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LEAN PROJECT MANAGEMENT FROM THE PERSPECTIVE OF ENTERPRISE ARCHITECTURE

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ABSTRACT

Modern Architecture, Engineering, and Construction (AEC) projects require integrated approaches for efficiency and sustainability. Lean Construction (LC) optimizes processes and minimizes waste, but cultural resistance and limited stakeholder engagement hinder its adoption. Enterprise Architecture (EA) aligns strategies with technological and operational processes, enhancing decision-making and resource use. This study examines the combined impact of LC and EA on project outcomes, utilizing practices, developing strategies, and validating findings through a focus group at a large engineering firm. Results indicate that integrating these frameworks improves project coordination, reduces inefficiencies, and fosters continuous improvement, despite challenges like resistance to change and training gaps. The study highlights interdisciplinary approaches that unite technology, processes, and people. Combining LC with a robust EA framework enhances collaboration, agility, and alignment, promoting sustainable innovation in the AEC sector.

KEYWORDS

Lean Construction, Enterprise Architecture, Project Management, AEC industry.

INTRODUCTION

The construction sector faces growing complexity, market uncertainty, and rising sustainability demands (Forcael et al., 2020; Koskela, 2020), where LC adapts lean production to construction, maximizing value and minimizing waste (Ballard et al., 2007). This approach aligns Industry 4.0 tools with Lean Construction 4.0, leveraging technologies as innovative drivers. Success depends on strategy and team engagement, not just technology. (Muñoz-La Rivera et al., 2021).

In this sense, Enterprise Architecture (EA) links the organization's strategic objectives and business capabilities with the technological layer, integrating people, processes, and resources within a systemic framework (Ross et al., 2006; The Open Group, 2023). This integration within the AEC industry breaks silos, optimizes information flow, and guides technology for value creation during the project lifecycle (Henderson & Venkatraman, 1999).

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This study explores the synergy between LC and EA, examining their combined impact on operational efficiency, change management, and stakeholder collaboration to foster a more agile and responsive construction sector. While existing research has extensively analyzed the individual application of LC and EA within the AEC industry, little attention has been given to how these frameworks can work together to address systemic misalignments between strategic objectives and operational processes. Moreover, the fragmented adoption of digital tools highlights the need for a more integrated approach to reduce waste and enhance project coordination. This study addresses this gap by proposing a structured integration framework, identifying key barriers to implementation, and providing empirical insights from a focus group with industry professionals, offering a foundation for improving strategic alignment and operational efficiency in complex construction projects.

LEAN CONSTRUCTION

LC FUNDAMENTALS

LC applies Lean principles from manufacturing to construction, aiming to maximize client value while minimizing waste of resources, time, and effort. It optimizes complex project processes through continuous improvement, reducing non-value-adding activities and enhancing workflow efficiency. Its fundamentals include precise value specification, managing workflow, and creating adaptable production systems (Koskela, 2020).

LC uses value stream mapping and collaborative planning to identify inefficiencies and prioritize solutions. These principles effectively address challenges in a changing industry (Ballard et al., 2007).

LC 4.0 AND PEOPLE

LC 4.0 integrates Industry 4.0 technologies, marking a significant evolution in construction project management (González et al., 2023). Tools such as BIM, digital simulations, virtual and augmented reality, and artificial intelligence optimize processes and improve decision-making. However, for these technologies to integrate into workflows, they must align with users' needs and capabilities (Muñoz-La Rivera et al., 2021).

Decision-makers play a central role in determining the adoption of technologies in projects. Often, solutions fail to integrate into workflows, causing professionals to resort to traditional methods like printed drawings, despite the availability of robust BIM models (Forcael, 2024). This challenge highlights the need for technologies that are innovative, accessible, intuitive, and relevant for field teams, ensuring effective integration into processes. Otherwise, tools may be underutilized and fail to contribute practically to projects (Musa et al., 2023).

A people-centered approach that involves all stakeholders from design to execution is essential. Training, cultural adaptation, and suitable technological tools are crucial for optimizing LC 4.0 practices, transforming interactions with technology, and enhancing its application in construction projects (Narvaez Rojas et al., 2021).

ENTERPRISE ARCHITECTURE AND LEAN MANAGEMENT

FOUNDATIONS OF ENTERPRISE ARCHITECTURE

EA is a systemic perspective (Atencio et al., 2024), a way to structure, understand, and manage organizations through a standardized representation of their components and relationships. EA can be structured into five layers that represent different organizational domains, as presented in the ArchiMate EA framework (Archi, 2023). ArchiMate is one of the most widely used frameworks for modeling EA, which was developed by The Open Group (The Open Group, 2021). ArchiMate provides a standardized modeling language comprising a set of organizational artifacts such as roles, goals, constraints, applications, data, etc. This framework allows organizations to visualize relationships across different organizational layers, including and organized from the strategy to the data components at the bottom: (1) Strategy Layer outlines strategic objectives, business capabilities, and necessary actions to fulfill the mission; (2) Business Layer includes processes, functions, roles, and services supporting strategic goals; (3) Application Layer covers applications and systems for business processes; (4) Technology Layer details the technological infrastructure (hardware, networks, software) supporting upper layers; (5) Implementation and Migration Layer describes how programs and projects effect necessary architectural transformations.

The inception of EA comes from the information technology (IT) industry, with an architectural conception of the organization proposed by Zachman (1999) as a framework. Over time, with the adoption of EA in the IT sector and its expansion to other industries, a set of benefits have been realized after its implementation (Atencio, Bustos, et al., 2022; Niemi & Pekkola, 2020), enhancing organizational performance and strategic alignment.

EA is a structured approach that enables organizations to align their strategy, business processes, information, technology, and infrastructure (Lapalme et al., 2016). EA offers a more comprehensive framework for organizational transformation than other system-thinking approaches. For instance, System Dynamics (SD) focuses on system behavior over time, while EA provides a structured model for planning and implementing change at the enterprise level (Sunkle et al., 2013). Organizational Cybernetics (OC) and Viable System Model (VSM) emphasize self-regulation and adaptability, but EA extends these principles by ensuring alignment between business processes and technology (Fu et al., 2016). Also, EA encompasses Business Process Architecture (BPA) as one of its architectural layers, providing an integrated view of operations (Gonzalez-Lopez & Bustos, 2019). Beyond these advantages, EA supports interoperability with management and governance tools like the Balanced Scorecard, Business Model Canvas, and COBIT (Lankhorst, 2017). These traits make EA well-suited for LC integration, allowing waste reduction, process optimization, and organizational alignment. By structuring digital transformation in the AEC sector, EA boosts Lean methodologies through consistency, interoperability, and continuous improvement in complex projects.

EA provides a framework for documenting business knowledge, identifying dependencies, synergies, resource inefficiencies, and improving alignment with stakeholders and goals (Perez-Castillo et al., 2019); improved information quality and decision-making; enhanced efficiency, innovation, agility, and standardization; optimized resource use (integration, consolidation, reuse) (Kutnjak, 2021); Enhanced return on investment with lower costs; provided vision for improvement; promoted collaboration and communication (Atencio, Bustos, et al., 2022).

Over time, interest in EA's research and practical application has shifted to sectors such as AEC (Atencio, Bustos, et al., 2022). EA offers AEC a viable option for managing project complexity, resources, and aligning interoperability among BIM, business processes, and strategy (Atencio, Muñoz, et al., 2022)

ENTERPRISE ARCHITECTURE FOR LC PROCESSES

Integrating Lean principles with EA is underexplored. Lean Enterprise Architecture (LEA) applies lean principles —value, value stream, flow, pull, and perfection— to reduce waste, enhance stakeholder alignment, and promote adaptability in dynamic environments (Ogheneyome, 2024). LEA structures enterprise transformation into planning, integration, and implementation phases to align IT assets with organizational goals (Porter, 1996). This methodology is used across sectors like aerospace and chemicals to tackle transformation challenges. For example, the Lean Enterprise framework in chemicals combines lean manufacturing, digitalization, and sustainability to meet market demands and achieve operational efficiency and environmental goals (Comm & Mathaisel, 2008). Similarly, the LEA framework in aerospace maintenance ensures enterprise-wide improvements by addressing silos and focusing on flow and value delivery (Mathaisel, 2005).

Implementing LEA presents challenges like organizational resistance, skill gaps, and balancing agility with governance. However, its focus on responsive, value-driven architecture showcases its utility for modern enterprise transformation (Ogheneyome, 2024). Despite potential benefits, integrating Lean principles and EA is mostly theoretical in the AEC sector. Previous studies mainly examine Lean or EA separately (Koskela, 2020; Ross et al., 2006), providing little empirical evidence on how combining the frameworks might resolve coordination issues, enhance technological adoption, and boost cross-functional collaboration. The present study proposes a framework aligning LC and EA practices, identifies implementation barriers, and offers recommendations based on industry focus group insights.

METHODOLOGY

A Focus Group was held with professionals from Pares & Alvarez, a leading Chilean engineering firm founded in 1994. The company has completed over 5,600 projects in mining, energy, chemicals, water, and more, with a global presence in America, Asia, Europe, and Oceania, and offices in Chile, the USA, Peru, and Australia. It employs over 1,000 people and has a monthly production capacity exceeding 136,000 hours, specializing in environmental projects, consulting, procurement, and construction management. Pares & Alvarez was selected for this study due to its adaptability to complex projects with tailored teams, ensuring customized solutions. The firm emphasizes transparency, collaboration, and environmental responsibility, integrating cutting-edge tools like BIM, achieving ISO 19650:1-2 certification in 2022 as the first Chilean engineering firm to do so. This expertise makes it an ideal case for exploring the integration of LC and EA into the AEC industry. Choosing this company also stems from its reputation as a leading engineering firm, with executives continually seeking new methods. Thus, evaluating LC and EA's joint incorporation served as a case study for their future implementation in daily work.

The focus group, led by a moderator, set rules for time, confidentiality, and objectives to gather insights from a multidisciplinary team through five thematic areas (Table 2). This methodology encouraged open dialogue, allowing participants to share ideas and experiences, with in-depth questions addressing critical issues. This structured approach captured multiple perspectives, stimulated interaction, and provided qualitative findings on adopting LC and its strategic alignment with EA in engineering and construction.

SELECTION OF PARTICIPANTS

Six experts were selected for the study, summarized in Table 1.

Table 1: Professional profiles of the experts

Profession	Role	Area of expertise	Experience (years)
Chemical engineer	Operations Manager/ Consultant	Engineering Projects for the Heavy Industry	28
Mechanical engineer	Head of Innovation and BIM Processes	Piping Projects and BIM Methodology	17
Architect	BIM Coordinator	BIM Methodology Implementation	16
Civil engineer	Deputy Manager of Specialties and BIM Project Director	Mining Projects Management and BIM Methodology	20
Chemical engineer	Technical Manager	Engineering projects	19
Senior Draftsman	BIM Coordinator	BIM Methodology Implementation	20

Discussion Script

A script was prepared with open questions and key themes, as shown in Table 2.

Table 2: Focus Group Topics and Questions

Topic	Questions
Topic 1 - Innovation and trends in the construction industry	1. How do you perceive recent technological advancements in the industry? 2. What emerging technologies are transforming how projects are developed? 3. What are the main barriers to adopting new technologies in the sector? 4. How are your organization's strategic objectives aligned with the technologies implemented in projects? 5. How are technological projects prioritized based on their strategic value to the organization?
Topic 2 - Project management and workflow optimization	6. What project management methodologies do you primarily use? Which have been most effective? 7. What aspects of the workflow do you consider critical to ensuring the success of a project? 8. What specific tools do you use to plan, coordinate, and monitor your projects? 9. What practices are being implemented to align business operations with client needs and industry regulations? 10. What mechanisms do you have to ensure alignment between project objectives and business performance indicators?
Topic 3 - Use of BIM and LC in the construction sector	11. How has BIM impacted project planning, design, and execution in your experience? 12. What benefits have you identified when applying Lean Construction principles in your projects? 13. What challenges do you face in integrating tools like BIM or Lean methodologies with traditional systems? 14. How do you evaluate the interaction between technological tools and collaborative processes in your projects? 15. How do you assess the integration and adaptability of your software tools within existing workflows? 16. To what extent are industry standards and best practices considered when selecting technological tools? 17. How do you manage the interoperability of technologies (e.g., BIM, collaboration platforms) with legacy systems?
Topic 4 - Collaboration and participation in projects	18. How do you evaluate client participation in the different stages of a project? What could be improved? 19. What experiences have you had with extreme collaboration methodologies or similar approaches? What lessons were learned? 20. How do you address communication and coordination challenges between disciplines and project stakeholders? 21. What technological governance processes exist to regulate the adopting of new technologies?
Topic 5 - Academia-Industry collaboration	22. What type of academic research do you consider most helpful in addressing real-world problems in the industry? 23. How do you perceive the role of academia in developing practical methodologies or tools for construction? 24. What strategies could be implemented to strengthen collaboration between universities and companies in applied projects? 25. How can academia assist the industry with technological change in current projects?

ANALYSIS OF RESULTS

The results analysis was a content analysis, which involved identifying and categorizing recurring ideas, themes, and concepts obtained through the discussions held during the Focus Group. The process can be broken down into the following stages:

INITIAL CODING

The transcripts were reviewed, and codes were assigned to the relevant parts of the text. These codes were deductive—based on theory and prior background—and inductive—emerging from the information gathered in the Focus Group. The review of the transcripts led to the definition of seven core codes: 1) Technology Adoption, 2) Implementation barriers, 3) Lean methodologies, 4) Efficiency and productivity, 5) Coordination and collaboration, 6) Resistance to change, and 7) Collaboration with academia.

CATEGORIES

After coding, similar codes were grouped into categories or themes. These five categories capture the essence of the discussion in the Focus Group: 1) Innovation and Technological Trends, 2) Management Methodologies and Workflow Optimization, 3) Enterprise Architecture and Technological Integration, 4) Collaboration and Participation, and 5) Academia-Industry Linkage.

INTERPRETATION

The integrated analysis examines the interaction between Lean Construction and Enterprise Architecture, using predefined categories and the frequency of key codes. The quantitative results identify both implementation barriers and opportunities for strategic alignment between methodologies and organizational structures. Table 3 presents the key codes and their corresponding frequencies.

Table 3: Key Codes and Frequencies

Code	Frequency (%)
Technology Adoption	18%
Implementation barriers	15%
Lean methodologies	20%
Efficiency and productivity	12%
Coordination and collaboration	10%
Resistance to change	10%
Collaboration with academia	15%

The results in the frequency table show, on the one hand, a marked interest in Lean Methodologies (20%) and Technology Adoption (18%), which suggests that practices aimed at efficiency and digital innovation occupy a central place in the discussion. However, the presence of Implementation Barriers (15%) and Resistance to Change (10%) underlines the existence of cultural and organizational obstacles that make consolidating these initiatives difficult. For its part, the academy-industry linkage (15%) stands out as a factor that, if strengthened, could alleviate these challenges, accelerating the assimilation of lean tools and methodologies in the construction industry.

Below, the incidence of each code in the defined categories is presented, illustrating its relevance and the emerging synergies of the Focus Group:

Innovation and technological trends

Examples of responses:

"The technology is available, but the real problem is resistance and uncertainty about Return on Investment (ROI)." *(Implementation barriers, Resistance to change).*

"BIM, drones, and 3D printing are examples of how we can streamline processes and reduce errors." *(Technology adoption, Efficiency and productivity).*

Focus Group participants highlighted that advancements in digital tools, such as 3D modeling, artificial intelligence applied to planning, and the incorporation of drones for project monitoring, have redefined efficiency standards in the sector. According to (Koskela, 2020), the innovative drive in construction seeks to streamline processes and improve the quality of information available for decision-making. Along these lines, BIM enables centralized and more precise data visualization, while robotics and augmented reality offer disruptive possibilities for quality control and on-site training (Muñoz-La Rivera et al., 2021).

However, implementation barriers persist, primarily due to resistance to change and uncertainty about the ROI. Construction projects, often constrained by tight margins and demanding deadlines, face challenges in adopting technologies that do not quickly demonstrate their financial or productivity benefits (Forcael, 2024). Additionally, some professionals still perceive innovations as "experiments" with no immediate practical utility, which generates distrust and reinforces the inertia of traditional methods (Musa et al., 2023).

From the perspective of EA, the technological and business layers must align to ensure that the adoption of solutions (e.g., BIM, Artificial Intelligence (AI)) addresses strategic objectives and actual user needs (Ross et al., 2006).

Methodologies and Workflow Optimization

Examples of responses:

"We use a combination of Lean and traditional planning; for example, Primavera for the macro schedule and Last Planner for daily coordination." *(Lean Methodologies, Coordination, and Collaboration).*

"The key is constantly measuring hours consumed, actual progress, and commitment fulfillment." *(Efficiency and productivity, Lean methodologies).*

The results highlight how hybrid methodologies are emerging as a key strategy for optimizing workflows. For example, the combination of traditional tools such as Primavera for macro scheduling and Last Planner for daily coordination illustrates how structured planning is balanced with operational flexibility. This approach reflects the principles of Lean Construction (Ballard et al., 2007; Koskela, 2020), where waste reduction and collaboration are realized through the constant measurement of hours consumed, actual progress, and commitment fulfillment.

The integration of Kanban and MS Project strengthened the process layer in the EA, optimizing activity sequences and information. This finding aligns Lean practices with the strategic objectives of the upper layer (Henderson & Venkatraman, 1999), ensuring that operational management (e.g., tracking productivity metrics) supports organizational goals such as value maximization (Womack & Jones, 1996).

Enterprise Architecture and Technological Integration

Examples of responses:

"If we invest in BIM software, we evaluate whether it aligns with our strategic objectives and whether the client requires it." *(Technology adoption, Implementation barriers).*"Enterprise Architecture helps avoid purchasing tools that do not provide real value, preventing silos and duplication of information." *(Coordination and collaboration, Efficiency and productivity).*

The results show that effective technology adoption requires strategic alignment and interdisciplinary coordination. The approach in the first example reflects how enterprise architecture (EA) prevents technological fragmentation, preventing the acquisition of valueless tools and information silos. Regarding BIM, participants highlighted its contribution during the design phase and in coordinating specialties. However, a gap was observed between BIM's potential and practical application, where many construction teams still rely on printed plans and manual methods (Forcael, 2024). The challenge lies in transferring information from the digital model to daily execution, ensuring that workers and supervisors trust and understand the data provided by BIM (Musa et al., 2023).

Through EA, disconnected or duplicated technological implementations are avoided, ensuring digital solutions align with the organization's vision and integrate with Lean processes (Porter, 1996). This synergy forms the foundation of the LEA concept, which aims to reduce waste, optimize value flow, and align IT with operations (Hammer & Champy, 1993; Womack & Jones, 1996) (Womack & Jones, 1996; Hammer & Champy, 1993).

Collaboration and Participation

Examples of responses:

"Our weekly meetings allow us to identify problems and adapt quickly; without collaboration, delays multiply." *(Coordination and collaboration, Efficiency, and productivity).*

"When the client does not have a team to receive the BIM model, the collaborative process loses momentum." *(Implementation barriers, Resistance to change).*

Early collaboration between disciplines and transparency in communication emerged as key factors for reducing errors and expediting decision-making. The use of virtual platforms (Teams, BIM 360, CDE repositories) and "extreme collaboration" methodologies (joint model review sessions, Big Room) demonstrate benefits in multidisciplinary coordination (Ballard et al., 2007). However, challenges persist when the client does not actively participate or lacks a team with sufficient digital competencies to interact with models and shared data environments (Forcael et al., 2020).

Additionally, the human factor, including leadership attitudes and team motivation, becomes critical for sustaining collaboration over time (Muñoz-La Rivera et al., 2021). Lack of trust, skepticism toward new procedures, and the absence of incentives can lead to resistance against participation initiatives, affecting execution quality and client satisfaction.

For collaboration to flow effectively, EA's organizational and process layers must align with the company's culture, creating appropriate communication and governance channels that drive value creation at every stage (Ross et al., 2006).

Academy-industry collaboration

Examples of responses

"Collaboration with universities occurs, but it is not systematic: academic timelines and construction timelines often do not align." *(Academia-industry collaboration, Implementation barriers).*

"We need graduates to have more knowledge of BIM and Lean; this would streamline the learning curve in the company." *(Lean methodologies, Technology adoption).*

Participants agreed that collaboration with academia can be a key factor in driving innovation and reducing educational gaps in areas such as BIM, AI, simulations, and lean processes (Forcael et al., 2020). However, there is a lack of systematic mechanisms connecting the real needs of construction projects with university research and developments, whose timelines and objectives often differ from the pace of construction projects (Narvaez Rojas et al., 2021).

Knowledge transfer is significant for training new talent and designing technologies that are more accessible and adapted to on-site realities. Joint R&D&I (Research, Development, and

Innovation) projects—where companies provide specific problems, and academia offers research and prototyping methodologies—emerge as the most effective pathway for fruitful collaboration. However, companies and universities must define agreements ensuring applicable results within reasonable timeframes.

Within the alliance layer of EA, interaction with universities enables organizations to tackle challenges related to innovation and training, facilitating the adoption of Lean methodologies and new technologies on solid foundations (Narvaez Rojas et al., 2021).

INTEGRATED SYNTHESIS

Table 4 exemplifies the incidence of the codes in each category, showing how often (in %) the codes appeared within the textual units classified in each category.

Table 4: Distribution of Codes in Main Thematic Categories

Code	Innovation and Technological Trends	Management Methodologies and Workflow Optimization	Enterprise Architecture and Technological Integration	Collaboration and Participation	Academia-Industry Linkage
Technology Adoption (18%)	40%	20%	25%	5%	10%
Implementation barriers (15%)	30%	10%	25%	20%	15%
Lean methodologies (20%)	10%	55%	10%	15%	10%
Efficiency and productivity (12%)	15%	40%	5%	30%	10%
Coordination and collaboration (10%)	10%	25%	10%	45%	10%
Resistance to change (10%)	20%	10%	15%	40%	15%
Collaboration with academia (15%)	5%	10%	5%	15%	65%

From the analysis of correlations between categories and codes, it is clear that "Technology adoption" presents a notable incidence (40%) within the category of Innovation and Technological Trends, which coincides with the growing relevance of digital tools as drivers of modernization in the AEC industry. On the other hand, "Lean Methodologies" stands out (55%) in the field of Flow Management and Optimization, reflecting the consolidation of approaches such as Last Planner and Kanban in the dynamics of projects that seek to maximize efficiency and reduce waste (Ballard et al., 2007; Koskela, 2020). On the other hand, "Academy-industry linkage" is concentrated 65% in the homonymous category, underlining the need to strengthen R&D&I initiatives that enable the specialized training of professionals and the systematic adoption of innovative solutions. While these associations are potentially evident, the purpose of this research is to quantify and empirically validate them within the specific framework of the AEC industry. These correlations evidence the synergistic interaction between Lean components, technological developments, and cooperation with the university sector, providing quantitative solidity to the qualitative interpretation of the findings. This fact reinforces the idea that the strategic integration of business architecture, lean culture, and academic collaboration constitutes a pillar for the sustainable evolution of the construction sector.

On the other hand, the balanced distribution of codes in "Enterprise Architecture and Technological Integration" (with none exceeding 25%) suggests a multifactorial reality in the AEC industry. This pattern reflects inherent complexity, where aspects such as systems interoperability and technological scalability hold equal relevance, without clear dominance. It may indicate an intermediate evolutionary phase where emerging technologies vie for priority. The uniformity highlights the need for holistic strategies that integrate regulatory standardization and cultural adaptation, avoiding isolated solutions. The percentage balance emphasizes that success relies on the synergy between technology, processes, and human capital, not on specific tools.

CONCLUSIONS

Integrating LC with Industry 4.0 technologies optimizes construction and enhances client value. Tools like BIM, AI, and augmented reality minimize waste and boost collaboration in complex environments (Koskela, 2020; Muñoz-La Rivera et al., 2021). However, simply having these technologies does not ensure success; developing skills and fostering cultural adaptation for active participation from the entire project team, from design to execution, is essential. The integration of LC and EA provides a structured framework to ensure these technologies are effectively aligned with project objectives, reducing inefficiencies and improving decision-making by bridging the gap between strategy and execution. Empirical findings from our focus group underscore how EA enhances standardization, improves coordination across project phases, and promotes a structured approach to continuous improvement.

The EA offers a structured framework integrating organizational strategy with digital technologies and lean practices. This approach minimizes the risks of disconnected solutions, enhances coordination across organizational layers —strategic, process, and technological—, and maximizes the impact of innovations. EA helps establish a roadmap identifying investment priorities, skills development, and collaborative models for continuous improvement (Henderson & Venkatraman, 1999; The Open Group, 2023). By ensuring the interoperability of digital tools, such as BIM and AI, and aligning them with LC principles, EA helps mitigate inefficiencies related to fragmented information flows and siloed decision-making.

As organizations adopt lean principles in EA, future research aims to develop metrics and integrate LEA with Agile and DevOps, enhancing its role in fostering innovation and efficiency in complex businesses (Comm & Mathaisel, 2008; Ogheneyome, 2024). Agile emphasizes iterative development and collaboration, while DevOps merges development and operations via automation and continuous delivery (Comm & Mathaisel, 2008; Ogheneyome, 2024). These methods enhance workflow and complement EA by ensuring flexibility and integration of digital tools in LC projects.

Finally, LC and EA drive a comprehensive management model focused on reducing inefficiencies and creating an organizational value perspective. This study provides evidence that integrating LC and EA enhances project coordination by fostering a structured decision-making process, reducing operational inconsistencies, and ensuring continuous feedback mechanisms for project improvement. Evidence suggests that consolidating collaborative planning, digitizing processes, and standardizing best practices enables AEC sector companies to attain greater agility, resilience, and competitiveness. However, successful adoption relies on effective change management and the commitment of all stakeholders —professionals, clients, and training entities—, to foster a more innovative, sustainable, and people-centered future construction.

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