DOI: 10.32347/2412-9933.2025.62.38-46
UDC 69:004.8

Tsai Mykola
Postgraduate student at the Department of Project Management,
https://orcid.org/0009-0004-3836-3867
Kyiv National University of Construction and Architecture, Kyiv

Zdrilko Mykola
Postgraduate student at the Department of Project Management,
https://orcid.org/0009-0008-7138-4132
Kyiv National University of Construction and Architecture, Kyiv

INTEGRATED AI-POWERED AND BIM-ANALYTICS MANAGEMENT MODEL EDUCATIONAL PROJECTS FOR SUSTAINABLE DEVELOPMENT

Abstract. *Modern educational infrastructure development faces unprecedented challenges, demanding innovative project management approaches capable of simultaneously ensuring construction efficiency, pedagogical effectiveness, and sustainability goals. Traditional project management methods have proven inadequate for managing the complex stakeholder ecosystems characteristic of educational institutions. Although Building Information Modeling (BIM) and Artificial Intelligence (AI) technologies have demonstrated significant potential in construction management, their integration remains largely unexplored for educational projects. This research develops an integrated AI-driven management model that combines predictive analytics with intelligent Building Information Modeling, specifically tailored for sustainable educational development projects, addressing critical gaps in current approaches through comprehensive platform optimization. The proposed model utilizes a four-layer architecture encompassing a data acquisition infrastructure, an AI analytics engine, intelligent recommendation generation, and proactive control systems. The core innovation lies in an AI-BIM fusion model that creates intelligent building models, which evolve throughout project lifecycles via multi-modal neural networks combining Convolutional Neural Networks (CNNs) for spatial data, temporal analysis networks, and transformer architectures for natural language understanding. Educational space optimization algorithms incorporate evidence-based pedagogical principles to predict the impact of design decisions on learning outcomes, while simultaneously balancing acoustic performance, lighting quality, and sustainability metrics. The system processes multiple information streams, including BIM geometry, educational requirements via Natural Language Processing (NLP), real-time sustainability metrics, and stakeholder communications. Proactive control employs machine learning algorithms, trained on educational project outcomes, to identify early warning indicators and provide predictive intervention strategies through graduated levels of automation. The integrated AI-driven management model represents a paradigm shift in the project management of educational facilities, establishing new frameworks that treat educational outcomes as primary design drivers. Its theoretical contributions extend beyond traditional construction project management, providing validated approaches for holistic intelligence tailored to complex building typologies. The model demonstrates an effective integration of spatial, temporal, and semantic information streams while preserving human-centric decision-making processes, potentially transforming how society designs, delivers, and sustains the built environment.*

Keywords: artificial intelligence; building information modeling; educational environment; proactive project management; machine learning; predictive analytics; BIM integration; sustainable development; smart buildings

Introduction

The contemporary landscape of educational infrastructure development presents unprecedented challenges that traditional project management approaches struggle to address effectively. Educational facilities represent substantial long-term investments that must simultaneously meet immediate construction constraints while adapting to rapidly evolving pedagogical methodologies, technological integration requirements, and sustainability mandates. Unlike conventional commercial or residential projects, educational buildings serve as dynamic environments where spatial design directly influences learning outcomes, making their successful delivery far more complex than standard construction endeavors.

The convergence of artificial intelligence and Building Information Modeling technologies offers a transformative opportunity to address these multifaceted challenges through intelligent, data-driven project management. While BIM has revolutionized construction visualization and coordination, and AI has demonstrated remarkable capabilities in pattern recognition and predictive analytics, their integration remains largely unexplored, particularly in the context of educational facility development. This research presents an integrated AI-powered management model that combines advanced machine learning algorithms with intelligent Building Information Modeling to create a comprehensive platform specifically designed for sustainable educational development projects.

Problem Overview

Educational facility development projects represent one of the most complex challenges in contemporary construction management, requiring the integration of diverse stakeholder requirements, long-term sustainability objectives, and evolving pedagogical needs. The traditional approaches to managing such projects have proven inadequate in addressing the multifaceted nature of educational infrastructure development, creating significant gaps between project delivery outcomes and educational effectiveness. This section examines the fundamental limitations of current project management approaches and identifies key areas where technological innovation can provide transformative solutions.

Current Challenges in Educational Project Management

Educational construction projects face a unique constellation of challenges that distinguish them from conventional building developments, primarily stemming from the need to balance immediate construction constraints with long-term educational objectives that may evolve throughout the facility’s operational lifetime. Traditional project management approaches often fail to account for the dynamic nature of educational environments, where changes in curriculum, teaching methodologies, and technology integration can significantly impact spatial requirements, while the stakeholder management challenge proves particularly acute as school administrators focus on educational outcomes and operational efficiency, construction teams prioritize schedule adherence and cost control, and this multiplicity of perspectives often leads to communication breakdowns, requirement conflicts, and design decisions that satisfy immediate needs but compromise long-term functionality.

Limitations of Traditional BIM Implementation

While Building Information Modeling has transformed construction project visualization and coordination, its application to educational facilities reveals significant limitations. Current BIM implementations excel at managing geometric and material data but struggle to incorporate the behavioral and functional aspects that determine educational effectiveness, as traditional BIM models can accurately represent what a classroom looks like but cannot predict how different spatial configurations will impact student engagement or learning outcomes. Moreover, the temporal dimension of educational facility requirements presents additional challenges, since educational spaces must accommodate not only current programmatic needs but also anticipate future changes in curriculum, technology integration, and teaching methodologies, while traditional BIM models represent static snapshots of design intent rather than dynamic systems that can adapt to evolving requirements.

Artificial Intelligence Potential and Current Gaps

Artificial intelligence technologies have demonstrated remarkable potential for addressing complex project management challenges through predictive analytics, pattern recognition, and automated decision-making. However, current AI applications in construction remain largely disconnected from the spatial and temporal data that BIM systems manage, representing a significant missed opportunity for comprehensive project intelligence.

The educational construction sector has been particularly slow to adopt AI technologies, despite the potential for machine learning to address the sector’s unique challenges. Furthermore, existing AI applications in construction focus primarily on operational efficiency and cost optimization, with limited consideration for the pedagogical objectives that define educational project success.

Analysis of Recent Research and Publications

The rapid advancement of digital technologies in construction management has generated substantial research interest in the integration of artificial intelligence and Building Information Modeling systems. However, the literature reveals significant fragmentation in approaches and limited focus on educational facility development as a distinct domain requiring specialized solutions. This comprehensive review examines current research trends, identifies technological capabilities, and highlights critical gaps that justify the development of integrated AI-BIM management models specifically designed for educational projects.

BIM Technology Evolution in Construction Management

The evolution of Building Information Modeling technology has progressed significantly beyond its origins as a three-dimensional visualization tool. Recent research by Mohd N. D. Saupi, and N. A. Ismail, has demonstrated the implementation of 5D BIM in construction management, revealing both substantial benefits and persistent challenges faced by construction professionals [1]. Their work highlights how the integration of cost and schedule data with geometric models enables more sophisticated project analysis.

Honcharenko, T. has specifically addressed the application of BIM technology for creating information models of development territories, demonstrating the potential for comprehensive spatial data integration in construction projects [2]. This research provides foundational understanding of how BIM can extend beyond individual building models to encompass broader development contexts.

S. Dolhopolov, T. Honcharenko, and colleagues have pioneered approaches to construction site modeling that combine AI technologies with BIM platforms, creating “multi-stage analysis” systems for building object models [3]. Their research demonstrates how machine learning algorithms can enhance BIM data interpretation, particularly in object classification and construction progress monitoring.

D. Chernyshev, S. Dolhopolov, and their research team have developed digital object detection systems that combine BIM technology with artificial intelligence for construction site analysis [4]. Their approach represents a significant advancement in real-time construction monitoring, though it remains limited to geometric object recognition rather than comprehensive project intelligence.

The multi-stage approach to construction site modeling has been further refined by S. Dolhopolov, T. Honcharenko, and colleagues, who have developed comprehensive frameworks for construction site modeling objects using artificial intelligence and BIM technology [5]. Their research demonstrates advanced methodologies for processing complex construction environments through systematic AI-driven analysis stages.

Building upon this foundation, the same research team has extended their work to develop multi-stage classification systems for construction site modeling objects, achieving enhanced accuracy in object recognition and categorization through AI algorithms based on BIM technology [6]. This advancement represents significant progress in automated construction site analysis and real-time project monitoring capabilities.

Artificial Intelligence Applications in Construction

J. Zhang and S. Jiang have conducted extensive analysis of AI applications in construction management, identifying key trends in predictive analytics, automation, and decision support systems [7]. Their research reveals that while AI adoption has accelerated significantly, implementation remains fragmented across different project phases and organizational functions.

K. Alimi, R. Jin, and colleagues have explored artificial intelligence applications in construction and demolition waste management, revealing sophisticated approaches to waste prediction, sorting, and recycling optimization [8]. M. R. Altaie and M. M. Dishar have investigated how artificial intelligence applications can enhance knowledge management processes in construction project management [9].

M. Francis, S. Perera, and their research team have conducted systematic literature reviews of artificial intelligence applications for proactive dispute management in the construction industry [10]. Their findings indicate that AI can significantly reduce project conflicts through early warning systems and automated risk assessment.

The methodological approaches to AI project management have been further developed by Berezutskyi, I., Honcharenko, T., and colleagues, who have proposed systematic frameworks for choosing appropriate types of IT project management in complex technological environments [11]. Their work provides valuable insights into the selection criteria and implementation strategies for AI-powered management systems.

The integration of robotics, AI, and BIM technologies has opened new frontiers in facility management and renovation processes. J. Chen, W. Lu, and colleagues have proposed innovative frameworks for defect digital twinning that combine these technologies to create comprehensive maintenance and renovation management systems [12]. Their technical framework demonstrates how AI-powered defect detection can be integrated with BIM models to support lifecycle facility management, providing valuable insights for educational facility maintenance strategies.

Educational Facility Design and Management Research

J. V. Santos, L. Ramos and M. Mallari have assessed facility management performance in educational institutions, providing a foundation for digitalizing reporting systems that could support AI-driven optimization [13]. M. Ensafi, S. Alimoradi and colleagues have examined machine learning and artificial intelligence applications in building construction, identifying current status and future trends [14].

P. D. Desai, S. Sandbhor and A. K. Kaushik have developed AI and BIM-based approaches to construction defect optimization, demonstrating how intelligent systems can prevent quality issues that could compromise educational effectiveness [15].

Risk assessment methodologies have particularly benefited from AI integration, with G. Ryzhakova, T. Honcharenko and their research team developing sophisticated approaches using fuzzy logic for risk assessment in construction enterprise management systems [16]. This research demonstrates how uncertain and qualitative risk factors can be effectively quantified and managed through intelligent algorithms.

Sustainability Integration in Construction Projects

The integration of sustainability practices with BIM and construction project management has been extensively studied, revealing both opportunities and persistent barriers. T. O. Olawumi, D. W. Chan and colleagues have conducted Delphi surveys of international experts to identify barriers to BIM and sustainability integration in construction projects [17]. Their research reveals that while technical capabilities exist for sophisticated sustainability analysis, organizational and cultural barriers often prevent effective implementation, particularly in educational projects where multiple stakeholder groups must coordinate sustainability efforts.

Comprehensive morphological analysis of sustainability integration in construction project management has been conducted by A. Goel, L. S. Ganesh and A. Kaur, who analyzed over two decades of research literature to identify patterns and trends [18]. Their work reveals that successful sustainability integration requires systematic approaches that consider environmental, social, and economic dimensions simultaneously, though few studies have specifically addressed educational facility requirements.

The emergence of Industry 4.0 technologies has created new opportunities for sustainability improvement in construction projects. Abbasnejad, B., Soltani, S., and colleagues have conducted systematic literature reviews on Industry 4.0 technology integration for sustainability improvement in transportation construction projects, identifying state-of-the-art practices and future directions [19]. While their focus on transportation projects differs from educational facilities, their analysis of digital technology integration provides valuable insights for sustainable construction management.

The advancement toward Industry 5.0 represents the next evolution in digital construction management. W. Xian, K. Yu and their research team have surveyed key enabling technologies and future trends in advanced manufacturing for Industry 5.0, identifying how human-machine collaboration can enhance sustainability outcomes [20]. Their work suggests that the integration of AI, BIM, and human expertise could create unprecedented opportunities for sustainable educational facility development.

Identified Research Gaps

The comprehensive analysis of recent literature reveals several critical gaps that significantly limit the potential for truly integrated educational facility project management. While substantial progress has been made in individual technology domains, the convergence of artificial intelligence and Building Information Modeling specifically for educational projects remains largely unexplored, creating substantial opportunities for innovative research contributions. The most significant gap exists in the development of integrated systems that can simultaneously optimize construction efficiency, educational effectiveness, and sustainability performance, as current research approaches treat these objectives as separate domains rather than recognizing opportunities for synergistic solutions. Additionally, existing AI algorithms rarely incorporate pedagogical principles or evidence-based educational design criteria, preventing the development of intelligent systems that can predict how spatial design decisions impact learning effectiveness over facility operational lifetimes. Furthermore, current project management tools provide limited capability for translating complex technical data into appropriate formats for diverse stakeholder groups with vastly different expertise levels, while traditional BIM systems excel at representing current design conditions but lack capability for modeling how educational spaces must adapt to evolving pedagogical methodologies and technological integration requirements over decades of operation. Table provides a comparative analysis of traditional project management approaches versus the proposed AI-BIM integrated model for educational facility development.

Table - ***Comparative Analysis of Traditional vs. AI-BIM Integrated Project Management Approaches***

Aspect	Traditional Approach	AI-BIM Integrated Model
Data Integration	Fragmented, manual collection	Automated, multi-source integration
Decision Making	Reactive, experience-based	Predictive, data-driven analytics
Stakeholder Communication	Static reports, technical language	Dynamic, role-specific dashboards
Design Optimization	Sequential, single-objective	Simultaneous, multi-criteria optimization
Quality Control	Periodic inspections	Real-time automated monitoring
Risk Management	Historical precedent-based	AI-powered predictive modeling

End of Table

Aspect	Traditional Approach	AI-BIM Integrated Model
Educational Consideration	Secondary constraint	Primary design driver
Adaptability	Limited post-construction	Dynamic response capability
Learning Capability	Project-specific knowledge	Cross-project knowledge accumulation

Presentation of the Main Material

The proposed integrated AI-powered management model represents a paradigm shift in educational facility project management, combining advanced artificial intelligence capabilities with sophisticated Building Information Modeling technologies to create a comprehensive platform for sustainable development. This section presents the detailed architecture, technical components, and implementation strategies that enable the model to address the complex challenges identified in educational project management while providing practical solutions for real-world application.

Conceptual Framework and System Architecture

The proposed integrated AI-powered management model employs a four-layer architecture designed to transform how educational development projects are conceived, planned, and executed, as illustrated in Fig. 1. Integrated AI-Powered Management Model for Sustainable Educational Development Projects. This architectural approach recognizes that educational facilities require fundamentally different management strategies compared to conventional construction projects, due to their complex stakeholder ecosystems, long operational lifetimes, and direct impact on learning outcomes.

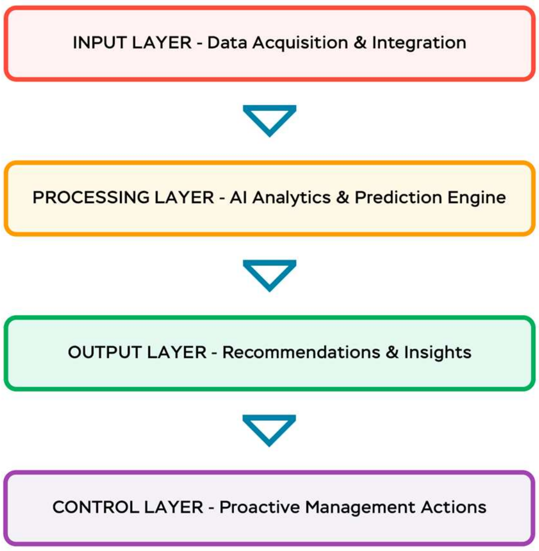

Figure 1 - Integrated AI-Powered Management Model for Sustainable Educational Development Projects

The integration philosophy underlying this architecture differs fundamentally from existing approaches that treat AI and BIM as separate tools. Rather than simply applying AI algorithms to BIM data, the model creates bidirectional information flows where AI insights continuously refine BIM models, while updated BIM data improves AI prediction accuracy. This creates a learning system that becomes more effective throughout each project's lifecycle and accumulates knowledge across multiple projects to improve future performance.

Data Acquisition and Integration Infrastructure

The foundation layer, designated as the Data Acquisition and Integration Infrastructure and detailed in Fig 2. INPUT LAYER – Data Acquisition & Integration, serves as the comprehensive data collection and standardization engine for the entire system. This layer addresses a critical challenge in educational project management by integrating heterogeneous data sources that traditionally operate in isolation.

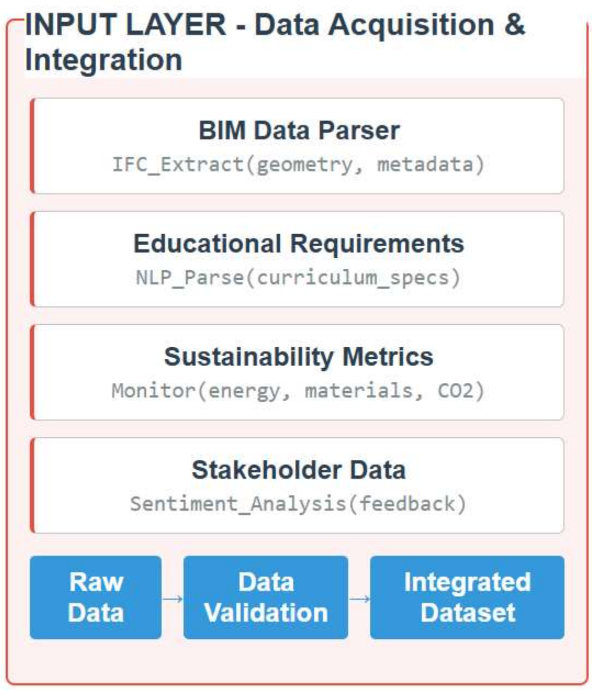

Figure 2 - INPUT LAYER – Data Acquisition & Integration

The system processes multiple data streams with sophisticated algorithms, including geometric and parametric information from BIM models such as spatial dimensions and material specifications, educational requirements derived through natural language processing of curriculum specifications that translate pedagogical goals into spatial requirements, real-time sustainability metrics from environmental monitoring systems tracking energy consumption and resource utilization, and stakeholder communications analyzed through sentiment analysis and priority ranking algorithms to understand concerns and preferences across diverse project participants.

The layer integrates diverse data types including BIM geometry, educational requirements, sustainability metrics, and stakeholder feedback through data fusion algorithms that handle both quantitative metrics such as schedules and budgets alongside qualitative factors such as educational philosophy. Advanced data validation and normalization algorithms ensure consistency and quality across all input streams by employing machine learning techniques to identify inconsistencies and gaps in real-time. The standardization engine converts disparate data formats into unified structures compatible with subsequent processing layers, enabling reliable analysis and decision-making throughout the project lifecycle while maintaining traceability for regulatory compliance and stakeholder transparency.

AI Analytics and Predictive Intelligence Engine

The second layer, the AI Analytics and Predictive Intelligence Engine shown in Fig. 3.

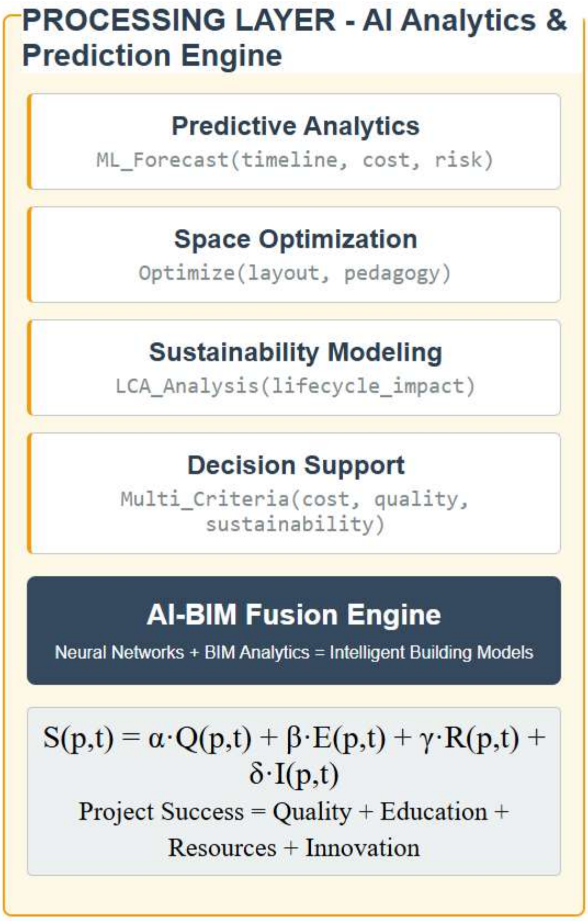

Figure 3 - PROCESSING LAYER – AI Analytics & Prediction Engine

PROCESSING LAYER – AI Analytics & Prediction Engine, represents the cognitive core of the integrated system, transforming standardized data into actionable insights through sophisticated machine learning algorithms. This layer employs ensemble learning methods that combine multiple predictive models for enhanced accuracy in timeline and budget forecasting, risk assessment, and outcome prediction.

The AI-BIM Fusion Engine represents the most significant technical innovation, creating "intelligent building models" that evolve throughout the project lifecycle rather than remaining static representations of design intent. This fusion engine employs a multi-modal neural network architecture that combines convolutional neural networks for spatial data processing, long short-term memory networks for temporal sequence analysis, and transformer architectures for natural language understanding. The mathematical framework governing this integration enables the system to process geometric, temporal, and semantic information streams simultaneously, creating comprehensive project intelligence that considers all relevant factors in educational facility development.

Intelligent Recommendations and Insights Generation

The third layer, the Intelligent Recommendations and Insights Generation system presented in Fig. 4. OUTPUT LAYER – Recommendations & Insights, addresses the critical challenge of translating complex AI-derived insights into formats that are appropriate and actionable for diverse stakeholder groups. This layer recognizes that effective project management requires not only accurate analysis but also effective communication that enables informed decision-making across all project participants.

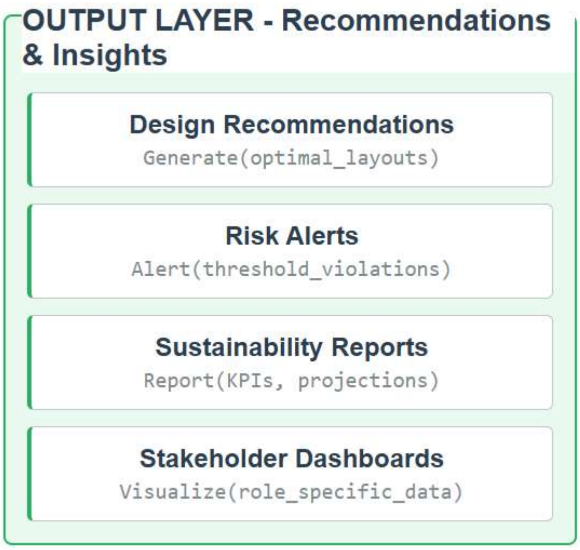

Figure 4 - OUTPUT LAYER – Recommendations & Insights

The natural language generation subsystem creates customized reports, summaries, and recommendations that maintain technical accuracy while adapting vocabulary, detail level, and presentation format to match the expertise and responsibilities of specific stakeholder roles. For construction professionals, outputs emphasize technical specifications, schedule implications, and resource requirements. For educational administrators, the same underlying analysis is presented in terms of learning outcome impacts, operational efficiency, and alignment with educational objectives.

The real-time dashboard generation capabilities provide dynamic, interactive interfaces that enable stakeholders to explore project data and predictions according to their specific interests and decision-making needs. These dashboards automatically update as new data becomes available and project conditions change, ensuring that all stakeholders maintain current understanding of project status and emerging opportunities or challenges.

Proactive Control and Automated Management Actions

The fourth layer, the Proactive Control and Automated Management Actions system depicted in Fig. 5. CONTROL LAYER – Proactive Management Actions, transforms the system from a passive analytical tool into an active management participant that can implement decisions and coordinate responses to changing project conditions. This layer operates through carefully designed automation levels that balance efficiency with appropriate human oversight and accountability.

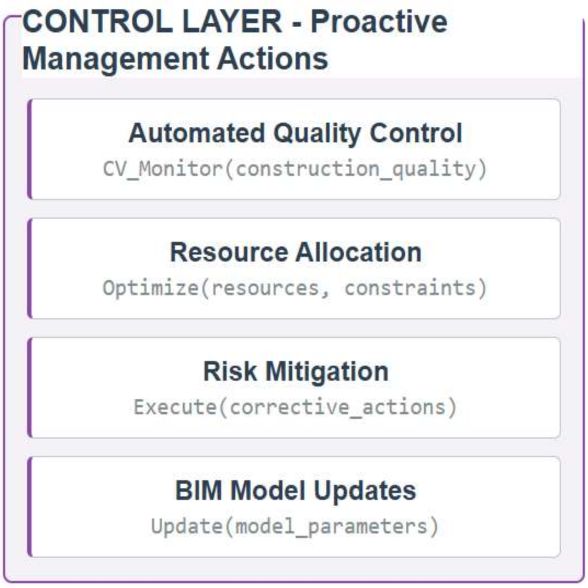

Figure 5 – CONTROL LAYER – Proactive Management Actions

The proactive control system represents a fundamental shift from traditional reactive project management toward predictive intervention strategies that prevent problems rather than merely responding to them efficiently. This system employs machine learning algorithms trained on educational project outcomes to identify early warning indicators of potential issues, from schedule delays and cost overruns to quality problems and stakeholder conflicts.

The stakeholder communication interface addresses one of the most challenging aspects of educational project management by providing intelligent translation between the technical language of construction professionals and the educational terminology familiar to school administrators, teachers, and community members. This system employs natural language processing to generate role-specific project updates that maintain technical accuracy while using appropriate vocabulary and context for each audience.

Conclusions

This research presents a comprehensive AI-powered management model that addresses fundamental limitations in current approaches to educational facility development by creating deep integration between artificial intelligence and Building Information Modeling technologies. The theoretical contributions of this work extend beyond traditional construction management to establish new frameworks for project intelligence that consider educational outcomes as primary design drivers rather than secondary constraints. The model's multi-modal neural network architecture demonstrates how diverse information streams can be synthesized to create holistic project understanding that encompasses spatial, temporal, and semantic dimensions simultaneously.

The practical implications of this integrated approach enable improvements in project delivery efficiency, sustainability performance, and educational effectiveness that current approaches cannot achieve. The model provides project teams with enhanced capability to manage complex educational projects successfully while optimizing multiple objectives simultaneously rather than treating them as competing constraints.

The current limitations of this model primarily concern the need for substantial historical data to train machine learning algorithms effectively and the requirement for organizational change management to implement comprehensive AI-BIM integration successfully. Future research should focus on developing transfer learning approaches that can adapt the model to different educational contexts with limited training data, creating more sophisticated algorithms for predicting long-term educational impact, and establishing standardized metrics for measuring educational facility effectiveness.

The broader impact of this work extends beyond educational construction to demonstrate how artificial intelligence and Building Information Modeling can be integrated to address complex, multi-stakeholder project challenges in various domains. As the construction industry undergoes digital transformation, this research provides a framework for developing intelligent project management systems that can balance competing objectives while maintaining human-centered decision-making processes.

The success of this approach in educational facility development suggests significant potential for application to other building types that serve complex human activities, potentially transforming how society designs and delivers built environments that support human flourishing.

References

1. Mohd Saupi, N. D., & Ismail, N. A. (2025). Implementation of 5D building information modelling (BIM) in construction management: Benefits and challenges faced by construction professionals. *Built Environment Journal*.

2. Honcharenko, T. (2018). The use of BIM-technology to create an information model territories for development. *Management of Development of Complex Systems*, 33, 131–138.

3. Dolhopolov, S., Honcharenko, T., Terentyev, O., Predun, K., & Rosynskyi, A. (2023). Information system of multi-stage analysis of the building of object models on a construction site. *IOP Conference Series: Earth and Environmental Science*, *1254*.

4. Chernyshev, D., Dolhopolov, S., Honcharenko, T., Sapaiev, V., & Delembovskyi, M. (2022). Digital object detection of construction site based on building information modeling and artificial intelligence systems. *International Workshop on Information Technologies: Theoretical and Applied Problems*.

5. Dolhopolov, S., Honcharenko, T., Savenko, V., Balina, O., Bezklubenko, I., & Liashchenko, T. (2023). Construction site modeling objects using artificial intelligence and BIM technology: A multi-stage approach. *2023 IEEE International Conference on Smart Information Systems and Technologies (SIST)*, 174–179.

6. Dolhopolov, S., Honcharenko, T., Terentyev, O., Savenko, V., Rosynskyi, A., Bodnar, N., & Alzidi, E. (2024). Multi-stage classification of construction site modeling objects using artificial intelligence based on BIM technology. *2024 35th Conference of Open Innovations Association (FRUCT)*, 179–185.

7. Zhang, J., & Jiang, S. (2024). Review of artificial intelligence applications in construction management over the last five years. *Engineering, Construction and Architectural Management*.

8. Alimi, K., Jin, R., Nguyen, B.N., Nguyen, Q., Chen, W., & Hosking, L. (2025). Exploring artificial intelligence applications in construction and demolition waste management: A review of existing literature. *Journal of Science and Transport Technology*.

9. Altaie, M. R., & Dishar, M. M. (2024). Integration of artificial intelligence applications and knowledge management processes for construction projects management. *Civil Engineering Journal*.

10. Francis, M., Perera, S., Zhou, W., & Nanayakkara, S. (2025). Artificial intelligence applications for proactive dispute management in the construction industry: A systematic literature review. *Journal of Information Technology in Construction*.

11. Berezutskyi, I., Honcharenko, T., Ryzhakova, G., Tykhonova, O., Pokolenko, V., & Sachenko, I. (2024). Methodological approach for choosing type of IT projects management. In *2024 IEEE 4th International Conference on Smart Information Systems and Technologies*, 14–19. https://doi.org/10.1109/SIST61555.2024.10629587

12. Chen, J., Lu, W., Ghansah, F.A., & Peng, Z. (2022). Defect digital twinning: A technical framework to integrate robotics, AI and BIM for facility management and renovation. *IOP Conference Series: Earth and Environmental Science*, 1101.

13. Santos, J. V., Ramos, L., & Mallari, M. (2024). Assessment of facility management performance: A basis for digitalizing reporting systems in educational institutions. *Journal of Interdisciplinary Perspectives*.

14. Ensafi, M., Alimoradi, S., Gao, X., & Thabet, W. Y. (2022). Machine learning and artificial intelligence applications in building construction: Present status and future trends. *Construction Research Congress 2022*.

15. Desai, P. D., Sandbhor, S., & Kaushik, A. K. (2023). AI and BIM-based construction defects, rework, and waste optimization. *2023 International Conference on Emerging Smart Computing and Informatics (ESCI)*, 1–6.

16. Ryzhakova, G., Honcharenko, T., Predun, K., Petrukha, N., Malykhina, O., & Khomenko, O. (2023). Using of fuzzy logic for risk assessment of construction enterprise management system. In *2023 IEEE International Conference on Smart Information Systems and Technologies (SIST)*, 208–213. https://doi.org/10.1109/SIST58284.2023.10223560

17. Olawumi, T. O., Chan, D. W., Wong, J. S., & Chan, A. P. (2018). Barriers to the integration of BIM and sustainability practices in construction projects: A Delphi survey of international experts. *Journal of Building Engineering*.

18. Goel, A., Ganesh, L.S., & Kaur, A. (2019). Sustainability integration in the management of construction projects: A morphological analysis of over two decades' research literature. *Journal of Cleaner Production*.

19. Abbasnejad, B., Soltani, S., Karamoozian, A., & Gu, N. (2024). A systematic literature review on the integration of industry 4.0 technologies in sustainability improvement of transportation construction projects: State-of-the-art and future directions. *Smart and Sustainable Built Environment*.

20. Xian, W., Yu, K., Han, F., Fang, L. S., He, D. L., & Han, Q. (2024). Advanced manufacturing in Industry 5.0: A survey of key enabling technologies and future trends. *IEEE Transactions on Industrial Informatics*, 20 (1), 1055–1068.

21. Chernyshev D., Dolhopolov S., Honcharenko T., Haman H., Ivanova T., Zinchenko M. (2022). Integration of Building Information Modeling and Artificial Intelligence Systems to Create a Digital Twin of the Construction Site, *2022 IEEE 17th International Conference on Computer Sciences and Information Technologies (CSIT)*, pp. 36–39. DOI: 10.1109/CSIT56902.2022.10000717.

The article has been sent to the editorial board 08.06.2025

Цай Микола Ігорович
Аспірант кафедри управління проєктами,
https://orcid.org/0009-0004-3836-3867
Київський національний університет будівництва і архітектури, Київ
Здрілько Микола Вікторович
Аспірант кафедри управління проєктами,
https://orcid.org/0009-0008-7138-4132
Київський національний університет будівництва і архітектури, Київ

ІНТЕГРОВАНА МОДЕЛЬ УПРАВЛІННЯ ОСВІТНІМИ ПРОЄКТАМИ ДЛЯ СТАЛОГО РОЗВИТКУ НА ОСНОВІ ШТУЧНОГО ІНТЕЛЕКТУ ТА BIM-АНАЛІТИКИ

Анотація. *Об'єктом дослідження є процес формування висновку будівельно-технічної експертизи системою підтримки процесу відновлення об'єктів нерухомості. Предметом дослідження є моделі і методи штучного інтелекту, що здатні розв'язувати задачу формування експертного висновку щодо категорії технічного стану будівельних конструкцій і об'єктів в цілому. Метою роботи є обґрунтування вибору моделі для розв'язання задачі оцінювання технічного стану об'єктів будівельно-технічної експертизи на основі дослідження моделей і методів штучного інтелекту, що здатні розв'язувати задачу нечіткої класифікації. Для оцінки технічного стану будівельних конструкцій і об'єктів в цілому запропоновано застосовувати дерева рішень з градієнтним прискоренням. Цей метод виправляє помилки попередніх ітерацій і враховує величину різних типів помилок. Показано, що механізм ітеративного навчання дає змогу експертам будівельно-технічної експертизи уточнювати чи доповнювати дані, на основі яких роблять висновки. Коригування висновків ансамблів дерева рішень з градієнтним прискоренням експерти можуть робити відповідно до нормативної бази. Формалізовано вхідні і вихідні дані моделі з урахуванням такого антропогенного фактора, як вплив зброї. Визначено п'ять основних конструктивних елементів, для кожного з яких доцільно навчати ансамблі дерев. Показано функцію втрат, що допомагає приділяти особливу увагу граничним станам будівель і споруд, коли ризик помилки може призвести до повної непридатності або порушення функціонування конструкцій або їхніх елементів. На основі аналізу низки досліджень як предмет подальших досліджень обґрунтовано вибір мультиагентної теорії для забезпечення масштабування і гнучкості системи підтримки процесу відновлення об'єктів нерухомості.*

Ключові слова: штучний інтелект; інформаційне моделювання будівель; освітнє середовище; проактивне управління проєктами; машинне навчання; прогнозна аналітика; BIM-інтеграція; сталий розвиток; розумні будівлі

Link to publication

APA Tsai, M., & Zdrilko, M. (2025). Integrated AI-powered and BIM-analytics management model educational projects for sustainable development. *Management of Development of Complex Systems*, 62, 38–46, dx.doi.org\10.32347/2412-9933.2025.62.38-46.

ДСТУ Цай М. І., Здрілько М. В. Інтегрована модель управління освітніми проєктами для сталого розвитку на основі штучного інтелекту та BIM-аналітики. *Управління розвитком складних систем.* Київ, 2025. № 62. С. 38 – 46, dx.doi.org\10.32347/2412-9933.2025.62.38-46.