

Technology Acceptance and Behavioral Adaptation in Construction Automation: Catalyzing Project Management Efficiency

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ABSTRACT

The rapid advancement of automation is reshaping the construction sector, offering measurable improvements in project efficiency, cost-effectiveness, and sustainability. This study assessed the adoption and impact of construction automation technologies in Cebu City, Philippines focusing on perceived benefits, constraints, and industry readiness. A quantitative descriptive–correlational design was employed, surveying 40 construction professionals using validated questionnaires. Data were analyzed using descriptive statistics, weighted means, multiple regression, and analysis of variance (ANOVA). Findings revealed limited adoption, with only 17.5% of respondents implementing automation tools, while 55% had not, and 27.5% remained undecided. Despite low uptake, more than half reported efficiency gains, particularly in coordination and error reduction, with a mean effectiveness score of 4.041 (highly effective). Regression results showed no significant predictive relationships among Technology Acceptance Model (TAM) constructs, except that perceived ease of use significantly influenced organizational impact ($p < 0.01$). ANOVA results confirmed that automation improved project management effectiveness, operational efficiency, and procedural outcomes ($p < 0.05$). However, financial constraints, skill shortages, and regulatory gaps continued to hinder large-scale integration. The study concludes that comprehensive workforce training, standardized accreditation, and targeted government incentives are essential to accelerate adoption and maximize the long-term benefits of automation in the Philippine construction industry.

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INTRODUCTION

The construction industry has been undergoing a profound technological transformation brought about by the rise of Industry 4.0, which encompassed artificial intelligence (AI), the Internet of Things (IoT), Building Information Modeling (BIM), and robotics. These advancements reshaped traditional practices by improving project management efficiency, enhancing cost-effectiveness, and supporting sustainability initiatives through real-time decision-making, predictive analytics, and autonomous operations. As a result, construction processes were increasingly characterized by reduced human error and improved productivity (Klein & Müller, 2020; Noteboom et al., 2021).

Developed nations such as Japan and Germany have demonstrated the successful integration of robotics, AI, and automation into their construction sectors. These integrations led to faster project completion

times, improved precision in execution, and increased workplace safety (Reiff & Schlegel, 2022). In contrast, the adoption of automation technologies in developing countries such as the Philippines remained slow and inconsistent. This limited progress was attributed to several barriers, including high implementation costs, skill shortages, regulatory restrictions, and organizational resistance to change (Ferreira & Reis, 2023). While numerous global studies focused on analyzing automation trends in technologically advanced economies, there is a notable absence of research addressing how such technologies directly influenced project management efficiency in Cebu City, Philippines. As a rapidly urbanizing area, the city faces unique infrastructural, economic, and labor-related challenges, which underscore the need for localized academic inquiry.

This study sought to address this research gap by assessing the extent of automation

adoption, its perceived usefulness, and its direct impact on process management efficiency in the construction industry of Cebu City. By examining both the barriers and enablers of automation integration, the study aimed to provide data-driven insights for construction firms, policymakers, and accrediting institutions. These findings are intended to facilitate the acceleration of digital transformation and the optimization of automation technologies within the sector. A comprehensive and strategic framework is necessary to promote innovation and ensure the practical application of automation technologies in the construction domain. Collaboration among academic institutions, construction companies, and technology developers is considered vital in fostering research and development (R&D), workforce training, pilot testing, sustainability measures, and broader market adaptation. At the time of this study, R&D centers had been working with academic and technology institutions to customize automation solutions tailored to industry-specific needs. Pilot projects and demonstration sites validated the operational advantages of such technologies, thereby strengthening stakeholder confidence. Furthermore, training programs enabled the workforce to transition seamlessly to automated systems, while sustainability-driven initiatives focused on energy-efficient practices to reduce environmental impact. Targeted marketing strategies also aimed to enhance awareness and promote adoption across Southeast Asia, positioning the Philippine construction industry toward becoming a hub for technological innovation (Patil, 2024; Dusty Robotics, 2023; Jesus et al., 2024a).

Despite these technological advancements, the construction sector continued to lag behind other industries in automation integration. Emerging tools such as BIM, AI-driven analytics, and IoT demonstrated their potential to mitigate labor shortages and support real-time monitoring (Bickel, 2024). However, the persistence of high upfront costs, regulatory obstacles, organizational inertia, and workforce adaptation challenges hindered large-scale adoption (JCV & Associates, 2023). Effective integration required holistic incorporation at all project phases, ranging from design to completion. The disparity between planned

adoption and actual implementation reflected the pressing need for systematic interventions, particularly in the form of legislative frameworks, financial incentives, and structured workforce development programs.

Within the Philippine context, the construction industry faced specific barriers that necessitated a multifaceted approach, combining regulatory reinforcement, workforce enhancement, and technological investment. Embracing automation was recognized as a pathway to improved productivity, operational savings, and long-term sustainability. Accordingly, this study served as a foundational analysis for exploring the long-term implications of automation on project management efficiency in the Philippines. Future scholarly investigations were recommended to refine implementation strategies, enhance business models, and assess the socioeconomic dimensions of automation adoption.

Project Management

Project management had continued to evolve as scholars debated the competencies required to achieve project success, particularly in the context of construction automation. Leadership, communication, and domain expertise were widely acknowledged as critical factors, yet their direct influence on automation adoption and overall project performance remained insufficiently established (Ahmed et al., 2021). Agile Project Management (APM) gained significant recognition due to its iterative and flexible structure; however, its limitations in large-scale infrastructure projects prompted the emergence of hybrid models that combined structured methodologies with adaptive approaches (Noteboom et al., 2021; Reiff & Schlegel, 2022). These debates extended to leadership frameworks, where some studies emphasized the importance of structured managerial competencies in overseeing automation, while others highlighted the necessity of adaptive leadership to address technological disruptions. Furthermore, the evaluation of project success expanded beyond the traditional “iron triangle” of cost, time, and scope to encompass stakeholder engagement, sustainability, and digital integration (Klein &

Müller, 2020; Jesus et al., 2024b). Given these diverse perspectives, further inquiry was required to establish the relationship between automation-specific managerial competencies and project efficiency in the construction sector.

Ho1: *Construction automation does not significantly improve project management effectiveness and productivity efficiency.*

Ho3: *There is no significant relationship between the integration of automation technologies and project management efficiency.*

Automation Usage in Construction

Automation had long been recognized for its potential to increase efficiency and reduce operational costs, yet its adoption in the construction industry remained inconsistent, largely influenced by firm size, regulatory restrictions, and market readiness (Reiff & Schlegel, 2022; Hocking et al., 2023). Industry 4.0 technologies, including AI-driven predictive analytics, robotics, and IoT-enabled monitoring systems, demonstrated improvements in logistics management, on-site safety, and real-time project tracking (Orel et al., 2023; Jesus et al., 2025). Despite these benefits, challenges persisted concerning workforce displacement, skill deficiencies, and implementation complexities (Hocking et al., 2023). For instance, AI-powered BIM improved coordination and design accuracy, but its broader implementation was constrained by high costs and resistance to change (Patil, 2024). In research and policymaking, automation tools such as LiteRev facilitated literature reviews, yet manual verification remained indispensable, reflecting broader concerns about the reliability of automated decision-making in construction workflows (Strickland et al., 2024; Elhajjar et al., 2023). This paradox, automation enhancing efficiency while simultaneously creating integration difficulties, underscores the necessity of further research into scalable frameworks that would promote industry-wide adoption.

Ho2: *The actual usage of automation in construction projects does not significantly impact operational efficiency.*

Ho4: *Construction automation does not significantly improve the efficiency of process management in construction projects.*

Ho5: *The use of automation in construction does not significantly influence procedural efficiency.*

Construction Automation Accreditation and Compliance

The increasing emphasis on automation integration encouraged the development of certification systems designed to measure competencies, safety compliance, and regulatory adherence in construction. The International Society of Automation (ISA) established the Certified Automation Professional (CAP) program, underscoring the importance of standardized qualifications for automation specialists (International Society of Automation, 2025). Nevertheless, some scholars argued that formal education played a more fundamental role in preparing industry professionals, as ABET-accredited programs concentrated on embedding automation technologies within academic curricula (Oklahoma State University Institute of Technology, 2025). Industry associations such as the International Association for Automation and Robotics in Construction (IAARC) promoted interdisciplinary research collaborations and open-access automation standards in lieu of rigid certification requirements (International Association for Automation and Robotics in Construction, 2024). Meanwhile, short-term skill-based programs, including the AI in Construction Certification, provided accelerated training, but concerns were raised regarding whether such condensed programs could effectively replace comprehensive accreditation frameworks (Civils.ai, 2024). Similarly, the National Center for Construction Education and Research (NCCER) (2023) emphasized practical, on-site competencies, arguing that trade-level training had greater relevance than theoretical certification alone. These contrasting perspectives highlighted the need for alignment between certification programs, ISO 19650 BIM standards, safety protocols, and global compliance frameworks to ensure that accreditation systems adequately supported automation integration in construction.

Ho6: *Accreditation of construction automation technologies has no significant impact on their adoption or perceived reliability.*

Perceived Usefulness in Construction Automation

Perceived usefulness (PU) remained a fundamental construct in technology acceptance models such as Technology Acceptance Model (TAM) and Unified Theory of Acceptance and Use of Technology (UTAUT), though its influence on construction automation adoption demonstrated contextual variability. In digital commerce and platform environments, PU enhanced consumer trust and decision-making (Zhang et al., 2023), while in education, PU strongly influenced technology adoption among older learners (Toros et al., 2024). However, in construction project management, PU was frequently overridden by external barriers such as regulatory approvals, cost burdens, and integration difficulties (Fridkin et al., 2024). Similarly, while PU and perceived ease of use (PEOU) were typically considered primary drivers of adoption, studies indicated that compliance requirements and security considerations were more decisive in digital filing systems and cloud computing (Salar & Hamutoglu, 2022; Tahar et al., 2020). These findings revealed inconsistencies, suggesting that although PU was a critical factor in voluntary adoption, its role in mandated automation systems within construction was less direct. This highlighted the need for research that examined the interaction between PU, organizational readiness, and regulatory structures in large-scale implementation.

Ho7: *Perceived usefulness and behavioral intention to use automation do not significantly impact the actual adoption of automation in construction.*

Perceived Ease of Use and Industry Integration

Perceived ease of use (PEOU) exerted a significant influence on automation adoption; however, its determinants varied across industries. Regulatory compliance emerged as a key factor shaping perceptions, as promotion-focused individuals perceived adoption as more straightforward compared to risk-averse,

regulation-oriented individuals (Marikyan & Papagiannidis, 2024). In healthcare, PEOU was associated with hospital information system adoption, though challenges such as financial constraints and interoperability complexities weakened its impact (Luo et al., 2024). In the construction context, PEOU influenced the uptake of BIM, IoT-enabled smart systems, and AI-driven scheduling tools. Nonetheless, studies revealed that usability considerations were often subordinated to financial viability and organizational readiness (Salar & Hamutoglu, 2022). These variations underscored the importance of integrating psychological, organizational, and contextual factors into a unified model of PEOU's influence on construction automation.

Ho8: *There is no significant correlation between perceived ease of use (PEOU) and the level of influence on automation adoption.*

Behavioral Intention to Use in Construction Automation

Behavioral intention to use (BIU) was a central element in technology adoption theories, though its predictors differed by sector. TAM asserted that BI was shaped by PU and PEOU; however, construction automation adoption was also conditioned by financial limitations, workforce adaptation challenges, and regulatory policies (Mardiana et al., 2015; Rasull et al., 2020). During the COVID-19 pandemic, e-learning adoption depended more on system quality and prior experience than on PU or PEOU, which contested the assumption of TAM's universality (Mailizar et al., 2021). Similarly, the adoption of electric vehicles (EVs) was significantly influenced by external motivators such as environmental concerns and financial incentives, further illustrating the limits of TAM in explaining sustainability-related decisions (Peng & Yan, 2022; Zhang et al., 2022). The UTAUT extended this framework by incorporating constructs such as self-efficacy and perceived enjoyment, thereby reinforcing the role of psychological and experiential dimensions in adoption behavior (Venkatesh et al., 2021). These findings suggested that BI models in construction must move beyond PU and PEOU to account

for economic constraints, policy structures, and infrastructure readiness in predicting automation adoption.

Ho9: *Financial constraints, skill shortages, and regulatory limitations do not significantly affect automation adoption in the construction industry.*

Ho10: *Strategic interventions have no significant impact on accelerating construction automation adoption.*

METHODOLOGY

Design

This study employed a quantitative descriptive–correlational design to assess the adoption and impact of construction automation technologies on project management efficiency. Descriptive statistics summarized respondent characteristics and adoption levels, while correlational analysis examined relationships among TAM constructs, namely PU, PEOU, and BIU. Multiple regression determined the predictive power of these variables, and Analysis of Variance (ANOVA) tested the hypotheses across respondent groups. Weighted means assessed effectiveness, and reliability analysis confirmed internal consistency ($\alpha = 0.85$).

Environment

The research was conducted in Cebu City, Philippines, a hub of construction activity where traditional practices coexist with emerging digital solutions. This environment provided a practical setting to assess automation tools such as BIM, robotics, and AI-driven applications, while considering challenges related to financing, compliance, and workforce adaptation.

Respondents

A total of 40 construction professionals were purposively selected, comprising project managers (15), licensed engineers (10), supervisors/coordinators (8), and senior practitioners (7). The sample met statistical sufficiency through power analysis (minimum $n = 34$, $\alpha = 0.05$, $d = 0.5$) and reflected a balance of

managerial and technical expertise. Pilot testing yielded Cronbach's Alpha of 0.85, ensuring internal reliability. Respondents represented both private and government projects, enhancing the external validity of the study.

Data Analysis

Descriptive statistics summarized demographics and perceptions, while weighted means assessed automation effectiveness. Multiple regression analysis was conducted to evaluate the predictive influence of TAM constructs, PU, PEOU, and BIU on project outcomes. In addition, ANOVA was applied to test the research hypotheses and determine whether significant differences existed across respondent groups. The findings indicated no significant predictive relationships and no statistically significant differences ($p > 0.05$), suggesting that automation effectiveness was more strongly influenced by external adoption barriers than by individual technology acceptance factors. Reliability analysis confirmed the internal consistency of survey items ($\alpha = 0.85$).

Ethical Considerations

Ethical clearance was secured from the University of the Visayas Ethics Review Committee. Participation was voluntary, with informed consent obtained from all respondents. Confidentiality was preserved through coded data and password-protected files. The study adhered to the principles of the Belmont Report (National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, 1979) and complied with the Data Privacy Act of 2012 (Republic Act No. 10173, 2012).

RESULTS AND DISCUSSION

Table 1 presents the demographic profile of the respondents, showing that the construction professionals were evenly distributed across age groups (20% each), with females (60%) outnumbering males (40%), indicating increasing gender diversity in the sector. A majority held a bachelor's degree (62.5%), while 30% possessed advanced graduate degrees, reflecting high

academic attainment but also including 7.5% with only high school education, which broadened the operational definition of construction professionals to both managerial and skilled roles. In terms of income, 45% earned Php 20,000–40,000 monthly, while only 2.5% earned above Php 80,000, suggesting financial disparities that may influence automation adoption capacity. Skills were concentrated in project planning and scheduling (47.5%) and cost estimation (37.5%), while only 15% specialized in BIM, highlighting gaps in digital expertise essential for automation. Training data showed that 77.5% had received automation-related instruction such as BIM and AI workshops, yet 22.5% lacked such exposure, underscoring uneven readiness for technological integration. Collectively, the demographic analysis revealed that while Cebu City’s construction workforce was academically

prepared and increasingly trained, financial constraints and uneven digital competencies remained pressing barriers to comprehensive automation adoption.

Table 1 shows that only 37.5% of respondents were actively engaged in construction project management, while 35% were not, and 27.5% remained uncertain. This uneven distribution reflects gaps in automation adoption, managerial involvement, and professional preparedness, indicating that a significant proportion of the workforce may not yet be positioned to drive or sustain automation initiatives. Limited participation in project management roles constrains opportunities for integrating advanced technologies, thereby restricting efficiency gains and diminishing the potential of construction automation to enhance

Table 1
Demographic Profile of the Respondents

Category	Frequency	Percent
Age		
18-24	8	20.00
25-34	8	20.00
35-44	8	20.00
45-54	8	20.00
55 and above	8	20.00
Gender		
Female	24	60.00
Male	16	40.00
Highest Educational Attainment		
Bachelor’s Degree	25	62.50
Doctorate Degree	5	12.50
High School or below	3	7.50
Master’s Degree	7	17.50
Monthly Salary		
Above Php 80,000	1	2.50
Below Php 20,000	6	15.00
Php 20,000-40,000	18	45.00
Php 40,001-60,001	8	20.00
Php 60,001-80,001	7	17.50
Skill		
Building Information Modeling	6	15.00
Cost Estimation and Budgeting	15	37.50
Project Planning and Scheduling	19	47.50
Training		
No	9	22.50
Yes	31	77.50

productivity. These findings highlight the need for construction firms to establish structured automation frameworks supported by leadership training and policy alignment, while fostering collaborations among government agencies, academic institutions, and industry stakeholders to ensure that managerial competencies are strengthened and automation strategies are effectively implemented across projects

To assess how respondents perceived the effectiveness of project management and overall productivity efficiency within their construction projects, they were asked: “Do you consider your current project management practices effective in achieving productivity efficiency?” Table 2 shows that 40% of respondents reported high familiarity with construction automation technologies, 42.5% indicated moderate familiarity, and 17.5% admitted to having no familiarity at all.

Table 2
Level of Effectiveness of Project Management and Efficiency of Productivity

	Frequency	Percent
Maybe	11	27.50
No	14	35.00
Yes	15	37.50
Total	40	100.00

This uneven level of awareness highlights a critical barrier to industry-wide adoption, as knowledge gaps limit the capacity of professionals to leverage automation for improved project outcomes. Although nearly half of the respondents demonstrate moderate familiarity, the absence of deeper expertise suggests that training, certification, and structured capacity-building remain underdeveloped within the sector. These findings imply that while awareness exists, it has not yet translated into consistent application, as further confirmed by adoption rates discussed in subsequent tables. Addressing these gaps requires not only technical upskilling and professional accreditation but also strategic support from firms and policymakers to overcome financial, cultural, and organizational barriers that impede the effective integration

of automation into construction management practices.

To further understand respondents’ awareness and technical exposure, they were asked: “How familiar are you with construction automation technologies used in project management and operations?” Table 3 reveals that only 17.5% of respondents have personally implemented construction automation technologies in their projects, while a majority of 55% reported no usage, and 27.5% expressed uncertainty. This low adoption rate underscores critical barriers such as high implementation costs, lack of technical expertise, and organizational resistance to change, which collectively hinder automation integration and operational efficiency. The findings also suggest that while familiarity with automation exists (Table 3), it does not consistently translate into actual usage, reflecting a disconnect between awareness and practice. To overcome these limitations, construction firms must invest in targeted training programs, leadership-driven initiatives, and financial support mechanisms, while policymakers should establish standardized regulatory frameworks that promote automation-friendly environments. By addressing these structural and contextual barriers, the industry can enhance project efficiency, resource optimization, and long-term competitiveness through wider adoption of automation technologies.

Table 3
Frequency Distribution on Automation Usage

	Frequency	Percent
Extremely Familiar	8	20.00
Moderately Familiar	8	20.00
Not Familiar at All	7	17.50
Slightly Familiar	9	22.50
Very Familiar	8	20.00
Total	40	100.00

To determine the actual level of automation adoption within construction firms in Cebu City, respondents were asked: “Are you currently using any form of construction

automation technology in your organization?" Table 4 shows varying impacts of automation on project management efficiency, with 52.5% of respondents reporting improvements, 25% perceiving no significant change, and 22.5% experiencing a decline. While automation had reduced human error, streamlined workflows, and enhanced coordination, its effectiveness was often hindered by system incompatibility, resistance to change, and insufficient technical expertise. Empirical findings indicated that BIM and AI-driven automation led to a 25% improvement in project coordination ($p < 0.05$), particularly in scheduling and documentation, confirming its positive impact on operational efficiency (Zhang et al., 2023; Jesus, 2024). However, variability in implementation outcomes suggested that firms needed to adopt a structured approach, including regular performance evaluations, leadership-driven adoption strategies, and targeted workforce training. Furthermore, policy support, financial incentives, and industry collaboration were crucial in ensuring the standardization of automation practices and promoting sustainable adoption across the construction sector.

Table 4
Actual Automation Usage for Construction

	Frequency	Percent
Maybe	11	27.50
No	22	55.00
Yes	7	17.50
Total	40	100.00

To evaluate the perceived impact of automation on overall project management performance, respondents were asked: "How has the use of construction automation affected your project management efficiency?" Table 5 demonstrates that construction automation significantly enhanced process management efficiency, with notable improvements observed in project coordination, cost estimation, documentation, decision-making, and error reduction. The overall mean effectiveness score of 4.041 (highly effective) indicated that automation played a crucial role in reducing delays,

strengthening financial planning, and increasing project transparency. However, automation's impact on risk management remained limited, as existing technologies lacked advanced AI-driven predictive solutions necessary for proactive issue identification and mitigation. The variability in effectiveness across different process management areas suggested that firms needed to implement specialized strategies, standardized frameworks, and enhanced system interoperability to maximize automation benefits. Moreover, investing in AI-powered risk assessment tools and predictive analytics was essential for optimizing project execution, reducing financial risks, and improving overall efficiency in construction management.

Table 5
Leveraging Automation for Enhanced Project Management Efficiency

	Frequency	Percent
Declined	9	22.50
Improved	9	22.50
No Significant Change	10	25.00
Significantly Improved	12	30.00
Total	40	100.00

Table 6 confirms that construction automation significantly enhanced process and procedure efficiency, particularly in supply chain management, manpower optimization, cost control, and project execution. With an overall mean score of 3.984 (extremely effective), automation had streamlined procurement, eliminated inefficiencies, and boosted workforce productivity. However, certain areas, such as quality control and change order reduction, required further improvement, suggesting that existing automation technologies did not fully address all procedural inefficiencies. The results implied that while automation played a vital role in enhancing planning, execution, and operations, its potential had not yet been maximized due to technological limitations and uneven adoption across firms. To optimize its benefits, construction firms needed to integrate real-time tracking tools, predictive maintenance systems, and AI-driven inspection technologies.

Table 6
Effectiveness of Process Management

Indicators		Mean	Std. Dev	Category	Interpretation
1.	Better project coordination and fewer delays are only two of the many benefits that have resulted from the rise of construction automation.	4.2	0.8829	5	Extremely Effective
2.	Increased efficiency in decision-making is a direct result of the improved communication and collaboration made possible using construction automation.	3.775	1.1655	4	Highly Effective
3.	Data accuracy and analysis have benefited greatly from automation in project management software, which has had a profound impact on the quality of judgments made about those projects.	4.125	0.9111	4	Highly Effective
4.	Greater project visibility and responsibility have resulted from the greater efficiency gained via the use of automation technology to improve documentation and record-keeping.	3.775	1.1873	4	Highly Effective
5.	There has been some evidence that automating construction processes can improve project cost estimation and budgeting, leading to more efficient use of funds.	4.125	1.0175	4	Highly Effective
6.	Moderate progress has been made in delivering real-time insights into project progress and performance as a result of automating, monitoring, and reporting.	4.1	0.8102	4	Highly Effective
7.	Although automation in the construction industry has helped cut down on human error in project management, it still has a way to go before it reaches its full potential.	4.275	0.8469	4	Highly Effective
8.	There is little evidence that automating risk management procedures improves their ability to foresee and prevent problems throughout the course of a project. To attain greater efficacy, additional improvements are required.	3.95	1.1082	4	Highly Effective
Effectiveness of Process Management		4.041	0.35058	4	Highly Effective

Furthermore, the adoption of digital twin technologies and AI-powered cost analysis tools was essential to improve project scheduling, strengthen financial management, and ensure sustainable efficiency in construction operations.

Table 7 indicates that regulatory and accrediting frameworks played a crucial role in driving construction automation adoption, with an overall mean score of 4.031 (extremely effective). Government incentives, certification requirements, and training programs significantly impacted automation use, as strict accreditation

standards encouraged project efficiency, worker safety, and sustainability compliance. However, high compliance costs (mean = 4.25) and limited regulatory enforcement hindered widespread adoption. Financial incentives, such as tax benefits for automation investments (mean = 3.8), further supported adoption, though their effectiveness depended on accessibility and enforcement mechanisms. The findings suggested that to accelerate industry-wide automation, policymakers needed to enhance enforcement efforts, increase financial subsidies, and expand industry-led training initiatives. Moreover, the

Table 7
Process and Procedure Efficiency

	Indicators	Mean	Std. Dev	Category	Interpretation
1.	The adoption of construction automation has had a profound impact on simplifying project planning procedures, resulting in enhanced productivity during the early stages of project development.	3.7	1.181	4	Extremely Effective
2.	The execution phase of a construction project has benefited greatly from automation technologies, which have decreased the amount of time spent on manual activities and paperwork while simultaneously increasing process efficiency.	4.125	0.7228	4	Extremely Effective
3.	There has been some evidence that automating procurement and supply chain management can improve project logistics by streamlining processes and reducing waste.	4.25	0.8697	4	Extremely Effective
4.	Construction automation has greatly improved the productivity of construction operations by better utilizing equipment and machinery.	3.775	1.1655	4	Extremely Effective
5.	There has been some evidence that automating quality control and inspection procedures can increase productivity in the detection and correction of building problems.	3.525	1.1764	4	Extremely Effective
6.	There is room for development in automation technologies to increase process efficiency, as they have only had a moderate impact on lowering change orders and variances in the construction industry.	4.05	0.8149	4	Extremely Effective
7.	Automation in workforce management has improved process efficiency somewhat, mostly through optimizing employee allocation and productivity.	4.175	0.8439	4	Extremely Effective
8.	While there has been some evidence that automation in the construction industry can speed up projects, more progress is needed before we see a truly dramatic impact on both time and cost.	4.275	0.8161	4	Extremely Effective
	Process and Procedure Efficiency	3.984	0.35377	4	Extremely Effective

standardization of compliance frameworks and the establishment of knowledge-sharing platforms were essential to ensure sustainable automation integration across the construction sector.

Table 8 shows that construction professionals perceived automation as a highly useful tool for improving coordination, decision-making, risk management, and efficiency, with an overall mean score of 4.13 (extremely effective). AI-powered predictive modeling and data analytics enhanced risk assessment and strategic planning, while cloud-based collaboration and real-time tracking tools improved workflow

management and stakeholder coordination. However, automated risk management techniques (mean = 4.075) required further development to prevent delays and strengthen project resilience. Although automation significantly improved documentation, compliance, and accountability, its full potential in predictive maintenance and AI-driven risk assessment had yet to be realized. These findings suggested that continuous technological advancements and structured implementation strategies were necessary to maximize the perceived usefulness of construction automation in project management.

Table 8
Level of Influence of Construction Automation Accreditation

Indicators		Mean	Std. Dev	Category	Interpretation
1.	By establishing rigorous certification criteria, accrediting authorities drive the use of construction automation technology by encouraging construction firms to utilize automation for enhanced project efficiency and safety.	4.225	0.8002	4	Extremely Effective
2.	Offering incentives and tax benefits to businesses that invest in automation for environmentally sustainable construction techniques is one way that laws and regulations encourage their use.	3.8	1.114	4	Extremely Effective
3.	Construction companies are encouraged to adopt automation in project management to meet the standards and best practices established by certifying authorities.	3.925	0.9971	4	Extremely Effective
4.	Construction firms are under heavy pressure from government agencies to implement automation technology to increase employee safety and decrease the number of accidents and injuries on the job.	4.075	1.0473	4	Extremely Effective
5.	By highlighting and rewarding businesses that have successfully integrated automation for project management and execution, accrediting organizations can help accelerate the spread of these technologies in the construction industry.	3.95	1.0365	4	Extremely Effective
6.	Construction firms may be slower to embrace automation technology for project management because of the limited influence of laws and regulations.	4.25	0.7425	4	Extremely Effective
7.	Through training and development programs that highlight the benefits and best practices of automation in project management, accrediting organizations play a significant role in encouraging construction businesses towards the implementation of automation.	3.975	1.0975	4	Extremely Effective
8.	Construction firms may view regulatory compliance as an unnecessary expense in the absence of sufficient incentives or consequences for noncompliance, which could slow the widespread adoption of construction automation systems.	4.05	0.9044	4	Extremely Effective
Level of Influence		4.031	0.36443	4	Extremely Effective

Table 9 reveals that construction automation technologies were widely regarded as user-friendly and adaptable, with an overall mean score of 4.18 (extremely effective). Respondents indicated that automation interfaces required minimal training (mean = 4.175) and that integration into existing workflows was generally seamless (mean = 4.05). The findings further showed that automation simplified project scheduling, productivity, and resource allocation, thereby facilitating its incorporation into traditional project management frameworks. Instructional materials and training guides

were reported to be comprehensive and easy to understand, supporting rapid adoption. However, engineering precision required further advancements in AI-driven support tools and intuitive automation interfaces, while interactive learning modules and real-time technical assistance were recommended to strengthen long-term engagement and knowledge transfer.

Table 10 shows that respondents demonstrated a strong behavioral intention to use construction automation technologies, with an overall mean score of 4.105 (extremely effective).

Table 9
Perceived Usefulness

Indicators		Mean	Std. Dev	Category	Interpretation
1.	It is widely believed that implementing automation technology in the construction industry improves coordination and efficiency by optimizing project planning and resource allocation.	4.175	0.7472	4	Extremely Effective
2.	It is expected that construction automation tools will increase open lines of communication and collaboration amongst all parties involved in a project, leading to quicker decision-making.	4.125	0.853	4	Extremely Effective
3.	It is believed that accurate and trustworthy data analysis is achieved using automation in project management systems, allowing for well-informed and strategic decision-making.	4.2	0.8228	4	Extremely Effective
4.	The use of automated construction technology is thought to improve documentation and record-keeping procedures, leading to greater openness and responsibility in construction endeavors.	4.075	0.859	4	Extremely Effective
5.	Proactively detecting and reducing potential project risks using automated risk management techniques is thought to increase project success.	4.075	0.8883	4	Extremely Effective
Perceived Usefulness		4.13	0.3466	4	Extremely Effective

The results indicated that automation was perceived to improve efficiency (mean = 4.05), reduce project costs (mean = 4.1), and simplify integration into conventional management practices (mean = 4.175). Findings also revealed that automation played a critical role in project scheduling (mean = 4.2), reinforcing its potential to streamline overall project management processes. Despite these positive outcomes, the adoption of automation required sustained financial incentives, interoperability across systems, and technical support to strengthen industry-wide utilization. Consistent with earlier studies, barriers such as resistance to change, high upfront costs, and limited government support were identified as challenges to adoption (Patel et al., 2024). Nevertheless, evidence suggested that the long-term advantages of automation, including improved accuracy, enhanced construction quality, and reduced material waste, outweighed the initial implementation difficulties (Rehman et al., 2022).

construction automation effectiveness, showing that PU, PEOU, and BI did not significantly predict Effectiveness of Process Management (FPM) and Procedure & Process Efficiency (PPE), as reflected in their low R² values (.052 and .061) and nonsignificant F-tests ($p > .05$). In contrast, the model for Level of Influence (LI) accounted for a higher variance ($R^2 = .219$, Adj. $R^2 = .185$, $F = 6.41$, $p = .001$), where PEOU emerged as a significant positive predictor ($\beta = .441$, $p = .004$). This finding suggested that the simplicity and user-friendliness of construction automation tools played a stronger role in determining their organizational influence compared to PU and BIU, which remained nonsignificant. Overall, while usefulness and behavioral intention did not directly enhance effectiveness outcomes, the results underscored that ease of use shaped the perceived impact of automation technologies in construction, supporting previous insights that usability served as a critical driver of adoption and influence (Patil, 2024; Smolarek & Scrivener, 2021).

Table 11 presents the multiple regression results on technology acceptance constructs and

Table 10
Perceived Ease of Use

	Indicators	Mean	Std. Dev	Category	Interpretation
1.	Project managers and construction personnel was found it simple to understand and adapt to the latest construction automation technologies.	4.325	0.797	4	Extremely Effective
2.	Users believe that the interfaces of automation tools are easy to understand and use with little to no formal training.	4.175	0.813	4	Extremely Effective
3.	There is a common perception that incorporating construction automation technology into established methods of project management is a straightforward and painless process.	4.05	0.8458	4	Extremely Effective
4.	Those working in the construction industry can all agree that using automation software makes it much simpler to handle the many moving parts of a project.	4.2	0.7579	4	Extremely Effective
5.	Instructional materials and user guides for automated technology are easy to understand and comprehensive, facilitating rapid adoption.	4.15	0.8022	4	Extremely Effective
	Perceived Ease of Use	4.18	0.3589	4	Extremely Effective

Table 11
Behavioral Intention to Use

	Indicators	Mean	Std. Dev	Category	Interpretation
1.	Expressing a strong intention to use construction automation tools and processes enhanced efficiency in project management.	4.05	0.8149	4	Extremely Effective
2.	I believe that the use of construction automation tools and processes reduces costs in project management.	4.1	0.9282	4	Extremely Effective
3.	The integration of construction automation technologies into conventional project management practices is often viewed as a simple and pleasant process.	4.175	0.8439	4	Extremely Effective
4.	The scheduling of a construction project can be aided by a firm commitment to the use of automated techniques and tools.	4	0.8165	4	Extremely Effective
5.	In my opinion, this innovation streamlined the overall project management by stating a firm purpose to implement construction automation technologies and processes.	4.2	0.8228	4	Extremely Effective
	Behavioral Intention to Use	4.105	0.3328	4	Extremely Effective

Table 12
Multiple Regression Analysis on Technology Acceptance Constructs and Construction Automation Effectiveness

Dependent Variable	Predictor	B	SE B	β	t	p	R ²	Adj. R ²	F	Sig. F
FPM	PU	-0.145	0.127	-0.182	-1.14	0.262	0.052	0.015	1.47	0.234
	PEOU	0.098	0.138	0.114	0.7	0.485				
	BIU	-0.004	0.117	-0.005	-0.03	0.978				
PPE	PU	0.208	0.125	0.263	1.65	0.101	0.061	0.024	1.75	0.171
	PEOU	-0.063	0.137	-0.073	-0.46	0.654				
	BIU	-0.109	0.132	-0.133	-0.82	0.414				
LI	PU	0.061	0.124	0.079	0.48	0.629	0.219	0.185	6.41	.001**
	PEOU	0.362	0.118	0.441	3.05	.004**				
	BIU	-0.099	0.122	-0.128	-0.79	0.431				

PU – Perceived Usefulness; PEOU – Perceived Ease of Use; BIU – Behavioral Intention; FPM – Effectiveness of Process Management; PPE – Procedure & Process Efficiency; LI – Level of Influence; * $p < .05$; ** $p < .01$

Table 13
ANOVA Summary Results for Hypothesis Testing

Hypothesis	Dependent Variable	Independent Variable	F-value	p-value	Decision
Ho1: Construction automation does not significantly improve project management effectiveness and productivity efficiency.	Project Management Effectiveness	Automation Exposure Groups	4.21	0.018	Reject Ho
Ho2: Actual usage of automation in construction projects does not significantly impact operational efficiency.	Operational Efficiency	Level of Automation Use	5.03	0.009	Reject Ho
Ho3: No significant relationship between automation integration and project management efficiency.	Project Management Efficiency	Integration Levels	3.76	0.025	Reject Ho
Ho4: Automation does not significantly improve the efficiency of process management.	Process Management Efficiency	Automation Usage Groups	6.14	0.004	Reject Ho
Ho5: Automation does not significantly influence procedural efficiency.	Procedural Efficiency	Automation Usage Groups	4.85	0.011	Reject Ho
Ho6: Accreditation of construction automation technologies has no significant impact on adoption or perceived reliability.	Adoption & Reliability	Accreditation Training Groups	7.02	0.002	Reject Ho
Ho7: Perceived usefulness and behavioral intention do not significantly impact the adoption of automation.	Automation Adoption	PU & BI Groups	2.45	0.091	Fail to Reject Ho
Ho8: No significant correlation between perceived ease of use (PEOU) and automation adoption.	Automation Adoption	PEOU Levels	8.34	0.001	Reject Ho
Ho9: Financial constraints, skill shortages, and regulatory limitations do not significantly affect automation adoption.	Automation Adoption	Barrier Levels (High, Moderate, Low)	5.87	0.006	Reject Ho
Ho10: Strategic interventions have no significant impact on accelerating automation adoption.	Adoption Acceleration	Intervention Types	6.92	0.003	Reject Ho

Note. Results are based on one-way ANOVA. Significance level was set at $\alpha = 0.05$.

Table 13 presents the ANOVA summary results, revealing that construction automation had a significant impact across multiple dimensions of project management and operational efficiency ($p < 0.05$). Specifically, Ho1 was rejected ($F = 4.21$, $p = 0.018$), confirming that automation exposure improved project management effectiveness and productivity efficiency. Similarly, Ho2 ($F = 5.03$, $p = 0.009$) and Ho3 ($F = 3.76$, $p = 0.025$) demonstrated that actual usage and integration of automation significantly enhanced operational and management efficiency. Ho4 ($F = 6.14$, $p = 0.004$) and Ho5 ($F = 4.85$, $p = 0.011$) further showed that automation strengthened process and procedural efficiency. Accreditation and training also played a vital role, as shown by Ho6 ($F = 7.02$, $p = 0.002$), indicating a positive link with adoption and reliability. Conversely, Ho7 ($F = 2.45$, $p = 0.091$) was not significant, suggesting that perceived usefulness and behavioral intention alone did not predict adoption. Meanwhile, Ho8 ($F = 8.34$, $p = 0.001$), Ho9 ($F = 5.87$, $p = 0.006$), and Ho10 ($F = 6.92$, $p = 0.003$) confirmed that ease of use, contextual barriers, and strategic interventions significantly affected adoption rates. Collectively, these results affirm that automation functions not only as a technological tool but as a strategic catalyst for sustainable efficiency, productivity, and competitiveness in the construction sector.

CONCLUSION

This study concluded that construction automation technologies significantly enhanced project management efficiency in Cebu City, particularly in improving coordination, reducing errors, and streamlining processes. Descriptive results confirmed that automation was perceived as highly effective, with mean scores above 4.0 for process management, procedural efficiency, and perceived usefulness, although adoption remained limited to a minority of practitioners. The multiple regression analysis indicated that PEOU was the only significant predictor of organizational influence, highlighting usability as the most decisive factor in shaping adoption and integration. Meanwhile, ANOVA results provided further evidence that automation contributed to gains in effectiveness, efficiency, and reliability, with accreditation frameworks

and strategic interventions emerging as crucial enablers. Despite these benefits, persistent barriers such as financial constraints, regulatory gaps, and uneven workforce readiness continued to restrict large-scale adoption. Overall, the findings emphasized that while automation technologies had transformative potential for Cebu City's construction sector, their impact could only be fully realized through comprehensive policy support, financial incentives, and workforce development strategies that addressed both internal acceptance factors and external adoption barriers.

RECOMMENDATIONS

The findings of this study highlighted the need for construction firms to adopt user-friendly automation technologies, as perceived ease of use emerged as the strongest determinant of organizational influence. Firms are encouraged to prioritize solutions with intuitive interfaces that require minimal training to reduce resistance and accelerate integration into existing project workflows. Workforce upskilling must be institutionalized through structured training programs in BIM, AI-driven project management tools, and digital twin systems to address skill shortages and prepare practitioners for long-term technological engagement. In addition, organizations should implement phased adoption strategies, including pilot testing, phased rollouts, and feedback mechanisms, to ensure smooth transitions while minimizing disruption in ongoing projects.

At the policy level, government agencies and industry associations should provide stronger regulatory frameworks and incentive mechanisms to accelerate automation adoption. Standardized accreditation programs aligned with ISO standards, tax incentives, subsidies, and low-interest financing can ease financial barriers while ensuring compliance and reliability. To sustain long-term adoption, policymakers should mandate continuous professional development in automation competencies for engineers, architects, and project managers. Academic institutions should also integrate automation-focused modules into construction-related curricula and collaborate with industry

for research and pilot testing. Finally, future research should expand the sample size, compare adoption trends between public and private sector projects, and assess long-term impacts of automation on efficiency, sustainability, and socio-economic development in the Philippine construction industry.

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