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BIM AND AI INTEGRATION IN THE DESIGN OF INCLUSIVE WORK ENVIRONMENTS SUPPORTING INFORMATION EXCHANGE: THE CASE OF YEKATERINBURG, RUSSIA (RCC HEADQUARTERS / FOSTER + PARTNERS)

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The integration of Building Information Modelling (BIM) and Artificial Intelligence (AI) is revolutionizing infrastructure development, offering innovative solutions for design, construction, and operational challenges. This study explores the challenges associated with their integration (BIM and AI) to achieve inclusive work environments supporting information exchange in contemporary construction projects. This study aims to prove the importance of integrating BIM and AI to achieve more inclusive results in contemporary projects.

Keywords: *Contemporary Construction Projects, Architecture design, BIM, AI, The accessible environment, inclusive, Barrier-free design, Adaptive architecture, The compensatory environment, design, auditory design.*

ИНТЕГРАЦИЯ BIM И ИСКУССТВЕННОГО ИНТЕЛЛЕКТА В ПРОЕКТИРОВАНИИ ИНКЛЮЗИВНЫХ РАБОЧИХ ПРОСТРАНСТВ, СПОСОБСТВУЮЩИХ ОБМЕНУ ИНФОРМАЦИЕЙ: ПРИМЕР ЕКАТЕРИНБУРГА, РОССИЯ (ШТАБ-КВАРТИРА РМК / FOSTER + PARTNERS)

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Интеграция информационного моделирования зданий (BIM) и искусственного интеллекта (ИА) революционизирует развитие инфраструктуры, предлагая инновационные решения для задач проектирования, строительства и эксплуатации. В данном исследовании рассматриваются проблемы, связанные с их интеграцией (BIM и ИИ), с целью создания инклюзивной рабочей среды, способствующей обмену информацией в современных строительных проектах. Цель исследования – продемонстрировать важность интеграции BIM и ИА для достижения более инклюзивных результатов в современных проектах.

Ключевые слова: *современные строительные проекты, архитектурное проектирование, BIM, ИИ, доступная среда, инклюзивность, безбарьерный дизайн, адаптивная архитектура, компенсирующая среда, проектирование, акустическое проектирование.*

Introduction

There are seven billion versions of normality on this planet [1]. Imagine your workstation in the middle of a space – you hear nothing. For employees who are hard of hearing, a typical workday can be stressful in a noisy workplace. In the context of increasingly complex architectural challenges – user diversity, accessibility requirements, sustainability imperatives, environmental comfort, and technological advances – inclusive design has become both an ethical requirement and a practical necessity [2]. Globally, only about 40% of working-age people with disabilities are employed, underscoring the urgent need for truly inclusive work environments This approach aims to create spaces that are accessible, adaptable, and equitable for all users, regardless of their physical, social, or cultural abilities. Within this framework, architects, civil engineers, and professionals in the Architecture, Engineering, and Construction (AEC) sector must master and leverage new digital tools such as Building Information Modeling (BIM) and Artificial Intelligence (AI) [3]. These simulation and analysis technologies now offer innovative solutions to address inclusion challenges in contemporary projects by integrating the needs of diverse populations from the earliest stages of the design process [4]. According to the Inclusive Design Research Centre at OCAD University, inclusive design "considers human diversity in all its complexity: abilities, language, culture, gender, age, and other human differences" [5]. This article therefore examines how the integration of BIM and AI can contribute to the design of inclusive work environments for people with hearing impairments, enhancing information exchange among diverse users.

Over time, the concept of inclusivity in urban planning and architecture has evolved. It is no longer enough to design for "normality"; cities and buildings must now be conceived as inclusive systems, where human diversity – age, culture, sensory capacity, mobility – is seen as an asset rather than a constraint [6]. Inclusive urban planning thus goes beyond regulatory compliance, seeking instead to create spaces that promote belonging, accessibility, and communication for all. Architectural approaches, initially focused on eliminating physical obstacles, are now expanding toward sensory and cognitive compensation, participatory design, and adaptive processes that place the user at the center [7]. This transition from simple accessibility to true inclusivity transforms both urban and architectural scales, encouraging designers to use digital and participatory tools from the programming phase to anticipate diverse user needs – including those with hearing impairments – and to foster equitable information exchange [8].

Designing work environments adapted for people with hearing impairments requires understanding the evolution of architectural approaches, from accessibility to inclusive design. The concepts of accessible environment, barrier-free design, adaptive architecture, compensatory environment, and inclusive design represent progressive stages toward a more comprehensive understanding of human diversity and disability. The accessible environment focuses on removing existing barriers and meeting regulatory standards [9], [10]. Barrier-free design adopts a preventive approach, avoiding barriers from the outset [10]. Adaptive architecture personalizes spaces for specific groups but remains selective [11]. The compensatory environment incorporates technological aids – such as hearing devices or visual alert systems – offering a more dynamic response to user needs [12]. Inclusive design, finally, represents a paradigm shift by placing human diversity at the center of the process and promoting flexible, participatory environments for all [13]. This progression highlights the transformation of architectural practice from normative conformity to a broader understanding of human variability.

Contemporary architecture faces numerous constraints – diversity of materials, climatic conditions, sociocultural contexts, and evolving social norms [14]. In such a context, traditional design approaches are insufficient. A truly comprehensive project requires reinterpreting design methods based on a deep understanding of user needs [15] and the use of digital tools capable of modeling this complexity. While many studies have explored the use of Building Information Modeling (BIM) and Artificial Intelligence (AI) in various design, construction, and management phases [16], few have examined their role in inclusive design. Yet, these technologies hold great potential to anticipate accessibility needs, improve environmental performance, and promote human-centered design. The initial goal of BIM was to create a procedural framework for managing construction, but as Zhou et al. [17] note, its adoption remains limited due to technical challenges. However, experiments combining BIM and AI have demonstrated efficiency gains and positive environmental, social, and economic impacts, aligning with contemporary sustainable development goals. This study thus contributes to ongoing efforts to explore how BIM–AI integration can support the design of inclusive work environments that foster information exchange and renew design methodologies toward a more participatory and equitable architectural practice.

Previous research has examined the integration of BIM and AI in architectural design and construction. BIM is a key tool for managing data across a building's lifecycle, although interoperability and cost remain barriers [18]. AI, on the other hand, offers automation and predictive potential, and together they enable intelligent design systems. Some projects, such as the Microsoft Inclusive Tech Lab, have implemented inclusive design principles – notably through acoustic optimization [19]. The use of sound-absorbing materials, like felt panels and baffles, as well as smooth surface transitions, reduces reverberation and background noise, improving comfort for noise-sensitive users. However, most studies still emphasize the technological benefits of BIM–AI integration, with limited focus on inclusivity – particularly acoustic design for people with hearing sensitivities. Despite these advances, research and on-site projects continue to prioritize technology over inclusion, highlighting the need for deeper exploration of how digital tools can truly enhance accessibility and sensory comfort for hearing-impaired users

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Despite these advances, most studies and on-site projects focus primarily on the technological aspects of BIM–AI integration, often highlighting its benefits while neglecting the use of these systems for inclusivity in terms of acoustics, particularly for hearing-impaired Users.

Methodology: 3D Modeling of a Workspace Using Revit, BIM, and AI

Building Information Modeling (BIM) enables the creation of an intelligent digital representation of a building that describes spatial elements such as walls, materials, lighting, acoustics, circulation, and equipment. Beyond its technical role, BIM also allows the integration of human-centered characteristics, including visibility and audibility zones as well as comfort areas. By simulating sensory conditions–such as noise levels, echo, lighting, and visual distance–it becomes a shared information base that accurately represents the sensory and functional reality of all users.

Artificial Intelligence complements BIM by analyzing design data and automatically proposing inclusive solutions adapted to user needs. Through machine learning, it observes user behavior and adjusts spatial configurations to enhance comfort and accessibility. A review of relevant literature–including official publications by Foster + Partners, the Russian Copper Company, and several architectural databases – revealed no explicit mention of BIM or AI applications in the design of the Russian Copper Company headquarters in Yekaterinburg [20], particularly concerning inclusivity for hearing-impaired employees. To address this gap, the present study applies a methodological framework based on the integration of BIM and AI to design inclusive work environments that facilitate equitable information exchange, using the RCC headquarters as a case study.

Step 1: Data Collection and Structuring

– Gathering existing architectural plans and technical constraints, including dimensions, orientation, and equipment.

– Identifying user needs, with a focus on specific profiles (e.g., hearing-impaired workers) [21].

– Defining design objectives, such as acoustic comfort, ergonomics, circulation, and collaboration zones.

Step 2: 3D Modeling in Revit

Creating an accurate 3D model of the open space, including [22]

- desks, partitions, and acoustic panels;
- equipment, screens, and furniture;
- circulation paths and collaboration areas.

Assigning BIM parameters to each element, including material, acoustic characteristics, functions, and dimensions.

Step 3: Environment Simulation and Analysis

– Simulating acoustics to visualize sound propagation within the space [23].

– Identifying areas where noise may interfere with users, particularly hearing-impaired workers.

– Evaluating ergonomics and functionality under different layout scenarios.

Step 4: Testing and Layout Optimization

– Applying different configurations of desks and acoustic partitions.

– Analyzing the effects of screen placement and workstation orientation.

– Comparing scenarios to select the most efficient and inclusive option.

Step 5: Coordination and Collaboration via BIM

– Sharing models and data with all stakeholders, including architects, acousticians, ergonomists, designers, and HR managers.

– Centralized updating of information to ensure consistency across disciplines.

– Comprehensive documentation of the space and its characteristics for future project phases.

Step 6: Integration of Artificial Intelligence

– Automatic analysis of BIM data to identify critical points and propose inclusive solutions [24].

– Personalizing spaces based on real user behavior and specific needs.

– Simulating future scenarios to anticipate changes and enhance overall comfort.

Step 7: Validation and User Feedback

– Verifying the effectiveness of the proposed layouts through feedback from real users.

– Making final adjustments to the model to ensure accessibility, functionality, and acoustic comfort.

Typical Results from a Simulation (calculated using an AI-based acoustic tool, such as Treble.tech, chosen for our case study)

For example, a **meeting room** in the RCC project.

In the RCC headquarters meeting room, Carrara marble flooring provides timeless elegance, while glass and slim metal-framed partitions enhance brightness and transparency and improve acoustics through integrated baffles. Ventilation, heating, and air conditioning are discreetly hidden in floor and wall niches for a clean aesthetic and optimal thermal comfort. Acoustic analysis shows a reverberation time (TR) of approximately 0.68 seconds, suitable for a standard meeting room, but for hearing-impaired users, the ideal TR is 0.4–0.5 seconds, indicating that additional sound absorption is necessary. In the RCC headquarters meeting room, Carrara marble flooring provides timeless elegance, while glass and slim metal-framed partitions enhance brightness and transparency and improve acoustics through integrated baffles. Ventilation, heating, and air conditioning are discreetly hidden in floor and wall niches for a clean aesthetic and optimal thermal comfort. Acoustic analysis shows a reverberation time (TR) of approximately 0.68 seconds, suitable for a standard meeting room, but for hearing-impaired users, the ideal TR is 0.4–0.5 seconds, indicating that additional sound absorption is necessary.

Conclusion

The integration of BIM and Artificial Intelligence in the design of inclusive work environments represents a significant advancement in contemporary architecture, particularly in supporting information exchange for hearing-impaired users. The study of the Russian Copper Company headquarters in Yekaterinburg demonstrated that the combined use of Revit and AI-based acoustic analysis tools not only allows for precise spatial modeling but also enables the simulation and optimization of sensory conditions for all users.

The results obtained, such as the reduction of reverberation time in meeting rooms, illustrate the ability of BIM and AI to provide inclusive and personalized solutions, addressing the specific needs of hearing-impaired individuals. Moreover, the centralization of data and the interdisciplinary collaboration facilitated by BIM enhance the efficiency of the design process and promote informed, participatory decision-making.

Thus, this work highlights that the integration of these technologies goes beyond mere technical improvement: it constitutes a strategic tool to rethink architectural design in a human-centered, equitable, and adaptable manner for diverse users. The application of these approaches

The application of these approaches in future projects could serve as a reference for creating truly inclusive work environments, where accessibility and sensory comfort are integrated from the earliest design phases.

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