



ORIGINAL

## Logistics 4.0: Exploring Artificial Intelligence Trends in Efficient Supply Chain Management

### Logística 4.0: Explorando las Tendencias de la Inteligencia Artificial en la Gestión Eficiente de Cadenas de Suministro

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#### ABSTRACT

**Introduction:** in the current era of globalization and digitalization, international logistics faces unique challenges and opportunities. The growing demand for efficient supply chain management, combined with the need to reduce costs and improve services, has led to the adoption of advanced technologies such as Artificial Intelligence (AI). AI has become a key catalyst in the transformation of logistics, giving way to what is known as Logistics 4.0. This paper explores the most recent trends of AI in international logistics and its integration into education, with a specific focus on the San Mateo University Foundation.

**Methods:** this mixed study, combining qualitative and quantitative methods, begins with quantitative data collection and analysis, followed by a qualitative phase. The qualitative approach focuses on students' perceptions of logistics training, while the quantitative approach describes how they perceive AI tools. The research included students and companies in Bogota, analyzing their familiarity with AI and its implementation in practice.

**Results:** the findings indicate that AI is increasingly relevant in logistics, especially in process automation and data-driven decision making. Most companies surveyed have a good understanding of AI, but less than half implement it in their operations. Students recognize the importance of AI in logistics and its positive impact on education. There is consensus on the role of AI in improving educational quality, highlighting its usefulness in optimizing processes and personalizing learning.

**Conclusions:** the research highlights the crucial role of AI in modern logistics and its ability to improve operational efficiency. The integration of AI in international business education is critical to enrich students' learning experience and prepare them for the challenges of the labor market. The blended methodology used is effective in gaining a holistic view of AI integration in logistics and its educational impact. The conclusions provide guidelines for curriculum development in international business with a focus on international logistics, aligning curricula with emerging trends in logistics and AI.

**Keywords:** Logistics 4.0; Artificial Intelligence; Supply Chain.

#### RESUMEN

**Introducción:** en la era actual de globalización y digitalización, la logística internacional enfrenta desafíos y oportunidades únicas. La creciente demanda de una gestión eficiente de las cadenas de suministro, combinada con la necesidad de reducir costos y mejorar los servicios, ha llevado a la adopción de tecnologías avanzadas como la Inteligencia Artificial (IA). La IA se ha convertido en un catalizador clave en la transformación de la logística, dando paso a lo que se conoce como Logística 4.0. Este artículo explora las tendencias más recientes de la IA en la logística internacional y su integración en la educación, con un enfoque específico en

la Fundación Universitaria San Mateo.

**Métodos:** este estudio mixto, que combina métodos cualitativos y cuantitativos, comienza con la recopilación y análisis de datos cuantitativos, seguidos por una fase cualitativa. El enfoque cualitativo se centra en la percepción de los estudiantes sobre la formación en logística, mientras que el cuantitativo describe cómo perciben las herramientas de IA. La investigación incluyó a estudiantes y empresas en Bogotá, analizando su familiaridad con la IA y su implementación en la práctica.

**Resultados:** los hallazgos indican que la IA es cada vez más relevante en la logística, especialmente en la automatización de procesos y toma de decisiones basadas en datos. La mayoría de las empresas encuestadas tienen un conocimiento bueno de IA, pero menos de la mitad la implementan en sus operaciones. Los estudiantes reconocen la importancia de la IA en la logística y su impacto positivo en la educación. Se observa un consenso sobre el papel de la IA en mejorar la calidad educativa, destacando su utilidad en optimizar procesos y personalizar el aprendizaje.

**Conclusiones:** la investigación resalta el papel crucial de la IA en la logística moderna y su capacidad para mejorar la eficiencia operativa. La integración de la IA en la educación de negocios internacionales es fundamental para enriquecer la experiencia de aprendizaje de los estudiantes y prepararlos para los desafíos del mercado laboral. La metodología mixta utilizada es efectiva para obtener una visión holística de la integración de la IA en la logística y su impacto educativo. Las conclusiones proporcionan directrices para el desarrollo curricular en negocios internacionales con un enfoque en la logística internacional, alineando los programas de estudio con las tendencias emergentes en logística y IA.

**Palabras clave:** Logística 4.0; Inteligencia Artificial; Cadena de Suministro.

## INTRODUCTION

In the current context of globalization and digitization of business operations, international logistics is facing unprecedented challenges and opportunities. The demand for efficient supply chain management has intensified, and the pressure to reduce costs, minimize delivery times and improve service quality has led to the adoption of cutting-edge technologies. Among these technologies, artificial intelligence (AI) has emerged as a key catalyst in the transformation of international logistics, driving what is now known as Logistics 4.0.<sup>(1,2)</sup>

The inclusion of AI in international logistics has triggered a true revolution in the management of business processes and operations in an increasingly interconnected world.<sup>(3,4,5)</sup> AI, with its ability to analyze large volumes of data, make autonomous decisions and adapt intelligently to changing conditions, has proven to be an indispensable tool for optimizing the supply chain and improving efficiency in international trade.<sup>(6)</sup>

The term "Logistics 4.0" has been coined to describe this new era of supply chain management, in which AI and related technologies play a central role.<sup>(7,8)</sup> In this context, this article dives into the exploration of the most recent and promising trends in the field of AI applied to international logistics. We will analyze how AI is transforming decision making, route planning, inventory management and real-time supply chain visibility.<sup>(9,10,11,12,13,14)</sup>

In addition, this article has a particular focus on the educational field, since the San Mateo University Foundation recognizes the importance of staying at the forefront in the teaching of International Business. In this sense, it seeks to design a curricular proposal that effectively integrates Artificial Intelligence in the undergraduate curriculum, with a special emphasis on international logistics.<sup>(15,16)</sup> The fundamental purpose of this proposal is to prepare students to face the challenges and capitalize on the opportunities that AI provides in the field of intelligent international logistics.

To achieve this objective, it is required to conduct a thorough analysis of AI trends in international logistics, identify AI technological tools used in teaching international logistics, and critically evaluate the impact of AI on the training of professionals in this field. These specific objectives will serve as the framework for our research, guiding the creation of a solid and adequate curricular proposal that is aligned with the needs of International Business students at Fundación Universitaria San Mateo.

This article seeks to contribute to knowledge in the field of international logistics and artificial intelligence, while promoting the training of highly qualified professionals to lead in a world where innovation and technological adaptation are essential for success in international business in the 21st century.

## METHODS

This research is framed within a mixed nature study, combining qualitative and quantitative methods, with a sequential explanatory approach. It consists of an initial phase in which quantitative data are collected and analyzed, followed by a second phase in which qualitative data are collected and evaluated. The mixing of these methods occurs when the initial quantitative results guide the collection of qualitative data.

In the qualitative area, the objective is to detail the perception of the International Business students of the San Mateo Foundation about the training process in logistics, as well as the learning modalities in Logistics, International Physical Distribution and Supply Chain. In the quantitative area, the objective is to describe how the second, third and fourth semester students of the San Mateo Foundation perceive the tools operated by Artificial Intelligence (AI), taking into account the categories established by UNESCO and the Ministry of National Education (MEN) in relation to the competencies that citizens of the 21st Century must acquire.

We sought to identify deep, dimensional qualities through extensive data collection in order to gain a close understanding of students' perceptions of their education and how to improve classroom learning. This led to a holistic analysis and interpretation, using a quantitative, percentage-based approach to interpret the responses of the sample group in this research. The questions in the questionnaire were developed considering a pilot test, where the questions were structured according to parameters of affinity with the dimension of AI-related skills, as well as the perception of employers and teachers currently teaching International Logistics.

#### *Population and Sample*

The sample consists of 54 companies located in the city of Bogota, specifically in the field of logistics, transportation and distribution. On the other hand, a total population of 94 students of the International Business program at Fundación San Mateo, located at Carrera 17 #25-25 in Bogotá, was considered. These students were enrolled at the time of the study, of which 51 students actively participated, distributed in the subjects of: Global Supply Chain with a participation of 29,4 %, International Physical Distribution with a participation of 29,4 % and International Logistics with a participation of 41,2 %. Finally, the population of universities in Bogota is composed of 124 institutions, of which 20 were selected as a representative sample.

## **RESULTS**

### **Results of Surveys in Logistics Companies in Bogota**

**Knowledge and Application of Artificial Intelligence:** In a sample of 54 companies in Bogota, specialized in logistics, transportation and distribution, the familiarity and applicability of artificial intelligence (AI) was analyzed. Of these, 64,8 % (35 companies) have a good knowledge of AI, and 5,6 % (3 companies) a high knowledge. However, only 48,1 % (26 companies) are currently implementing AI in their operations. This indicates that, although more than half of the respondents have knowledge of AI, its effective implementation in their work processes is still lacking.

**Level of AI Experience:** Four levels of experience were identified:

- Beginner (31,5 %, 17 companies): in the initial exploration phase.
- Not Used (31,5 %, 17 companies): due to limitations of resources, knowledge or perceived relevance.
- Intermediate (24,1 %, 13 companies): implementation in process, without reaching an advanced level.
- Advanced (13 %, 7 companies): established and optimized use, increasing efficiency and competitiveness.

**Frequency of AI Application:** Companies vary in the frequency of AI application:

- Occasionally (44,4 %, 24 companies): willing to consider its use in certain operations.
- Always (22,2 %, 12 companies): constant commitment to its use.
- Almost never (20,4 %, 11 companies): reluctance or limited use.
- Never (13 %, 7 companies): total lack of implementation.

**AI Application Areas:** Identified uses of AI include:

- Supply chain and operations improvement (59,3 %, 32 companies).
- Support in financial planning, sales and marketing (18,5 %, 10 companies).
- No application (11,1 %, 6 companies).
- Forecasting market conditions and new product development (3,7 % each).
- Development of techniques for supplier selection and product promotion (1,9 % each).

**Concerns about AI Implementation:** Among companies, the main concerns are:

- Reduction of personnel (38,9 %, 21 companies).
- Implementation costs (33,3 %, 18 companies).
- Absence of concerns (25,9 %, 14 companies).
- Data management and legal issues (1,9 %, 1 company).

**Perceived Benefits of AI:** The benefits mentioned include:

- Cost and risk reduction and improved planning (61,1 %, 33 companies).
- Increased efficiency and effectiveness (33,3 %, 18 companies).
- Improved customer service (5,6 %, 3 companies).

- No concerns mentioned (0 %).

Investment in AI: Investment in AI varies:

- No investment (44,4 %, 24 companies).
- Limited investment (22,2 %, 12 companies).
- Moderate investment (20,4 %, 11 companies).
- Significant investment (13 %, 7 companies).

Future Perspectives in AI: Areas of focus include:

- Integration of emerging technologies (42,6 %, 23 companies).
- Increased automation in decision making (31,5 %, 17 companies).
- Focus on sustainability and reduction of environmental impact (24,1 %, 13 companies).
- None (1,9 %, 1 company).

AI Applications in Logistics: Applications include Bing, Bart, Gamma, Opencomex, chatbots, macros, process automation, automatic reporting, UiPath, SAP, Chat GPT, RPA, Cloud, Got, Zoho, Magaya, CRM, RFID in goods, AI algorithms for parts cubing, and more.

AI Training Areas: The areas of interest are:

- Supply chain (46,3 %, 25 companies).
- Logistics (29,6 %, 16 companies).
- International physical distribution (18,5 %, 10 companies).
- In all areas (1,9 %, 1 company).
- Cybersecurity and AI programming (1,9 %, 1 company).

These results highlight the potential of AI in improving logistics operations and their supply chain, reflecting a diversity in the adoption and application of AI in the sector. In addition, they underscore the need to address ethical and security concerns, crucial for a successful implementation of these advanced technologies.

### Results of Student Surveys on Artificial Intelligence in International Business

Context and Objective of the Survey: In today's globalized and technologically advanced context, International Businesses face challenges that require constant evolution. Logistics, as a fundamental pillar in this area, has incorporated artificial intelligence (AI) as a key tool to optimize and transform processes.

This survey focused on gathering the perception of International Business students about the integration of AI in their curriculum, seeking to understand their opinions, expectations and suggestions about the future career in relation to the adoption of AI.

Student Participation: Of the 94 students in the International Business program, 51 participated, distributed in the following subjects:

- Global Supply Chain: 29,4 %.
- International Physical Distribution: 29,4 %.
- International Logistics: 41,2 %.

Perception about Artificial Intelligence:

- AI is seen as a useful tool that improves efficiency in several areas.
- Unemployment concerns, ethical and social challenges.
- Recognition of its potential to reduce costs and process time.
- Seen as a technology that transforms life and work.

AI Knowledge Level:

- A student with advanced knowledge.
- Several students at intermediate level.
- Most of them at the basic level.

Previous experience with AI:

- Most (34 out of 51) with previous experience with AI applications in studies or work.
- 17 out of 50 with no previous experience.

Improving Educational Quality with AI:

- Unanimity (51 out of 51) that AI implementation in business can improve education.

Educational Improvement Justification with IA:

- Process optimization and better understanding of concepts.
- Need to adapt to technological advances.
- Personalization of learning and facilitation of logistical processes.
- Improved labor competitiveness and information enrichment.

Impact of AI on Logistics:

- Coordination and optimization of transportation as a major impact.
- Automated warehousing and personalized consulting.
- Trend forecasting.

Benefits of AI in Education:

- More efficient data analysis.
- Ease and greater access to online educational resources.
- Personalization of learning and automation of repetitive tasks.

Skills Acquired with AI in Logistics:

- Data analysis, optimization for problem solving.
- Software programming and development.
- Competence in AI and machine learning.
- Analytical thinking and project management.

Preferred Teaching Resources and Approaches:

- Exploration of tools and software.
- Company outings, interaction with experts.
- Online courses and hands-on labs.

Known AI tools:

- Simulation platforms, chatbots, predictive analytics.
- Virtual reality and others.

Implementation of AI in University Classrooms:

- Variability in implementation, from little to no implementation.

Interest in learning more about AI:

- Majority interested in deepening their knowledge in AI.

Challenges of Implementing AI in University Logistics:

- Lack of resources, risk of plagiarism, lack of experience.
- Creativity and privacy concerns.

AI Tools Used:

- Diversity of tools, from virtual assistants to simulation platforms.

Suggestions on AI Incorporation in Logistics:

- Interest in optimizing specific processes.
- Need for more technology and concern for data accuracy.

The results reflect a varied student perspective towards AI in International Business, highlighting both enthusiasm for its implementation and concerns about its challenges. The suggestions and comments provided can guide the development of educational programs in International Business, adapting them to the demands of the labor market and preparing students for a technologically advanced business environment.

### Summary of Results of Artificial Intelligence Surveys in Logistics Universities

The survey, aimed at logistics teachers in 20 selected universities in Bogota, sought to assess the knowledge and experience with Artificial Intelligence (AI) and its acceptance in logistics teaching. A 17-question questionnaire with multiple choice and opinion questions was used, collecting data through Google Forms.

Main Findings:

Acceptance of Survey Data Use:

- Most respondents consented to the use of their responses for academic purposes.

Participation of Universities:

- 20 % of the universities in Bogota participated, including institutions such as Uniciencia, Santo Tomas, Área Andina, among others. These universities are updating their curricula to integrate AI, aiming at interdisciplinary programs covering technical, ethical and legal aspects of AI.

Respondent Profile:

- The majority (90 %) were logistics faculty, with one dean representing the remaining 10 %.

Knowledge of AI:

- Manuela Beltran University stood out for its high level of knowledge in IA. Other universities showed varying levels of knowledge, while some, such as Universidad Areandina and Sena, showed less knowledge, attributed to lack of resources and experience.

IA Teacher Training:

- Almost half of the teachers (47 %) did not feel qualified to teach AI in logistics, which could affect educational quality. The rest (53 %) felt adequately prepared.

Professional Development Opportunities in IA:

- A majority (65,2 %) indicated having received professional development opportunities in IA, while 34,8 % had no such opportunities.

AI Perception:

- Most teachers associate AI with complex problem solving and its ability to think and act like a human.

Benefits of AI in Logistics Education:

- Most believe that AI brings advanced educational resources and personalizes learning in logistics.

Reinventing Teaching with AI:

- Use of Machine Learning, chatbots and AI systems to provide practical learning opportunities.

Inclusion of AI subjects in the curriculum:

- Teachers suggest adding subjects such as software development, blockchain and big data to the logistics curriculum.

Use of AI in Logistics Courses:

- Some 50 % use AI systems, while 26,1 % employ chatbots and Machine Learning.

AI Tools Used:

- Diversity of tools mentioned, including Machine Learning, Chat GPT, Cloud 2, among others.

AI Implementation Challenges:

- Concerns about plagiarism, teacher training, teacher substitution and ethics in AI implementation.

Resources and Support for AI Learning:

- Universities offer laboratories, AI tools, specialized courses and internships.

Role of Chatbots and Virtual Assistants:

- Primarily for student assistance and counseling, but also for administrative tasks and educational entertainment.

Evaluation of AI Implementation Success:

- Majority through research projects and student surveys.

A mixed picture is evident regarding knowledge and adoption of AI in logistics teaching at universities in Bogota. While some institutions are making progress, others face significant challenges, especially in terms of teacher training and available resources. Effective implementation of AI in higher education will require

continued attention to these issues.

## DISCUSSION

The study focused on designing a curricular proposal that effectively integrates Artificial Intelligence (AI) in the International Business curriculum, particularly in the area of international logistics, at the San Mateo University Foundation. This effort is framed within the analysis and documentary structure of the institution, ensuring that the proposal is aligned with the existing educational planning, and at the same time, establishes a transversal project in the institution.

The integration of meaningful AI applications into international logistics teaching models highlights the importance of orienting education towards the competencies required for 21st century citizens.<sup>(17,18,19,20,21)</sup>

During the research and data collection phase, several reiterative evidences were highlighted as a result of a thorough analysis of the existing literature on AI learning.<sup>(22)</sup> This evidence highlights key areas of opportunity and integration, focusing on understanding the fundamentals of machine learning and its practical applications in logistics optimization.<sup>(23)</sup> The cross-cutting nature of engineering in this educational approach is notable, with skills in data analytics and statistics becoming critically relevant to the interpretation of vital supply chain information.<sup>(17,19,24)</sup>

In addition, familiarity with advanced techniques, such as natural language processing, is essential for the interpretation of documents, interactions and unstructured data related to logistics.<sup>(25)</sup> This competence becomes a valuable complement to the traditional educational model, enriching creativity and cooperative work in problem solving. The challenge is to adapt these elements to the traditional conceptual model of the institution, seeking not only to obtain results in terms of creativity and cooperation, but also to reflect and adapt the educational model to the current and future needs of the business environment.<sup>(26,27,28)</sup>

The implementation of this curricular proposal represents an important step forward for Fundación Universitaria San Mateo. By integrating AI into its International Business program, the institution positions itself at the forefront of business education, preparing its students to meet the challenges of the 21st century with a solid foundation in technology, data analytics and a deep understanding of international logistics. This holistic, cross-disciplinary approach ensures that graduates are equipped not only with technical knowledge, but also with critical thinking, creativity and collaboration skills essential to their success in the dynamic world of global business.

## CONCLUSIONS

The findings of this study shed light on fundamental aspects that are redefining current logistics practices:

1. **Crucial Role of Artificial Intelligence in Logistics:** the research underlines the growing importance of Artificial Intelligence in the field of logistics. It highlights its role in transforming supply chain management, highlighting process automation, data-driven decision making and efficient resource optimization.
2. **Increased Operational Efficiency:** the implementation of AI in logistics has been found to lead to significant improvements in operational efficiency. This is particularly evident in key areas such as route planning, inventory management and early detection of irregularities in the supply chain.
3. **Enriching the Educational Experience:** integrating AI into the International Business curriculum, with a focus on logistics, proves to be an effective strategy to enrich the educational experience for students. The practical application of AI tools in logistics concepts facilitates more immersive and applicable learning.
4. **Integral Development of Students:** the inclusion of AI in the education of students from second to fourth semester promotes comprehensive development, equipping them to meet the challenges of an increasingly technological and dynamic labor market.
5. **Effectiveness of the Mixed Methodology:** the adoption of a mixed methodology that combines quantitative and qualitative analysis has proven to be crucial to comprehensively understand the incorporation of AI in logistics and its impact on education.
6. **Guidelines for Curricular Development:** the findings of the study provide valuable guidelines for improving the curricular structure in International Business, specializing in International Logistics. These recommendations are aimed at improving the integration of IA into curricula, ensuring that they are aligned with current and emerging trends in logistics.

The findings of this study reflect the ongoing transformation in the field of logistics driven by AI and highlight the need to adapt International Business education to stay ahead of these dynamic changes.

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