to engage with BIM, others might dis-

play a more negative or cynical attitude towards technology, stemming from feelings of being too old to learn or doubts about the benefits of such innovations [2]. This inter individual variability underscores the necessity of tailored training approaches that consider cognitive capacities, ensuring that older construction professionals receive the support they need to transition to BIM effectively [1].

1.5. Integration into Daily Routines

Integrating BIM technologies into daily routines can also buffer against the cognitive decline often observed in older professionals. Establishing a consistent routine for using BIM tools can facilitate better retention of skills and knowledge, reducing the cognitive load associated with learning [2]. Social support from colleagues and a collaborative environment can further enhance the comfort level of older adults when navigating these technologies, thereby increasing the likelihood of successful adoption [1,2].

1.6. Technical Barriers

1.6.1. Software and Interoperability Issues

The adoption of Building Information Modeling (BIM) among construction professionals over 50 faces significant technical barriers, particularly concerning software interoperability and standardization. The complexity of integrating different software tools creates challenges, as stakeholders must navigate various data exchange protocols and file format compatibilities. This can lead to misunderstandings about essential information throughout the project lifecycle, resulting in inefficiencies and additional work methods being required to overcome these limitations [3,4].

1.7. Model Quality and User-Friendliness

Another critical barrier is the quality of the BIM models themselves. Inconsistent mod- el quality can result from a lack of clarity regarding the level of detail (LOD) required for different components, which can inflate the modeling workload and complicate project management [6]. Furthermore, the user-friendliness of BIM software is often cited as a deterrent, especially for older professionals who may not have extensive experience with modern technology. The need for comprehensive training programs focused on BIM workflows and software integration is essential for fostering a better understanding of these tools among older construction professionals [3,4].

1.8. On-Site Education and Technical Support

The necessity for on-site education and ongoing technical support further com- plicates the adoption of BIM technologies. As construction environments can be high-pressure, workers may revert to traditional methods when faced with difficulties in using BIM systems, thus limiting their effectiveness [3]. Furthermore, the availability of timely technical support is often lacking, making it difficult for older professionals to adapt to new technologies swiftly.

1.9. Financial Constraints

Costs associated with BIM training and technology implementation are significant barriers as well. Many construction professionals over 50 may find the financial investment in learning new technologies prohibitive, particularly if their firms have limited budgets for research and development. Consequently, this financial burden can hinder their willingness to embrace BIM, further entrenching traditional methods of operation [3-7].

1.10. Digital Literacy Challenges

Digital literacy also plays a crucial role in the technical barriers to BIM adoption. Older professionals may not have been raised in a digital environment, leading to difficulties in understanding and using advanced software tools. This generational gap in technology experience poses a significant challenge for the integration of BIM into their workflows [2].

1.11. Pedagogical Barriers

Pedagogical barriers significantly impact the effective adoption of Building Informa tion Modeling (BIM) among construction professionals over 50 years of age. These barriers stem from traditional educational approaches and the prevailing emphasis on rote memorization and standardized testing, which may not cater to the diverse learning needs of older professionals in the rapidly evolving field of construction technology [4,5].

1.12. Relevance to Effective Educational Theories

The effectiveness of pedagogical strategies is paramount for the successful integration of BIM. Traditional teaching methods often focus on teacher-led instruction, limiting opportunities for older learners to engage in self-directed learning. This contrasts with innovative pedagogies such as formative analytics and place-based learning, which emphasize learner autonomy and contextualized experiences [5]. According to Ferguson and Clow (2017), the strength of evidence regarding the impact of these modern approaches is crucial for validating their implementation in educational settings [5].

1.13. Relation to the Development of Twenty-First Century Skills

The construction industry increasingly demands critical thinking, problem-solving, and digital literacy skills, which are often neglected in conventional pedagogical models [4,5]. As the construction landscape shifts towards collaborative and tech- nologically advanced practices, older professionals may struggle to adapt without a robust framework for learning that supports the development of these skills. In particular, the need for creativity and innovation in managing unforeseen challenges becomes crucial in BIM applications [5].

2. Methods

2.1. Innovative Aspects of Pedagogy

Adopting innovative pedagogical approaches can address the unique challenges faced by older construction professionals. Formative analytics, for instance, enables learners to receive real-time feedback tailored to their specific needs, fostering. self-regulation and enhancing their learning experience [5]. Moreover, the incorpo- ration of technologies such as drones and robotics within educational frameworks can facilitate more engaging and relevant learning experiences, thereby mitigating resistance to change among older workers [4,5].

2.2. Level of Adoption in Educational Practice

Despite the potential benefits, the actual adoption of these innovative pedagogies in training programs for older construction professionals remains limited. Many educational institutions and organizations continue to favor traditional models, which may inadvertently reinforce existing cognitive barriers [4,5]. As a result, there is a pressing need to advocate for a shift towards more dynamic and responsive pedagogical frameworks that not only accommodate the learning preferences of older professionals but also align with the demands of contemporary construction practices.

2.3. Case Studies

2.3.1. Introduction to Case Studies

The examination of Building Information Modeling (BIM) adoption in construction, particularly among professionals over 50 years of age, involves a deep analysis of specific case studies that illustrate both the challenges and successes of implementing BIM technologies. These case studies serve as vital examples to understand the cognitive, technical, and pedagogical barriers that older construction professionals encounter.

2.4. Celsius Project Case Study

One significant case study is the Celsius project, a BIM initiative aimed at creating an office and laboratory building in Uppsala Science Park, Sweden. This project, which covers 12,000 square meters over six floors with a budget of approximately 45 million Euros, began design work in 2017 and was completed in November 2020. The Celsius project was awarded the 2020 building SMART Award, highlighting its innovative and digitalized construction process, marking it as a notable example in BIM research [3]. The project successfully implemented BIM technologies across all phases, showcase the potential for enhanced collaboration and efficiency in construction processes. This serves as a critical example of how organized efforts in BIM can mitigate some of the barriers faced by older professionals, provided there is a commitment to ongoing learning and adaptation to new technologies.

3. Results and Discussion

3.1. Challenges in BIM Adoption

Despite the successes highlighted in the Celsius project, the broader landscape of BIM adoption reveals ongoing challenges, particularly for older professionals. Research indicates that various factors hinder the successful implementation of BIM in renovation projects. These include a lack of awareness, inadequate skills, and technical limitations of existing BIM tools, which can be particularly pronounced among professionals who may not have grown up with rapidly changing technology [6-8]. Moreover, studies have pointed out that the transition to BIM requires not just a technological shift but also a change in business processes and organizational culture. For example, one contractor developed a digital app for supervisors to sign completion certificates, which later evolved to include safety briefings, illustrating the dynamic nature of BIM integration in project management [7].

3.2. Mixed-Methods Approach in Research

A mixed-method, multilevel longitudinal case study approach has been employed to delve deeper into these challenges, collecting empirical data from multiple construction organizations as they integrate BIM into their work processes. This method is particularly effective for understanding contemporary phenomena within their real-life contexts, as it can capture the complexities and nuances of adopting new technologies in construction, especially regarding older professionals' experiences [6-12].

3.3. Strategies for Overcoming Barriers

To successfully navigate the challenges associated with the adoption of Building Information Modeling (BIM) by construction professionals over 50 years of age, several strategies can be employed.

3.4. Continuous Learning and Training

One of the primary strategies for overcoming barriers is investing in continuous learning and comprehensive training programs. Offering tailored training that emphasizes practical, hands-on experiences can demystify BIM and illustrate its ad- vantages in real-world settings [9]. Professionals should be encouraged to participate in workshops that focus on BIM workflows, data exchange protocols, and software integration to foster a skilled workforce [4]. Such educational initiatives can help professionals adapt to the technological advancements inherent in BIM [10].

3.5. Cultivating a Supportive Environment

Establishing a system of mentorship is essential. Pairing experienced BIM experts with less experienced staff can create a supportive learning environment, easing the transition to new technologies [9]. Furthermore, seeking support from mentors or colleagues can provide valuable insights and guidance throughout the adaptation process [11].

3.6. Addressing Resistance to Change

Overcoming the resistance to change that often accompanies the transition to BIM involves demonstrating the long-term benefits of adopting new technologies. Edu- cation on how BIM can simplify daily tasks and enhance productivity is crucial [10]. Engaging professionals by showcasing success stories and positive outcomes from BIM implementation can motivate them to embrace the change [13].

3.7. Facilitating Interoperability

Investing in the training and education necessary to enhance interoperability between different software platforms is vital. This can be accomplished by integrating plug-ins that facilitate seamless data exchange between applications, thus improving the overall efficiency of BIM usage [4]. Continuous evaluation and updates of training resources are also necessary to align with evolving technological demands.

3.8. Managing Initial Costs

Managing high initial costs is another critical strategy. Companies should consider developing tailored curricula that reflect their specific needs, combining lectures with practical methods and industry-linked approaches. This alignment

can ensure that training is both relevant and effective in preparing professionals for BIM challenges [14].

3.9. Embracing a Problem-Solving Mindset

Lastly, fostering a problem-solving mindset among professionals can significantly enhance their ability to adapt to BIM. Encouraging them to stay proactive and open to new solutions can empower them to overcome technical and cognitive barriers [11]. Regularly revisiting project methodologies and outcomes can lead to continuous improvement and adaptation in the use of BIM technologies.

4. Conclusions

4.1. Future Trends

4.1.1. Evolving Adoption of BIM Technology

The future of Building Information Modeling (BIM) in the construction sector is likely to be characterized by wider adoption and deeper integration with other emerging technologies. As the architecture, engineering, and construction (AEC) industry increasingly becomes digital and data-driven, BIM is poised to play a central role in the design, construction, and management of buildings and infrastructure [15]. The ongoing digital transformation is expected to enhance collaboration among project stakeholders, improve project efficiency, and optimize the overall project lifecycle management [16,17].

4.2. Increased Pressure for Digital Transformation

With population growth and urbanization intensifying, the pressure on the construction industry to adopt BIM processes is mounting. BIM's ability to facilitate effective planning and execution of large-scale projects is critical for meeting these escalating demands [16]. As companies recognize the importance of integrating BIM into their workflows, adoption rates are projected to rise, contributing to an improved landscape for project delivery and management.

4.3. Integration with Other Technologies

The integration of BIM with other technological advancements is anticipated to yield significant benefits. For example, interoperability between BIM and tools such as augmented reality (AR), virtual reality (VR), and Internet of Things (IoT) solutions is expected to enhance project visualization and monitoring capabilities. This integration will allow stakeholders to interact with digital models in innovative ways, further enhancing collaboration and decision-making processes [15].

4.4. Focus on Education and Training

As the AEC industry continues to evolve, the emphasis on education and training for professionals—especially those over 50—will become increasingly important. Organizations are likely to invest in targeted training programs that focus on bridging the cognitive and technical gaps that older professionals may face when adopting new technologies like BIM [8]. These programs will not only help enhance digital skills but also foster a cultural shift toward embracing innovation in traditional practices [18].

4.5. Sustainable Practices and Data Security

Another trend shaping the future of BIM is the heightened focus on sustainability and data security. As the industry navigates increasing regulatory requirements and client expectations, integrating sustainability into BIM processes will become essential [15]. Moreover, with the rise of data-driven decision-making, ensuring data security will be a priority, requiring organizations to implement robust systems that safeguard sensitive project information [15].

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