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Review Article

Educational technologies and pedagogical innovations in operations management education: A systematic review

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ABSTRACT

Educational technologies are reshaping how operations management (OM) is taught in business education, shifting from lecture-based instruction to interactive, technology-enhanced learning. This systematic review analyzes 101 peer-reviewed studies published between 2000 and 2025, following the PRISMA protocol, to examine innovations in OM education across curriculum design, pedagogical approaches, technological tools, and industry-academia partnerships. Results show a growing reliance on blended and hybrid models supported by learning platforms, where simulations, ERP systems, and VR/AR foster experiential and immersive learning. Pedagogical strategies such as problem-based learning, case methods, and project-based approaches gain effectiveness when combined with digital tools that provide real-time feedback, collaboration, and authentic data-driven contexts. The literature also emphasizes aligning OM curricula with industry needs through analytics, sustainability, and digital transformation competencies, ensuring graduates are prepared for technology-intensive and sustainability-driven workplaces. To integrate these dimensions, this review introduces a SIPOC-based framework and a teaching-technology heatmap, conceptualizing OM education as a system innovation. This perspective highlights how curriculum content, pedagogical strategies, and digital technologies interact to generate transversal competencies in analytics, strategy, risk management, and Industry 4.0/5.0. The review contributes to management and educational technology research by mapping how innovations can be systematically embedded into OM courses, while identifying challenges and opportunities for future curriculum design and digital pedagogy.

Keywords: operations management education, educational technology, curriculum design, simulations, pedagogical approaches, emerging technologies

INTRODUCTION

Operations management (OM) has emerged as a critical component of business education, shaping the development of future managers and decision-makers. In an environment characterized by rapid technological advancements, globalization, and volatile market demands, OM equips graduates with competencies essential for organizational success (de Oliveira Ormond et al., 2018; Manresa et al., 2020). OM represents a foundational discipline in business education, concerned with how organizations design, plan, and control processes to deliver value efficiently and effectively. Within educational contexts, OM education refers to the structured process of teaching and learning managerial, analytical, and technological competencies that enable students to understand and improve operational systems in manufacturing, services, and public organizations (Fry et al., 2015; Kumar, 2016). This focus on both content (operations theory and tools) and pedagogy (how OM is taught) positions OM education as a core area of business curricula aimed at developing future managers capable of leading process innovation, productivity improvement, and sustainable transformation (Helmold, 2022; Maroto Álvarez et al., 2022).

The scope of OM education is broad, covering decision areas such as product and process design, supply chain management (SCM), lean operations, and quality assurance, which are relevant across manufacturing, services, healthcare, and finance (Greasley, 2019; Helmold, 2020, 2022; Moynihan, 2018). These topics are typically taught through a mix of analytical modeling, case-based reasoning, and experiential projects, all of which cultivate quantitative, problem-solving, and strategic decision-making skills, offering graduates a competitive advantage in the job market (Alkhateeb et al., 2012; Kader et al., 2017; Misra et al., 2016). Yet, despite its strategic importance, OM education faces persistent challenges. Quantitative models are often perceived as abstract, teaching remains fragmented across isolated modules, and many curricula lag the digital transformation that is shaping real-world operation (Essila et al., 2021; Muscatello, 2023).

Educational technologies have begun to address these challenges, bridge the gap between theory and practice by transforming the way OM is taught. Digital simulations, problem-based learning (PBL), and decision-support tools such as Excel Solver, LINGO, and ERP systems enable students to experiment with real operational data and observe the consequences of managerial decisions in real time (Das, 2015; Maroto Álvarez et al., 2022). More recently, artificial intelligence (AI) and immersive and interactive environments such as virtual reality (VR) and augmented reality (AR) have expanded the range of experiential learning in OM courses, offering opportunities for collaboration, visualization, and digital fluency (Al Rahamneh et al., 2023; Dev et al., 2020; Juan, 2023). These innovations not only bridge the gap between theory and practice but also redefine the competencies expected of graduates entering Industry 4.0 and 5.0 workplaces.

Theoretical and empirical foundations of OM education increasingly draw on constructivist and experiential learning paradigms, which emphasize active engagement, reflection, and contextual problem-solving (Kolb, 1984; Prince & Felder, 2006). Instructional design models such as blended and technology-enhanced learning extend these principles by leveraging digital platforms and immersive environments to simulate real operational contexts and improve collaboration between academia and industry (Bordoloi, 2016; Garrison & Vaughan, 2012; Pasi & Dhamak, 2025). Empirical research has shown that tools such as learning management systems (LMS), ERP simulations, and Industry 4.0 environments can significantly enhance students' decision-making, collaboration, and systems thinking (Netland et al., 2020; Strakos et al., 2023), driving operational excellence, resilience, and sustainable value creation (Gomaa, 2025). These frameworks underpin the pedagogical and technological convergence explored in this review, positioning educational technologies as catalysts for transforming OM instruction from theoretical abstraction toward applied, data-driven, and collaborative learning experiences.

Moreover, curriculum reforms emphasize interdisciplinary integration, linking OM with finance, marketing, and strategy, while partnerships with industry enhance experiential learning opportunities (Hoefle et al., 2020; Purohit & Dutt, 2024; Trimble et al., 2019). The teaching of OM can thus be viewed as a dynamic innovation system that brings together multiple stakeholders, including universities, industry partners, policymakers, and technology providers, all of them working collaboratively to shape learning outcomes (Almaraz-López et al., 2023; Palma et al., 2023). Within this system, curriculum design, pedagogical methods, and technological infrastructures function as interconnected components that generate skilled graduates and enable knowledge transfer (Aarnio et al., 2025).

However, despite significant progress, the literature on OM education remains fragmented. Existing studies often focus on individual innovations (e.g., simulations, ERP tools, or sustainability modules) rather than on how pedagogical, technological, and curricular elements interact as part of an integrated instructional system. There is also limited synthesis of how emerging technologies reshape learning objectives, assessment models, and faculty-industry collaboration. Consequently, there is a need for a systematic review that consolidates the dispersed evidence, identifies patterns across pedagogical and technological innovations, and proposes integrative frameworks for curriculum design.

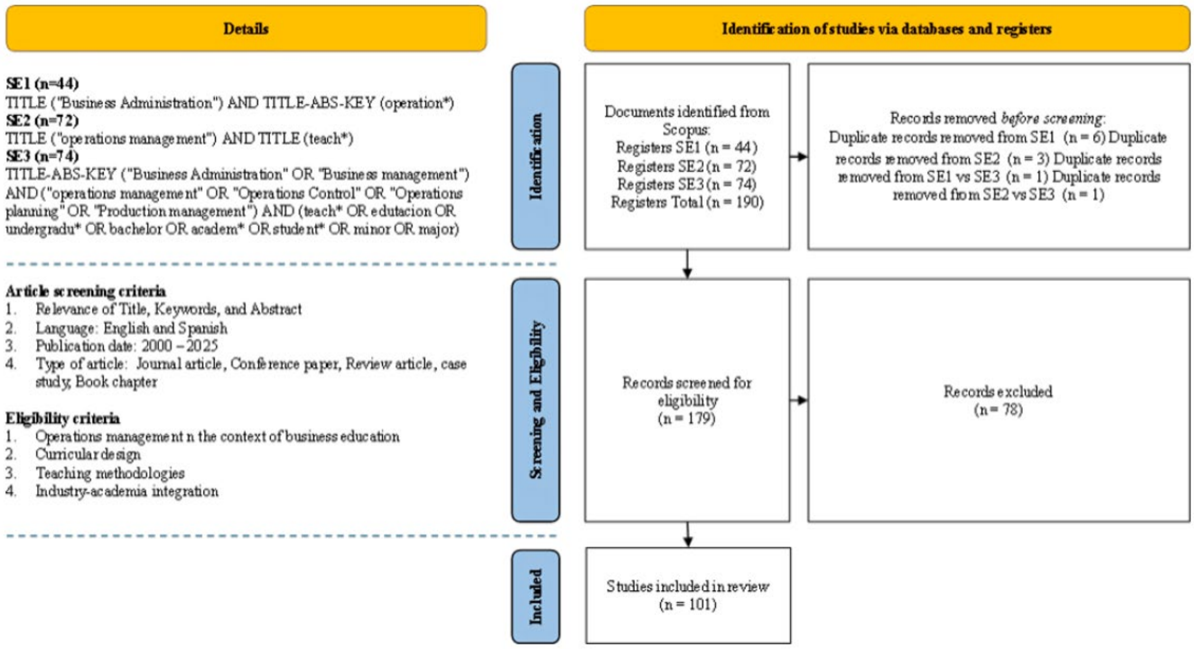

Figure 1. Search equations and PRISMA-based document selection process (Source: Authors' own elaboration)

To address these gaps, this study conducts a systematic literature review (SLR) following the PRISMA protocol. The review examines innovations in four interconnected dimensions:

(1) curriculum design and holistic models,

(2) pedagogical approaches,

(3) educational technologies, and

(4) industry-academia partnerships.

By framing OM education as an innovation system where pedagogy, technology, and curriculum coevolve, this study provides an integrated perspective on how educational technologies are transforming management education and offers a foundation for future research and instructional design in the digital era.

METHODOLOGY

This study followed an SLR approach, structured under the PRISMA protocol, to ensure transparency and replicability. Four steps guided the process: database selection, search strategy, inclusion and exclusion criteria, and corpus definition. Scopus was selected as the database given its comprehensive coverage of peer-reviewed and high-impact sources in management, education, and technology-related studies (Mohadab et al., 2020). Moreover, the inclusion of diverse document types (articles, books, and conference papers) provided a comprehensive representation of both theoretical developments and applied innovations in OM education, supporting a current and balanced view of the state of the art in the field. The search strategy targeted documents at the intersection of business administration, OM, and education. Since OM is often associated with terms such as operations control, operations planning, or production management, while teaching is linked to undergraduate, bachelor, students, and curriculum, these variations were included in three search equations (see **Figure 1**).

The search, conducted in August 2025, initially yielded 190 records, distributed across several publication types: journal articles (48%), conference papers (25%), book chapters (11%), books (10%), reviews (3%), conference reviews (2%), and one editorial (1%). After removing 11 duplicates, 179 documents remained. During the screening and eligibility phases, no exclusion was made based on document type, and titles and abstracts were reviewed to determine relevance to OM education, ensuring that full-text access was possible. Inclusion criteria comprised publications between 2000 and August 2025, written in English or Spanish, and explicitly addressing OM in the context of business education, curriculum design, teaching methodologies, or industry-academia integration. Therefore, inclusion was determined by content relevance to OM education to ensure a comprehensive and multidisciplinary overview of the field, including both pedagogical innovations and technological integrations.

Documents not explicitly framed as OM education studies but presenting substantial empirical or conceptual insights related to OM teaching, learning, or curriculum design were included after full-text review. The exclusion criteria thus focused on thematic irrelevance rather than document type. Specifically, we excluded documents unrelated to OM education, such as those focused solely on entrepreneurship, general sustainability management, or publications prior to 2000. All records were reviewed and coded to ensure methodological consistency. Ambiguous cases were resolved through iterative discussion and verification of relevance against the predefined inclusion criteria. The process ensured a transparent and replicable selection pathway consistent with PRISMA standards. After the full screening and eligibility assessment, the final corpus of 101 documents consisted of journal articles (56%), conference papers (28%), books (11%), book chapters (3%), one editorial (1%), and one review (1%).

The methodological design combined two complementary stages. First, a bibliometric analysis provided a descriptive overview of the field, focusing on publication trends, document types, geographic and institutional distribution, main journals, and keyword frequencies. It was conducted through manual extraction of metadata from Scopus, followed by descriptive tabulation in Excel to identify publication trends, sources, keywords, and geographic distribution.

Second, a content analysis was conducted on the final corpus of 101 documents to identify dominant themes in the literature. Each full text was read and coded inductively, focusing on objectives, methods, and findings related to OM education. The coding process captured recurring concepts such as curriculum design, pedagogical innovation, technological integration, and collaboration with industry stakeholders. The most frequent and conceptually coherent categories were then grouped into four overarching thematic clusters that represent the structure of the results section: strategic decision-making in OM, teaching approaches, tools and technologies for OM education, and industry-academia partnerships.

The combination of bibliometric and content analyses is particularly appropriate for systematic reviews in management education, as it allows quantitative mapping of publication patterns and qualitative synthesis of pedagogical trends. This dual approach enabled both a macro-level mapping of the field and a micro-level synthesis of its pedagogical and technological contributions.

RESULTS

The results are structured to map how curricular design, pedagogical innovation, and technological integration intersect in OM education. Each subsection corresponds to a component of this framework: the bibliometric overview situates the field's evolution; the analysis of decision areas reflects how OM concepts are represented in curricula; subsequent sections explore pedagogical and technological approaches; and the final part examines how academia-industry partnerships operationalize these innovations. This structure aligns directly with the guiding research questions and supports an integrated interpretation of how OM education functions as a system of applied innovation.

Bibliometric Analysis

The bibliometric analysis (n = 101) situates OM education as a growing research field. Publication trends (**Figure 2**) reveal irregular but increasing output since 2000, with notable peaks in 2012, 2020, and 2024. Articles dominate (51.5%), followed by conference papers (31.7%), while reviews remain rare (2.0%), indicating a still-developing synthesis tradition. Geographically, contributions are concentrated in the United States (37.6%), China (23.8%), India (21.8%), and the United Kingdom (19.8%), with Spain (13.9%) and Brazil (11.9%) reflecting an emerging presence from Europe and Latin America. At the institutional level, Universidad de Sevilla stands out (4 papers), alongside a dispersed set of universities with two contributions each, evidencing a fragmented but globally distributed landscape.

Regarding sources, Emerald Emerging Markets Case Studies leads (8 papers), emphasizing the use of cases in OM pedagogy, while proceedings such as ACM ICPS (4) and Winter Simulation Conference (3) highlight simulation and technology-enhanced approaches. Traditional journals like International Journal of Operations

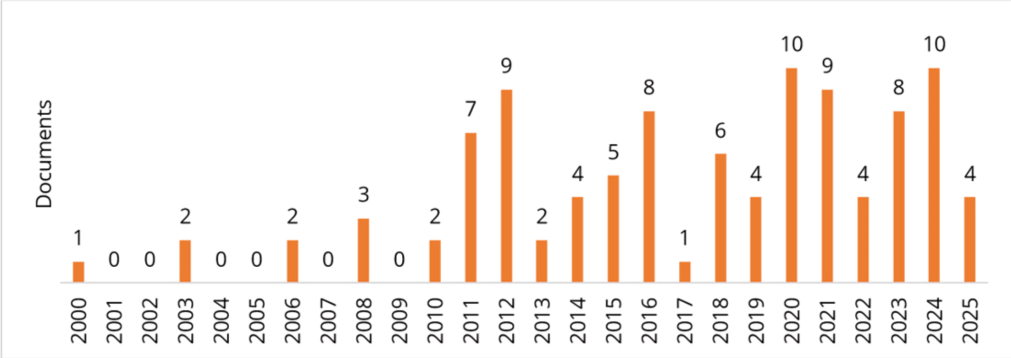

Figure 2. Documents published by year since 2000 (Source: Authors' own elaboration)

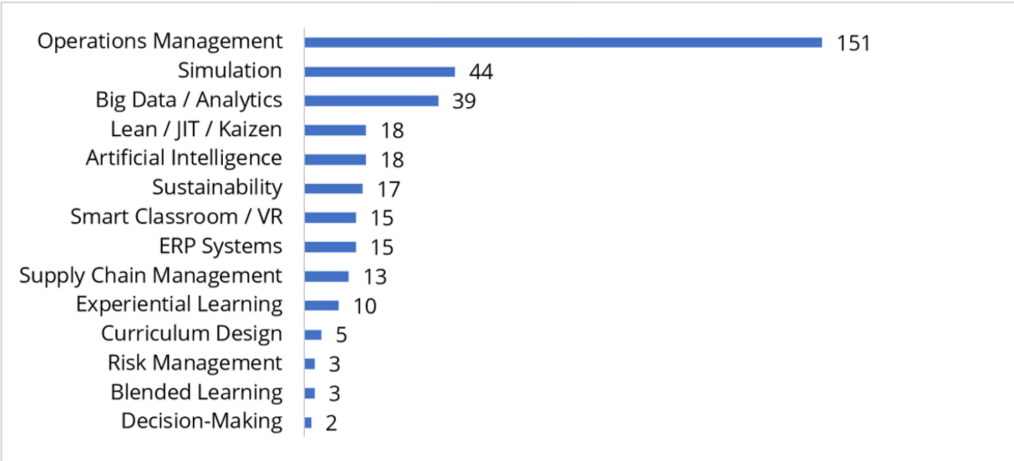

Figure 3. Frequency of keywords on OM education in business administration (Source: Authors' own elaboration)

and Production Management, Decision Sciences Journal of Innovative Education, contribute selectively. Keyword analysis (**Figure 3**) confirms OM as the field's structural axis, complemented by simulation, analytics, AI, ERP, and supply chain concepts. The presence of problem-based, experiential, and blended learning points to a transition toward active pedagogies, while gaps in interdisciplinarity, human-machine interaction, and digital transformation indicate future research opportunities.

Overall, the bibliometric evidence portrays OM education as an expanding yet fragmented domain, increasingly shaped by technology and pedagogy but still requiring stronger international collaboration and theoretical integration.

Strategic Decision-Making in OM

OM is a core discipline in business education, centered on the planning, design, and control of production and service processes to ensure efficiency and customer satisfaction. Key decision areas include operations strategy, product and process design, quality management, capacity planning, and inventory control, all of which remain essential for developing managerial competencies (Dathe et al., 2022; Helmold, 2022). A comprehensive OM curriculum further integrates topics such as SCM, facility location, human resources, sustainability, and risk management, equipping students to balance competitive priorities and organizational performance (Das, 2015; Demir, 2019; Greasley, 2019).

Decision-making in OM encompasses a set of interrelated areas where managers must allocate resources, design processes, and align operations with organizational strategy. These decisions directly affect competitiveness, efficiency, and responsiveness, while also shaping long-term sustainability (Bamford et al., 2023a; Helmold, 2022). For business education, the pedagogical value lies in exposing students to the complexity of operational trade-offs and the integration of OM with finance, marketing, human resources, and strategy (Šoljaková, 2017).

Table 1. Main OM decision areas

Decision area	Main questions addressed	Relevance for business education	Interrelations with other decision areas
Planning and scheduling	How to allocate tasks/resources? How to match demand over time?	Builds skills in optimization, forecasting, and HR planning.	Linked to capacity, HR, and supply chain timing.
Process and product design	What to produce and how? How to configure processes efficiently?	Connects design with efficiency, competitiveness, and feasibility.	Feeds into capacity, facilities, quality, sustainability.
Capacity planning	How much capacity is needed and when? How to handle variability?	Trains students in demand forecasting and strategic investment.	Influences facilities, supply chain, HR needs.
Quality management	How to meet requirements and ensure continuous improvement?	Develops customer focus and continuous improvement mindset.	Crosscuts HR, supply chain, and capacity reliability.
Inventory management	How much to hold? Which policies (JIT, EOQ, safety stock)?	Reinforces cost trade-offs and lean management practices.	Tied to supply chain, scheduling, and capacity.
Facility location and layout	Where to locate? How to arrange layouts efficiently?	Links operations to strategy and global competitiveness.	Inputs for supply chain, process, capacity, HR.
Supply chain management	How to coordinate flows and partners? What level of integration?	Emphasizes global integration, agility, and digital tools.	Interdependent with inventory, quality, facilities, sustainability.
Human resources and job design	How to allocate tasks, train, and retain employees?	Builds people management, ergonomics, adaptability skills.	Interacts with capacity, quality, and facility layout.
Sustainability and risk management	How to integrate responsibility and mitigate risks?	Aligns with SDGs, Industry 4.0/5.0, and resilience.	Crosscutting: product design, supply chain, quality, facilities.

The literature identifies several core decision domains: planning and scheduling, process and product design, capacity management, quality and inventory control, facility location and layout, SCM, and human resources and job design. Emerging themes such as sustainability, risk management, and data-driven decision-making extend these traditional domains, reflecting the influence of Industry 4.0 and global market dynamics. **Table 1** synthesizes these areas by outlining their central questions, educational relevance, and interrelations, underscoring that OM decisions are not isolated but mutually reinforcing. The following subsections briefly discuss each decision area, highlighting their importance in the curriculum and their role in equipping students with analytical, strategic, and practice-oriented competencies.

Planning and scheduling

Planning and scheduling are central to OM, as they determine how tasks, resources, and workforce are allocated to meet demand under multiple constraints such as capacity, inventory levels, and lead times (Dathe et al., 2022; Wolniak, 2020). Aggregate planning addresses medium-term capacity adjustments, while short-term scheduling focuses on job sequencing and resource allocation (J. Zhang et al., 2019). These decisions directly influence both efficiency—through cost reduction—and effectiveness—through customer service levels (Cano et al., 2020; Esmaeili et al., 2024).

To address their inherent complexity, OM education introduces students to diverse decision-support tools. Classical approaches such as heuristics and mathematical programming are complemented by simulation, which allows replication of dynamic industrial contexts (Bazargan, 2016). More recent developments include bio-inspired models such as metaheuristics, as well as AI-based scheduling systems that optimize plans in real time (Barták et al., 2010; Z. Li & Tian, 2025). These methods not only improve efficiency in manufacturing but also provide transferable skills for service industries and administrative contexts.

Process and product design

Process and product design shape efficiency, cost structures, and competitiveness, making them critical domains of OM (Ganesh et al., 2020; Stuart et al., 2002). Process design defines workflows, resource allocation, and layouts that influence throughput and quality (Greasley, 2019), while product design determines manufacturability, complexity, and customer satisfaction (Dathe et al., 2022). Recent advances highlight digital twins and mass customization. Digital twins integrate physical and virtual product models, enabling real-time traceability and decision-making (Tao et al., 2018). Mass customization balances efficiency with personalization, meeting customer needs without sacrificing economies of scale (Zawadzki & Zywicki, 2016).

Increasingly, design is also assessed through sustainability criteria, incorporating eco-design, green supply chains, and circular economy principles (Bocken et al., 2016; Zhu & He, 2017).In business education, case-based and experiential learning approaches are especially effective. Students learn to analyze real-world scenarios, redesign processes, and evaluate product-service systems, thereby linking creativity with analytical rigor (Ramirez-Nafarrate & López-Hernández, 2020).

Quality and inventory management

Quality management ensures that products and services consistently meet customer expectations, traditionally supported by frameworks such as total quality management, Kaizen, and Six Sigma (Dametew et al., 2020; Suárez-Barraza & Rodríguez-González, 2015). Modern approaches increasingly integrate AI, which enhances defect detection, compliance, and continuous improvement while reducing waste (Lakshminarayana et al., 2024). Inventory management complements quality by aligning demand forecasts with production and distribution, minimizing costs and stockouts (Tuomikangas & Kaipia, 2014). Advanced tools, including AI-driven forecasting and just-in-time systems, enable data-informed decisions and lean practices (Albayrak Ünal et al., 2023; Esmaeili et al., 2024; Silviu, 2025)..

Facility location and layout

Facility decisions, including where to locate plants or warehouses and how to design their internal layout, have long-term implications for cost and efficiency (Dathe et al., 2022). Multi-criteria decision-making models, often supported by AI and machine learning, now allow firms to optimize location and layout under dynamic conditions (Aboolian et al., 2021; Miao et al., 2024). Layout design directly influences the flow of people, materials, and information. In manufacturing, it ensures balanced lines and resource use, while in services it shapes customer experience and space utilization (Demir, 2019). Emerging applications of predictive maintenance and reinforcement learning further strengthen facility reliability and adaptability (Gavade, 2023; Mrugalska et al., 2024; Silviu, 2025).

Supply chain management

SCM integrates material, information, and financial flows across firms, requiring coordination among suppliers, logistics partners, and customers. Modern supply chains emphasize agility, adaptability, and alignment to remain competitive and resilient (Erhun et al., 2020; Misra et al., 2016). Digital innovations such as optimization models, big data analytics, and AI-driven simulations support transportation planning, inventory positioning, and resource allocation (Raut et al., 2019; Z. Li & Tian, 2025). At the same time, sustainability principles such as green logistics, waste reduction, and social responsibility are increasingly embedded in SCM strategies (Julianelli et al., 2020; Wu et al., 2024). In the classroom, teaching SCM through simulation games, physical teaching aids, and case-based learning helps students visualize complex processes and link strategy with execution (Poo & Qi, 2023).

Human resources and job design

Human resources and job design ensure that operational systems align with workforce efficiency, adaptability, and well-being. Decisions include task allocation, training, recruitment, and retention, increasingly supported by AI-driven tools for candidate screening, performance evaluation, and career development (Almaraghi, 2024; Kaur & Kaur, 2022; Venugopal et al., 2024). Equally important are ergonomics and inclusive workplace design, which reduce fatigue, improve productivity, and promote social sustainability (Priyanka & Subashini, 2024; Sardinha et al., 2024; Vujica Herzog & Harih, 2020). For students, integrating HR and job design into OM education emphasizes the human side of operations, demonstrating how workforce capabilities complement processes and technologies in achieving efficiency and resilience.

Other key areas for decision-making in OM

Beyond traditional domains, OM also encompasses services, mass customization, and data-driven decision-making. Service operations require tools for workforce allocation, queuing, and scheduling, which directly shape customer experience (Chejarla & Chatterjee, 2021). Mass customization integrates efficiency and personalization, demanding flexible processes and modular product designs (Medini, 2018). Data-driven

Table 2. Comparative teaching approaches in OM education

Teaching approach	Main features	Advantages	Challenges/ limitations	Complementarity with other approaches
Simulation and game-based learning	Games, discrete-event, role-play, feedback loops	Boosts engagement, systems thinking, real-time decisions	Needs software, support, and higher instructor workload	Pairs with cases (context), PBL (problem framing), blended models
PBL	Student-centered, open problems, teamwork	Builds problem-solving, teamwork, interdisciplinarity	Hard to assess, time-intensive, may confuse novices	Links with simulation (testing), projects (scaling), cases
Case studies	Real or adapted scenarios across industries	Connects theory–practice, strategic & critical thinking	Depends on case quality; limited interactivity	Combines with simulations, blended formats, discussion
Blended learning	Mix of online + face-to-face via LMS	Flexible, scalable, personalized pace	Needs robust infrastructure; risk of low engagement	Umbrella for PBL, cases, simulations
Project-based and experiential learning	Long-term applied projects, ERP sandboxes, visits	Fosters autonomy, teamwork, digital & practical skills	High coordination and resource needs; variable outcomes	Extends PBL, integrates industry & ERP tools
Other innovative approaches: Gagné's 9 events, crowd teaching, concept maps	Gagné's 9 steps, concept maps, crowd teaching	Diversifies methods, supports motivation & retention	Still experimental; inconsistent adoption	Flexible add-on to projects, blended, experiential

decision-making, supported by ERP, CRM, and SCM systems, enables organizations to optimize processes with quantitative models and predictive analytics (Berumen & Cavanaugh, 2021).

The integration of strategic decision-making areas into OM curricula requires pedagogical approaches that go beyond traditional lectures. The complexity of topics such as capacity planning, quality management, and supply chain integration demands instructional methods that enable students to apply analytical tools and make contextualized decisions. Consequently, educators have increasingly adopted active and experiential methodologies such as simulations, case studies, and PBL to translate these abstract concepts into practical skills. The following section explores how these approaches are being implemented and how they contribute to bridging the gap between theoretical knowledge and managerial practice in OM education.

Teaching Approaches in OM

Teaching approaches are central to shaping how OM is taught, influencing not only knowledge transmission but also the development of practical skills for decision-making in business contexts (Doran et al., 2013; T. Xu, 2021). Traditional methods often emphasized theory and quantitative analysis, but challenges remain regarding limited real-world applicability, innovation gaps, and assessment practices that privilege retention over problem-solving (Chen, 2014). To address these issues, OM education has progressively adopted active and experiential methodologies such as simulations, PBL, case studies, blended and project-based learning, and more recent approaches like design-based learning or crowd teaching (Y. Zhang, 2024). These methods foster collaboration, critical thinking, and adaptability, preparing graduates for complex environments shaped by digitalization and Industry 4.0. Importantly, no single approach suffices; instead, pedagogical effectiveness emerges from their integration into hybrid ecosystems that balance theory with practice.

Table 2 synthesizes the main approaches documented in the literature, outlining their features, advantages, challenges, and complementarities. This comparative perspective underscores the importance of combining methods to enhance engagement, contextualize learning, and strengthen systemic thinking in OM education.

Simulation and game-based learning

Simulation and game-based learning immerse students in realistic scenarios where they act as decision-makers under conditions of uncertainty. These tools enhance engagement, problem-solving, and systems thinking by providing immediate feedback and allowing experimentation with different strategies (de Araújo et al., 2019; Farashahi & Tajeddin, 2018). Formats range from discrete-event models and process mapping to role-playing and competitive business games that replicate supply chain or production contexts (Alstete, 2023; Costantino et al., 2012; Pernas-Álvarez & Crespo-Pereira, 2021). Despite their effectiveness, simulations require significant instructor preparation, technical infrastructure, and support to ensure usability and scalability (Riley & Ellegood, 2018). Within curricula, they are most impactful when combined with PBL, case studies, or blended formats, bridging the gap between theoretical instruction and applied managerial decision-making.

PBL

PBL shifts the focus from instructor-led teaching to student-centered exploration of realistic, open-ended problems. In OM education, it strengthens engagement and promotes problem-solving, teamwork, and interdisciplinary thinking by linking operational decisions to finance, marketing, and strategy (Farashahi & Tajeddin, 2018; Hoefle et al., 2020; May, 2022). The approach allows students to practice decision-making in complex contexts, often enhanced by digital tools such as supply chain simulators (May, 2022). However, PBL requires careful scenario design and facilitation, and its open-ended nature complicates assessment and grading, especially in large cohorts (Bamford et al., 2012). Despite these challenges, PBL equips graduates with critical skills for collaborative problem-solving in uncertain business environments.

Case studies

The case method remains a cornerstone of OM education, enabling students to apply theoretical concepts to real-world or adapted scenarios across industries strategy (Bazargan, 2016; Misra et al., 2016). It fosters critical and strategic thinking while reinforcing the interconnections between OM and broader business functions. Cases cover diverse topics, from warehouse location and scheduling to sustainability and entrepreneurship, and can employ innovative formats such as comics or digital simulations to increase engagement (Desai et al., 2024; Maqueira et al., 2020; Saldanha et al., 2024). Their effectiveness depends on design quality and scalability, but they provide powerful opportunities to bridge theory and practice in business curricula.

Blended and project-based learning

Blended learning combines digital platforms with face-to-face interaction, offering flexibility and access to resources while maintaining the need for instructor guidance. In OM, it supports the integration of simulations, PBL, and case studies within a structured ecosystem (Alfalla-Luque et al., 2011; X.-F. Li et al., 2021). Project-based learning complements this by engaging students in long-term, challenge-driven tasks, often linked to real business cases or ERP sandboxes. These projects enhance teamwork, digital literacy, and critical thinking, though they require significant coordination and industry collaboration (Manresa et al., 2020). Together, blended and project-based approaches provide students with flexible, experiential opportunities to connect theory with practice.

Other innovative approaches in OM education

Other pedagogical innovations enrich OM education by diversifying methods and reinforcing active learning. Models such as Gagné's nine events structure instruction for better retention, while experiential learning cycles link knowledge with practice (Medini, 2018; Miner et al., 2016; Ozturk, 2023). Collaborative practices like crowd teaching and hybrid methods that combine cooperative learning, online discussions, and student-developed simulations further extend engagement and adaptability (Estelles-Miguel et al., 2015; Fu, 2016). Collectively, these teaching approaches illustrate a pedagogical shift toward experiential and technology-enhanced learning, setting the stage for the following section on pedagogical tools that operationalize these methods within OM curricula.

Tools for Teaching OM

The effectiveness of OM education depends not only on pedagogy but also on the teaching tools that enable experiential and practice-oriented learning. Resources have evolved from textbooks and manuals to advanced software and Industry 4.0 technologies, reflecting shifts in both business practice and instructional

Table 3. Traditional and emerging technologies supporting OM education

Technology	Use in OM teaching	Advantages	Challenges/ limitations	Complementarity with other technologies	Teaching approaches integration
Textbooks, manuals, spreadsheets (Excel, Solver, OMPS, OMPScard)	Core resources for theory and quantitative modeling	Accessible, low-cost, builds analytical/ problem-solving skills	Oversimplifies complex systems, limited scalability	Feeds ERP/simulation cases	Case studies, PBL, simulations, blended learning
Concept maps and visualization tools	Map OM concepts, processes, decision areas	Boosts retention, systems thinking, theory–practice links	Dependent on student engagement, weak for complex data	Complements simulation/ blended tools	PBL, experiential, blended
ICT and LMS (Moodle, Blackboard)	Online/blended delivery, assessments, multimedia	Flexible, scalable, supports diverse learning styles	Needs infrastructure, digital literacy; risk of passivity	Hosts simulations, PBL, cases, VR	Blended learning, case studies
ERP-based simulations	Enterprise-wide decision-making practice	Bridges theory–practice, holistic view	High cost, resource-intensive, training required	Integrates with spreadsheets, PBL, ICT	Projects, experiential, PBL
VR and smart classrooms	Immersive plant/supply chain visualization	High engagement, experiential learning	Expensive, hardware/software dependent	Complements ERP, site visits, blended	Experiential, project-based
Programming and data analytics (Python, R, JupyterLab, Big Data, AI)	Predictive/ descriptive/ prescriptive analytics	Aligns with Industry 4.0, enhances employability, advanced problem-solving	Steep learning curve, dataset access, coding background needed	Links with ERP, ICT, IoT, simulations	PBL, projects, data-driven cases
Emerging tech (IoT, cloud computing, AR, additive manufacturing, cyber-physical systems, Industry 4.0/5.0)	Smart, automated, sustainable OM systems	Realism, innovation, prepares for cutting-edge practices	High costs, integration complexity, needs partnerships	Complements ERP, ICT, analytics	Projects, experiential, industry collaboration

design. **Table 3** synthesizes these technologies, ranging from traditional resources to advanced Industry 4.0/5.0 systems, highlighting their uses, benefits, challenges, and complementarities.

Traditional didactic materials

Textbooks, problem-solution manuals, and case studies provide the foundation of OM teaching by structuring theory and exercises (Yousef, 2012). Case studies remain particularly relevant for linking abstract concepts with managerial problems. However, these tools are increasingly insufficient on their own, as they tend to oversimplify complex operational realities. Their value today lies in serving as complements to interactive and technology-driven approaches.

ICT and Virtual Environments

ICT platforms have transformed OM education by enabling blended, flexible, and student-centered learning (T. Xu, 2021). LMS such as Moodle and Blackboard support assessments, feedback, and course structuring (Medina-López et al., 2011). During the COVID-19 shift, such platforms became essential, often paired with multimedia cases or blended formats (Díaz et al., 2011). More advanced tools include VR/AR simulations of factories and supply chains, which enhance discovery learning and engagement (Netland et al., 2020; Tortorella et al., 2021). Smart classrooms and digital ecosystems integrate preparation, interactivity, and feedback (H. Li et al., 2020). Concept maps and crowd teaching also strengthen collaboration and comprehension (Essila et al., 2021; Estelles-Miguel et al., 2015). Therefore, ICT tools foster digital literacy and adaptability, preparing students for technology-mediated business contexts.

Technological Tools	Teaching Approaches: Simulation and Game-based Learning	PBL	Case Studies	Blended Learning	Project-Based / Experiential Learning	Other Innovative Approaches
Traditional Tools (Textbooks, Spreadsheets)	Reinforces quantitative modeling	Basic modeling, limited for open problems	Spreadsheet-based analysis of cases	Support in printed + online quizzes	Simple project tracking, limited innovation	Low interactivity, minimal value
ICT Platforms and LMS	Deploys digital simulations	Team coordination in LMS	Online cases, debates	Strong host for blended learning	Project management & feedback	Multimedia & crowdteaching
ERP Systems and Sandbox Simulations	High-value supply chain simulation	Solution testing in ERP	ERP-based real-world cases	Integrated in hybrid courses	Full-cycle ERP projects	Role-play using ERP
Emerging Tech (VR/AR, Industry 4.0/5.0)	Immersive, AI-driven simulations	Complex problem-solving with big data	VR for site visits, AI analytics	Adds interactivity to blended models	Real-time IoT/AI for projects	AI tutors, VR labs, dashboards

Relevance level: *High-value sinergy* | *Good complementary* | *Limited value* | *Low value*

Figure 4. Heatmap matrix of teaching approaches and technological tools in OM education (Source: Authors' own elaboration)

Software and emerging technologies

Specialized software bridges OM education with professional practice. Spreadsheets and optimization packages (Excel Solver, LINGO, and D-Sight) provide accessible entry points for modeling and decision support (Maroto Álvarez et al., 2022). ERP systems extend this by simulating integrated decision-making across business functions, often via sandbox environments (Nisula & Pekkola, 2018).

Emerging technologies, including AI, big data analytics, IoT, and cyber-physical systems, enable students to engage with predictive models, digital supply chains, and data-driven problem solving (Lakshminarayana et al., 2024; Lopes & Martins, 2021; Prakash et al., 2025). Python, R, and JupyterLab are increasingly embedded in curricula to foster coding and analytics skills, while GitHub and data mining projects expose learners to collaborative, industry-standard practices (Qu et al., 2020). Industry 5.0 perspectives emphasize sustainability and human-centric design, aligning OM education with future societal and industrial demands (Borchardt et al., 2022).

Figure 4 presents a heatmap matrix of synergies between teaching approaches and technological tools, showing how digital innovations can be strategically aligned with pedagogy to maximize engagement, analytical depth, and real-world preparedness. The integration of these technologies with pedagogical methods demonstrates that OM education increasingly operates through hybrid ecosystems where learning design, digital tools, and industry interaction converge. This connection is further explored in the next section on academia-industry partnerships.

Industry-Academia Partnerships for OM Education

Bridging the gap between academic theory and industry practice is a pressing priority in OM education, particularly given the demands of globalization, digital transformation, and Industry 4.0 (Fry et al., 2015; Trimble et al., 2019). While academia shows broad agreement on OM content, practitioners emphasize the need for applied skills in areas such as SCM, capacity, inventory, and lean tools, exposing a persistent skills mismatch (Doran et al., 2013). Partnerships with industry address this challenge by offering students immersive experiences through site visits, projects, guest lectures, and collaborative research. These initiatives strengthen applied learning, foster technology transfer, and help meet human capital needs in areas such as SCM (Bamford et al., 2023b; Baveja et al., 2024; Muscatello, 2023). However, building sustainable collaborations remains resource-intensive, requiring institutional support and absorptive capacity from industry partners (van Herk & van Buul, 2023).

Best practices include co-creation of curricula, alignment with professional associations, and engagement of industry champions (Shrivastava et al., 2022). Beyond skills development, partnerships also advance sustainability goals by embedding competences related to the SDGs, promoting inclusive leadership, and preparing managers to address socio-environmental challenges (Dias et al., 2022; J. Xu et al., 2024; Lusa et al., 2024). In specialized fields such as air and space management, collaboration highlights the need for interdisciplinary approaches to ensure safety and sustainability (Saadé et al., 2025). Therefore, industry-academia partnerships are vital to reduce the skills gap, promote innovation, and prepare graduates to thrive in evolving business ecosystems. While challenges persist, the educational, professional, and societal benefits underscore the need to strengthen and institutionalize the initiatives (Magalhaes Freitas Ferreira et al., 2019).

TOWARD A HOLISTIC CURRICULUM IN OM EDUCATION

The findings from the previous sections collectively reveal that OM education is shifting from fragmented, discipline-specific approaches toward an integrated system that combines curriculum, pedagogy, and technology. This transformation mirrors broader developments in management education emphasizing experiential learning, digital transformation, and sustainability (Borchardt et al., 2022; Dev et al., 2020; Trimble et al., 2019). Within this context, OM curricula in business administration are increasingly designed as holistic programs that align learning outcomes with organizational realities and global challenges. Recent studies emphasize the importance of linking OM instruction to the company life cycle, embedding ERP-supported environments, and incorporating transversal competences such as risk management, mass customization, Industry 4.0 technologies, and the SDGs (J. Xu et al., 2024; Nisula & Pekkola, 2018). Such integrative designs ensure that OM is not perceived merely as a technical subject, but as a strategic axis in business education, equipping graduates with analytical, technological, and ethical competencies to address complex, dynamic business environments.

Holistic Curriculum Models in OM for Business Administration

Holistic curriculum models overcome fragmentation by integrating disciplinary content with experiential and cross-functional learning. The life-cycle model proposed by Nisula and Pekkola (2018) exemplifies this approach: ERP-based simulations run throughout the year, complemented by consulting-style teaching and collaborative learning communities. Similarly, courses such as experiencing operations immerse students through site visits and guest lectures, strengthening connections between theory and professional realities (Ferratt et al., 2016). These initiatives highlight the need for curricula that combine analytical, technical, and interpersonal skill development within coherent program structures.

Transversal Competences and Emerging Themes in OM Curricula

Modern OM curricula must emphasize transversal competences beyond traditional planning and process optimization. ERP-based learning provides coherence and integration (Ahmatkhonovich et al., 2025).. Emerging themes include mass customization, linking modular design with production planning and customer satisfaction (Guo et al., 2019; Medini et al., 2020); risk and uncertainty management, preparing students for volatile contexts (Al-Husain & Al-Eideh, 2024); Sustainability and social responsibility, through green supply chains, circular economy, and SDGs (Dias et al., 2022); and Industry 4.0/5.0 technologies, including big data, AI, IoT, and cyber-physical systems, which transform OM into smart and resilient systems (Borchardt et al., 2022; Choi et al., 2018). Together, these competences equip graduates to respond to global challenges and contribute to innovation in sustainable operations.

Challenges in Implementing OM Curricula

Despite its strategic role, OM integration faces barriers. The quantitative and interdisciplinary nature of OM can overwhelm students (Mustapha et al., 2015; T. Xu, 2021). Course fragmentation often limits appreciation of cross-functional decision-making (Muscatello, 2023). Digital adoption faces high costs, system complexity, and skill gaps in data analytics and AI (Afsharian, 2024; Ahmatkhonovich et al., 2025). **Figure 5** synthesizes these issues into a SIPOC-based framework that illustrates OM education as a systemic process involving diverse suppliers, curricular inputs, pedagogical processes, and outputs in the form of skilled graduates. Feedback loops capture the need for continuous curriculum innovation and knowledge transfer between academia, industry, and policy.

Reforming OM as a core course requires overcoming institutional inertia by embedding critical thinking, innovation, and sustainability competences (Baliga, 2020; Mrugalska et al., 2024). This study contributes by framing OM education as an innovation system, made visible through the SIPOC framework and the teaching-

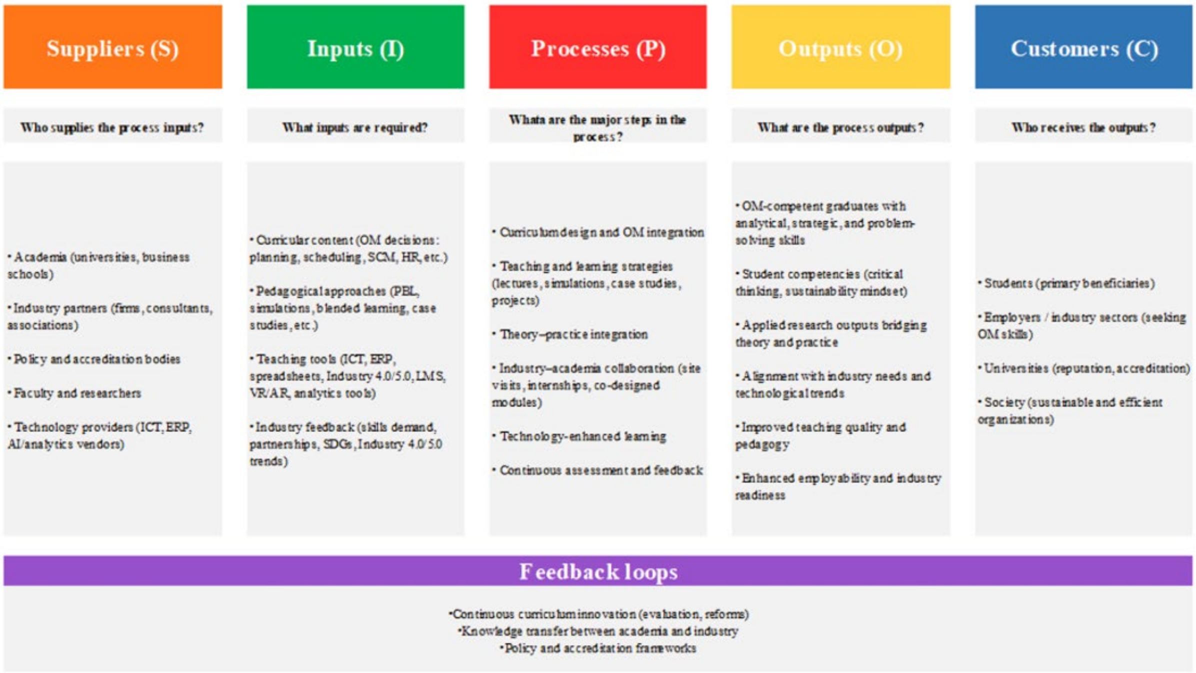

Figure 5. SIPOC-based framework of OM education in business administration programs (Source: Authors' own elaboration)

technology heatmap. These models synthesize existing knowledge and reveal complementarities, gaps, and opportunities for curriculum design, pedagogy, and industry-academia collaboration.

This discussion advances a system-level understanding of how OM education integrates curricular content, pedagogical innovation, and educational technologies to meet the demands of Industry 4.0 and sustainable business transformation. By framing OM education as an applied system of innovation, the review not only contributes to the theoretical foundations of management education reform but also provides actionable insights for educators and curriculum designers. These insights support the development of programs that align learning outcomes with evolving industry needs, including technological, organizational, and societal shifts.

CONCLUSIONS

This systematic review consolidates research on innovations in OM education, revealing how the field has evolved from fragmented, discipline-specific instruction toward an integrated, technology-enhanced, and practice-oriented learning system. By synthesizing 101 peer-reviewed studies published between 2000 and 2025, the review identifies how curriculum design, pedagogy, and educational technologies interact to shape the competencies required of future managers. This review confirms that OM has consolidated its role as a cornerstone of business administration education. Core OM areas such as planning and scheduling, product and process design, quality, inventory control, and SCM remain central, while transversal themes such as sustainability, risk management, and Industry 4.0 technologies are gaining prominence.

The findings indicate that OM education has increasingly adopted holistic and experiential curriculum models supported by digital technologies such as ERP systems, data analytics, simulation tools, and virtual environments. These resources, when combined with pedagogical approaches such as problem-based, blended, and project-based learning, help bridge the persistent gap between theory and practice. This convergence underscores OM's dual role as technical and strategic discipline within business administration programs, enabling students to develop analytical, managerial, and ethical capabilities aligned with Industry 4.0 and sustainable business transformation.

Beyond summarizing existing knowledge, this review contributes an integrative perspective by conceptualizing OM education as a dynamic interaction among academia, industry, policymakers, and technology providers. Through the SIPOC framework and the teaching-technology heatmap, the study offers a structured model that captures the systemic interdependencies across content, pedagogy, and technology. This model not only advances theoretical understanding but also serves as a practical tool for curriculum designers and educators seeking to align educational outcomes with evolving industrial and societal demands.

Therefore, OM education stands at the intersection of pedagogy, technology, and industry collaboration, providing a pathway for rethinking management education in the era of digital transformation and sustainability. The insights derived from this review contribute to both scholarship and practice by guiding the design of curricula that prepare graduates not only to manage operations efficiently but also to lead systemic innovation in a rapidly changing world.

Limitations and Future Research

This study has limitations. It relied exclusively on Scopus-indexed, peer-reviewed articles, excluding gray literature and works in other databases. As such, the findings reflect only part of the academic landscape. Future research should broaden coverage to include other databases and gray literature to capture emerging practices and experimental pedagogies. Further work is also needed to explore systematic integration of AI, big data, IoT, and cyber-physical systems into OM curricula without overwhelming students. For the academic community, the review provides a comprehensive synthesis that clarifies trends, identifies gaps, and delineates opportunities for future research. Future studies should deepen the empirical validation of holistic OM curriculum models, explore the long-term impact of digital learning tools on student outcomes, and investigate cross-regional differences in the adoption of educational technologies.

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