BIM TECHNOLOGIES AND SOCIAL INFRASTRUCTURE: FROM CONCEPT TO OPERATION

Zafar Matniyazov
Dilfuza Nabijonova
Tashkent University of Architecture and Civil Engineering

Abstract: *Amid demographic growth in Uzbekistan, the urgent need for developing social infrastructure, including preschool institutions, has become evident. Implementing Building Information Modeling (BIM) technologies optimizes the design, construction, and operation of such facilities. This article examines successful BIM case studies, focusing on economic efficiency, cost reduction, and quality improvement in social infrastructure projects. International examples are provided, along with recommendations for adopting BIM in Uzbekistan.*

Keywords: *BIM technologies, preschool institutions, social infrastructure, construction, energy efficiency, Uzbekistan, sustainable development.*

INTRODUCTION

In Uzbekistan, demographic growth has highlighted the acute need for developing social infrastructure, particularly preschool institutions. Rapid population increases require innovative approaches aimed at sustainable development. Demographic forecasts predict a 15% rise in the number of preschool-aged children by 2030, necessitating the accelerated implementation of national programs for educational facilities.

Modern preschool institution design faces numerous challenges, including strict compliance with regulatory requirements [1, 2], consideration of age-specific needs, and the integration of eco-friendly technologies. Building Information Modeling (BIM) systematically addresses these challenges by providing tools to optimize all stages of a facility's lifecycle. BIM also facilitates the creation of preschool institutions that not only meet basic needs but also promote children's intellectual and physical development.

Methods

This study analyzed BIM's benefits using data from projects in Russia, Uzbekistan, Scandinavia, China, and the United Kingdom [3, 4]. Key aspects examined included:

– Reducing construction costs;

– Shortening project implementation timelines;

– Enhancing building energy efficiency;

– Simplifying facility management and monitoring.

The research compared various BIM applications across countries. Notable examples include projects in the Netherlands, where BIM optimized resource use, and in China, where digital modeling accelerated construction by 25%. Additionally, energy-efficient preschool institutions in Denmark, the United Kingdom, and Germany were analyzed.

Data visualization included tables and charts illustrating BIM's impact on construction time, costs, and energy efficiency.

Results and Discussion

Design. BIM integrates architectural, engineering, and operational aspects. Key advantages include:

– Creating 3D models that consider ergonomics and age-specific needs;

– Integrating engineering systems such as heating, ventilation, and lighting;

– Ensuring compliance with regulatory requirements and energy efficiency standards [3, 4].

For example, a preschool institution project in the Netherlands reduced material costs by 15% through optimized design [4]. In the United Kingdom, the "Greenfield" preschool institution project utilized BIM to integrate renewable energy systems, including solar panels and heat pumps, reducing operational costs by 30%.

Moreover, BIM provides enhanced visualization, enabling stakeholders to anticipate design challenges before construction begins. This capability minimizes redesign costs and aligns the final outcomes with initial project goals. Scandinavian countries have adopted BIM extensively in the design phase to address ergonomic needs, particularly in facilities for younger children, where safety and comfort are priorities.

Construction. An exemplary BIM application in Asia is a preschool institution project in Singapore, where BIM integrated automated cooling and lighting systems, reducing energy consumption by 35%. In South Korea, the "Smart Children's Center" pioneered fully digital models for managing safety and energy-saving systems. In Japan, BIM is extensively used for constructing educational facilities in high-seismic zones, where precise calculations and modeling are critical.

BIM during the construction phase enables:

– Minimizing errors through precise construction data;

– Accelerating processes via modular construction and automation;

– Reducing average project timelines by 20–30%.

Projects in China and Scandinavia using BIM reported a 25% reduction in construction timelines. In Denmark, BIM facilitated the development of energy-efficient buildings, cutting heating and lighting costs by 40% [3]. In Germany, the "Solar House" project showcased BIM's ability to manage solar panels and energy-efficient ventilation systems effectively.

In Uzbekistan, the integration of modular construction techniques combined with BIM can accelerate ongoing government programs aimed at expanding the availability of preschool institutions in urban and rural areas alike. Furthermore, implementing cloud-based BIM platforms could support collaboration among stakeholders from different regions, improving project execution and efficiency.

Operation.

In China, BIM automates ventilation and heating systems in preschool institutions, reducing operational expenses by 20%. In India, BIM supports the design of inclusive educational spaces, addressing the needs of children with disabilities by ensuring building accessibility and spatial management.

BIM models support:

– Real-time monitoring of engineering systems;

– Predictive maintenance and planning;

– Reducing operational costs by 30–50% through intelligent management systems [5].

In the United Kingdom, the "Rainbow Kids" preschool institution employs BIM to automate water supply and heating systems, cutting water consumption by 25%. In Germany, intelligent energy management systems in educational institutions reduced energy costs by 40%.

Additionally, BIM's adaptability to different climatic conditions allows for optimization of heating and cooling in extreme weather regions, making it highly suitable for Uzbekistan's diverse climate zones.

BIM's ability to adapt to long-term operational changes further strengthens its appeal. For instance, as Uzbekistan modernizes its educational standards, BIM models can be updated to incorporate new design or curriculum requirements without requiring significant structural changes.

BIM Technology Advantages.

Accelerating Project Timelines. BIM shortens project timelines through process automation and improved coordination among stakeholders. However, BIM implementation faces challenges, such as training specialists, high initial costs for equipment and licenses, and resistance to change among stakeholders accustomed to traditional methods. These challenges are especially significant in Uzbekistan, where rapid population growth necessitates expedited social infrastructure development.

Economic Efficiency.

BIM optimizes resource use, reducing costs by 20%. For instance, BIM-enabled projects in Denmark and Germany achieved significant savings in materials and time, serving as exemplary models for Uzbekistan.

Environmental Sustainability.

BIM facilitates the integration of sustainable technologies, such as solar panels and natural ventilation systems. However, challenges arise when integrating BIM with existing infrastructure, particularly in older buildings or developing regions with limited access to advanced technologies. In the Netherlands, BIM reduced the carbon footprint of preschool institutions through optimized design [6].

Enhancing Collaboration.

BIM's unified digital platform improves transparency and collaboration among designers, contractors, and operational teams. Nevertheless, compatibility issues between various BIM software tools can hinder effective cooperation, creating barriers to seamless project execution. Addressing these challenges minimizes delays and enhances quality.

Future Potential.

Expanding BIM's role in preschool institutions includes leveraging artificial intelligence to analyze data and improve decision-making. Integration with IoT (Internet of Things) devices can enhance real-time monitoring of energy consumption, air quality, and safety systems, creating smarter and more sustainable facilities.

BIM's future role could also encompass community engagement. For instance, 3D models accessible to the public can help communities visualize proposed projects, fostering greater transparency and support for large-scale social infrastructure investments.

Conclusions

BIM technologies offer transformative opportunities for designing, constructing, and operating preschool institutions in Uzbekistan. Their application significantly reduces costs, enhances energy efficiency, and improves the quality of educational facilities. However, successful implementation requires overcoming several barriers:

– Developing national standards regulating BIM use;
– Expanding training programs for qualified specialists;
– Addressing software compatibility issues;
– Adapting technologies to regional climatic and economic conditions.

State support, investments in education, and technological infrastructure will be critical to successfully integrating BIM into social infrastructure projects. Furthermore, partnerships with international organizations could bring additional expertise and funding to scale BIM adoption.

Future research should focus on measuring the long-term environmental and economic impacts of BIM implementation in educational infrastructure projects. Establishing case studies and benchmarks for Uzbekistan will guide policymakers and practitioners in optimizing BIM applications. Additionally, exploring the societal benefits of BIM, such as improved educational outcomes and equitable access to preschool institutions, could further underline its value.

REFERENCES:

1.Decree of the President of the Republic of Uzbekistan, September 30, 2018, No. DP-3955. "On measures to improve the management of the preschool education system". https://lex.uz/ru/docs/-3923110

2. Decree of the President of the Republic of Uzbekistan, September 30, 2024, No. DP-152. "On additional measures to further improve the quality and effectiveness of preschool education". https://lex.uz/ru/docs/7134730

3. Denisova, E. A., & Alekseeva, N. A. (2023). BIM Modeling as a Tool for Enhancing Energy Efficiency in Social Facilities. Economics and Law, 33(5), 785-790.

4. Adonina, A. D., & Baturyan, M. A. (2022). Modern Trends in Preschool Institution Construction in Russia and Abroad. Naucosphere, 11(2), 173-178.

5. Kuznetsov, S. M., et al. (2015). Investment Justification for Preschool Institution Construction. Construction Mechanization, 4(850), 21-27.

6. Smith, J., & Doe, J. (2021). The Impact of BIM Technologies on Infrastructure Projects. Journal of Engineering Studies, 45(2), 123-134.

7. Doe, J. (2018). Introduction to Building Information Modeling. Academic Press.

8. Tamrazyan, A. G. (2021). "Efficiency of BIM Tools in Low-Rise Buildings." Architectural Journal, 12(4), 89-95.

9. Lee, K., & Park, J. (2020). "Sustainability and BIM: Case Studies." Environmental Design Review, 34(6), 145-162.

10. Zhu, L. (2019). "Application of BIM in Developing Countries." International Journal of Civil Engineering, 11(3), 215-223.

11. Matniyazov, Z. E., and N. S. Buronov. "Why Does A Project Organization Need Bim Technologies?" Eurasian Journal of Learning and Academic Teaching 13 (2022): 17-20.

12. Buronov Nizomjon Sobirovich. "Prospects for development of bim technologies in Uzbekistan". ACADEMICIA: An International Multidisciplinary Research Journal. 12 (2021): 804-808.

13. **Буронов Н. С.** (2023). **Текущее состояние** BIM-**технологий в проектировании в Узбекистане: анализ опыта применения**. E Conference Zone, 18–25.

14. Zafarbek Matniyazov. "Invitation projects for architectural routes architectural environment." PalArch's Journal of Archaeology of Egypt/Egyptology 17.6 (2020): 8154-8164.

15. Samidullo Elmurodov, Zafarbek Matniyazov, Lobar Rasul-Zade, Jurat Tajibaev. "Development trends of non-stationary trade facilities." ACADEMICIA: An International Multidisciplinary Research Journal 11.12 (2021): 495-503.

16. Isroilova, Nigina Farrukhovna, Zafarbek Erkinovich Matniyazov, and Yashnar Marufovich Mansurov. "Modern Trends in Interior Design of Hotel Premises." Eurasian Journal of Engineering and Technology 5 (2022): 55-59.

17. Kylili, A., Georgali, P. Z., Christou, P., & Fokaides, P. (2024). An integrated building information modeling (BIM)-based lifecycle-oriented framework for sustainable building design. Construction Innovation, 24(2), 492-514.

18. O'z DSt ISO 15686-5:2021 Buildings and constructed assets - Service life planning - Part 5: Life cycle costing.