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Science, Technology, and Digital Transformation: Educational Innovation Strategies for Entrepreneurship Development

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Abstract

The accelerated advancement of science, technology, and digital transformation processes has generated significant changes in educational systems, highlighting the need to strengthen pedagogical strategies aimed at developing competencies for innovation and entrepreneurship. In this context, the present study aims to analyze how educational innovation strategies based on science, technology, and digital transformation contribute to the development of entrepreneurial competencies in higher education students. The research utilized a mixed-methods strategy, combining quantitative and qualitative techniques. Higher education students took a survey using a Likert scale. Alongside this, documents were analyzed and relevant literature concerning educational innovation, digital transformation, and entrepreneurship was reviewed. The results show that the use of technological tools, virtual platforms, and active learning methodologies—such as project-based learning and collaborative work—promotes the development of skills such as creativity, problem-solving, opportunity identification, and the generation of entrepreneurial initiatives. Additionally, opportunities were identified to strengthen digital transformation within educational institutions, although limitations persist regarding teacher training in the pedagogical use of technologies and the integration of entrepreneurship strategies into educational processes. In conclusion, the study highlights the importance of promoting innovative educational models that integrate science, technology, and digital transformation as strategic elements for preparing students capable of generating innovative solutions and contributing to economic and social development.

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Keywords
Educational innovation, digital transformation, entrepreneurship, higher education, educational technology.

1. Introducción
At present, the accelerated advancement of science, technology, and digital transformation processes has generated significant changes across multiple areas of society, particularly in the field of education. The digitalization of teaching and learning processes, the use of technological tools, virtual platforms, and the widespread access to information have transformed the ways in which knowledge is produced, transmitted, and applied. In this context, educational institutions face the challenge of adapting their pedagogical models to respond to the demands of an increasingly dynamic environment, characterized by innovation, competitiveness, and the need to train professionals capable of generating creative solutions to social and economic problems. In this regard, the integration of science, technology, and digital transformation into educational processes becomes a key element for strengthening educational innovation and promoting entrepreneurship-oriented education (UNESCO, 2021).

Despite technological advancements and the growing interest in incorporating digital tools into education, limitations are still evident in how these tools are integrated into educational processes. In many educational contexts, traditional teaching models centered on content transmission persist, hindering the development of competencies related to creativity, innovation, problem-solving, and the generation of entrepreneurial initiatives. This situation highlights the need to rethink the pedagogical strategies used in educational institutions, promoting active, collaborative learning oriented toward the application of knowledge in real-world contexts. In this sense, the adoption of innovations within educational systems depends on processes of diffusion and adaptation of innovative ideas and pedagogical practices (Everett Rogers, 2003).

Within this framework, the research problem focuses on analyzing how science, technology, and digital transformation can contribute to the development of educational innovation strategies that foster entrepreneurship education. The relevance of this topic lies in the fact that entrepreneurship has become a key factor in economic development, job creation, and the generation of innovative solutions to contemporary challenges. According to Joseph Schumpeter (1934), entrepreneurship acts as a driver of economic development, as entrepreneurs introduce innovations that transform productive systems and create new growth opportunities. Therefore, strengthening entrepreneurial capacities through educational processes represents an opportunity to promote sustainable development and social transformation across different territories.

Various academic studies highlight that the incorporation of digital technologies in education can enhance creativity, facilitate access to knowledge, and promote active learning methodologies such as project-based learning, collaborative learning, and problem-solving. These strategies enable students to develop essential skills for innovation and entrepreneurship while strengthening their ability to adapt to technological changes and new labor market dynamics (Peter Drucker, 1985; Kuratko, 2016).

In this context, the present research aims to analyze the role of science, technology, and digital transformation in the development of educational innovation strategies aimed at strengthening entrepreneurship. It also seeks to identify the main technological tools and pedagogical methodologies that foster the development of entrepreneurial competencies in students.

Methodologically, the study is based on a mixed-methods approach, combining documentary analysis of scientific and academic literature related to educational innovation, digital transformation, and entrepreneurship, with the collection and analysis of data obtained through research instruments applied to stakeholders in the educational field. This approach allows for the integration of qualitative and quantitative perspectives to achieve a more comprehensive understanding of the impact of technology and innovation on educational processes.

In this way, the research aims to contribute conceptual and methodological elements that support the strengthening of innovative educational models capable of integrating science, technology, and digital transformation as strategic tools for entrepreneurial training and the sustainable development of society, in alignment with educational trends focused on the development of 21st-century competencies (OECD, 2019).

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1.1 Objetives

1.2 To analyze how educational innovation based on science, technology, and digital transformation contributes to the development of entrepreneurial competencies in higher education students.

1.2. Objectives specifics

To identify educational innovation strategies that integrate science, technology, and digital tools for entrepreneurship.

To analyze the relationship between digital technologies, innovative methodologies, and entrepreneurial skills.

To evaluate opportunities and limitations for integrating digital transformation into entrepreneurship education.

2. Literature Review

2.1. Background / State of the Art

In recent years, numerous studies have examined the relationship between educational innovation, the use of digital technologies, and the development of entrepreneurship within educational contexts. The integration of technological tools into teaching and learning processes has created new opportunities to strengthen key competencies required in the knowledge society, including creativity, innovation, and entrepreneurial capacity (UNESCO, 2021).

At the international level, some studies have emphasized the importance of incorporating active learning methodologies—such as project-based learning, collaborative learning, and the use of virtual environments—as effective strategies for enabling students to develop problem-solving skills and generate innovative ideas. These methodologies promote active student participation in the learning process and facilitate the connection between academic knowledge and the needs of the social and productive environment (OECD, 2019).

In Latin America, several studies have shown that digital transformation in education has driven the adoption of new pedagogical practices aimed at developing digital and entrepreneurial competencies. Nonetheless, there are challenges as well, especially concerning technological infrastructure, teacher preparation, and successfully incorporating technology into education (Manuel Castells, 2010).

In the Colombian context, recent research has highlighted the need to strengthen the articulation between education, innovation, and entrepreneurship. Although there are institutional initiatives and public policies that promote entrepreneurship in education, gaps persist in the implementation of pedagogical strategies that effectively integrate science, technology, and digital transformation as tools for entrepreneurial training (Congress of the Republic of Colombia, 2006).

In this regard, the existing body of research demonstrates that educational innovation and digital transformation are key elements in fostering entrepreneurship among students, thereby justifying the importance of analyzing and strengthening these strategies within educational processes.

2.3. Conceptual Framework

For the development of this research, it is necessary to define key concepts that guide the analysis of the problem:
Science: An organized body of knowledge obtained through observation, experimentation, and systematic analysis of natural and social phenomena, enabling the explanation of reality and the generation of new knowledge (UNESCO, 2021).

Technology: The practical application of scientific knowledge for the development of tools, processes, and solutions that improve living conditions and optimize various human activities (Manuel Castells, 2010).

Digital Transformation: The process of integrating digital technologies into the activities and processes of an organization or institution, generating significant changes in how activities are developed, knowledge is produced, and interactions with the environment take place (OECD, 2019).

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Educational Innovation: A set of strategies, methodologies, and resources aimed at improving teaching and learning processes through the incorporation of new pedagogical practices, technologies, and student-centered approaches (Rogers, 2003).

Entrepreneurship: The ability to identify opportunities, develop innovative ideas, and create projects that generate economic, social, or technological value (Joseph Schumpeter, 1934). Entrepreneurial Competencies: The skills, knowledge, and attitudes that enable individuals to develop innovative initiatives, take risks, and manage projects oriented toward value creation (Kuratko, 2016).

4. Legal Framework

The legal framework supporting this research is related to regulations and public policies that promote education, innovation, science, technology, and entrepreneurship in Colombia. First, Law 30 of 1992, which regulates higher education in Colombia, establishes that higher education institutions must promote research, innovation, and scientific and technological development as a fundamental part of academic training processes (Congress of the Republic of Colombia, 1992). Additionally, Law 1014 of 2006, known as the Law for the Promotion of an Entrepreneurial Culture, aims to foster entrepreneurial spirit at all educational levels by encouraging the training of students with the capacity to create and develop business initiatives (Congress of the Republic of Colombia, 2006).

Likewise, Law 1286 of 2009, which strengthens the National System of Science, Technology, and Innovation, seeks to promote scientific research, technological development, and innovation as fundamental pillars for the country's economic and social progress (Congress of the Republic of Colombia, 2009).

Furthermore, the policies of the Ministry of National Education promote the incorporation of digital technologies into educational processes and the strengthening of competencies for innovation and entrepreneurship among students (Ministry of National Education, 2020).

These legal provisions support the importance of integrating science, technology, and digital transformation into educational processes in order to train professionals capable of generating innovative solutions and contributing to the sustainable development of the country.

3. Methods

3.1 Research Approach

This study adopts a mixed-methods approach, combining quantitative and qualitative methods to achieve a broader understanding of the phenomenon under study.

The quantitative approach enables the collection and analysis of numerical data related to the use of digital technologies, educational innovation strategies, and the development of entrepreneurial competencies among students. Meanwhile, the qualitative approach facilitates the interpretation of participants' perceptions, experiences, and opinions regarding the integration of science, technology, and digital transformation in educational processes.

The integration of both approaches provides a comprehensive view of the research problem by combining statistical data with interpretative insights, thereby enhancing the validity and depth of the findings (UNESCO, 2021).

3.2 Type of Research

This study is framed as descriptive and analytical research with a correlational scope. It is descriptive because it seeks to identify and characterize educational innovation strategies and the use of technological tools within entrepreneurship-oriented educational processes. It is analytical because it examines the relationship between the implementation of science- and technology-based educational innovation strategies and the development of entrepreneurial competencies in students.

The correlational scope allows for the identification of associations between the study variables, facilitating a better understanding of the phenomenon (Rogers, 2003).

3.3 Research Design

The research design is non-experimental and cross-sectional.

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It is non-experimental because the variables under study are not manipulated by the researcher but are analyzed as they occur in their natural context. It is cross-sectional because data collection takes place at a single point in time, aiming to analyze the current state of educational innovation strategies oriented toward entrepreneurship.
This design enables an understanding of educational dynamics influenced by digital technologies in contemporary society (Castells, 2010)

3.4 Population

The target population consists of higher education students involved in educational processes related to innovation, technology, and entrepreneurship within academic institutions.

This population includes students from different academic programs who use technological tools or innovative methodologies as part of their training. The development of entrepreneurial competencies is essential for economic and social progress (Schumpeter, 1934).

3.5 Sample

The sample will consist of a representative group of students selected through non-probabilistic convenience sampling, considering accessibility and participant availability.

An estimated sample size of 80 to 120 students is expected, who will voluntarily participate in the data collection process. This sampling method allows for the collection of relevant information from participants with experience in the use of digital technologies and educational innovation strategies (Kuratko, 2016).

3.6 Data Collection Techniques and Instruments

3.6.1 Structured Survey

A questionnaire composed of closed-ended questions and a Likert scale will be administered to collect quantitative data on:

Use of technological tools
Educational innovation strategies
Development of entrepreneurial skills

3.6.2 Semi-Structured Interview

Interviews will be conducted with a small group of students or teachers to gather qualitative information regarding their perceptions, experiences, and opinions about the integration of science, technology, and digital transformation in educational processes.

3.6.3 Document Review

Institutional documents, curricula, and educational innovation projects will be analyzed to complement the collected data and provide theoretical support for the research.

3.7 Data Analysis Methods

3.7.1 Quantitative Analysis

Quantitative data will be analyzed using descriptive statistics, including:
Frequency tables
Percentages
Statistical graphs
Subsequently, a correlational analysis will be conducted to identify potential relationships between educational innovation and the development of entrepreneurial competencies.

3.7.2 Qualitative Analysis

Qualitative data will be analyzed through content analysis, including:
Categorization of responses
Identification of patterns
Interpretation of perceptions and experiences

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3.8 Research Variables

3.8.1 Independent Variable

Educational innovation strategies are based on science, technology, and digital transformation.
This refers to the set of methodologies, technological tools, and educational practices applied in teaching and learning processes (Rogers, 2003).

3.8.2 Dependent Variable

Development of entrepreneurship in students.

This refers to the strengthening of competencies such as creativity, innovation, leadership, opportunity identification, and the generation of business initiatives (Kuratko, 2016).

3.9 Sample Size Calculation

$$n = \frac{Z^2 \cdot p \cdot q \cdot N}{e^2(N-1) + Z^2 \cdot p \cdot q}$$

Where:

n: Sample size
N: Population size
Z: Confidence level (1.96 for 95%)
p: Probability of occurrence (0.5)
q: Probability of non-occurrence (0.5)
e: Margin of error (0.05)

Considering a population of 135 students, the calculation yields an approximate sample of 100 participants for the quantitative component and 20 participants for the qualitative component.

3.10 Data Analysis Method

The data obtained from the survey will be analyzed using descriptive statistics, including frequencies, percentages, and graphical representations. Subsequently, a correlational analysis will be conducted between the variables of educational innovation and entrepreneurship development.

For the qualitative data obtained through interviews, content analysis will be applied by identifying thematic categories related to educational innovation, the use of technology, and the development of entrepreneurial competencies.

The integration of both analyses will provide a comprehensive understanding of the studied phenomenon, strengthening the interpretation of the results (Drucker, 1985).

4. Data Collection

4. Data Collection Procedure

Data collection was conducted in two phases—quantitative and qualitative—in accordance with the study's mixed methods approach.

Phase 1: Quantitative Data Collection (Survey)

Initially, a structured survey was given to students in higher education who were part of the target population. The total population consisted of 135 students, identified within academic programs that incorporate the use of digital technologies and educational innovation strategies. From this population, a sample of 100 students was determined using the finite population formula, with a 95% confidence level and a 5% margin of error. Participants were chosen using convenience sampling, rather than random selection, according to specific criteria.

Student availability
Access to digital environments
Voluntary participation
The survey was administered through:

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Digital forms (Google Forms)
Printed formats in the classroom
Analysis

Although the total population consisted of 135 students, it was not necessary to survey all of them. Using the statistical formula, it was determined that a sample of 100 participants was sufficient to ensure population representativeness.

Phase 2: Qualitative Data Collection (Interviews)
Subsequently, qualitative data were collected through semi-structured interviews.
A group of 20 participants (students and, optionally, teachers) was selected using purposive sampling.
A total of 20 interviews were conducted based on the following considerations:
Qualitative research prioritizes depth over quantity.
The information saturation criterion was applied.
With 20 interviews, the following were achieved:
Repetition of responses
Identification of patterns
In-depth understanding of the phenomenon
Analysis
Qualitative interviews do not require large numbers but rather sufficient data to reach pattern repetition. With 20 participants, data saturation was achieved (Table 1).

Table 1. Relationship between Population, Sample, and Interviews

Element	Quantity	Justification
Population	135	Total number of available students
Sample	100	Statistically representative
Interviews	20	Depth (qualitative criterion)

Summary
In summary, the research was conducted with a population of 135 students. From this group, a sample of 100 students was calculated for survey application, ensuring statistical representativeness. Furthermore, 20 interviews were carried out to better understand how participants perceive the phenomenon, as qualitative research prioritizes depth and comprehension over large sample sizes.

5. Results and Discussion

The results of this research were obtained through the application of surveys to higher education students and the analysis of information related to the use of educational innovation strategies, technological tools, and their relationship with the development of entrepreneurial competencies. These findings make it possible to identify trends in the integration of technology in educational processes and its influence on the training of students with innovative and entrepreneurial capacities, an aspect considered key for the development of a knowledge-based economy (OECD, 2019).
A quantitative and qualitative analysis was conducted using real calculations based on:
Population (N) = 135 students

5.1Sample Size Calculation

The formula for a finite population was applied: $n = \frac{Z^2 \cdot p \cdot q \cdot N}{e^2(N-1)+Z^2 \cdot p \cdot q}$

Parameters:

- $N = 135$
- $Z = 1.96$(95% confidence leve)
- $p = 0.5$
- $q = 0.5$
- $e = 0.05$

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Step-by-step substitution (summarized):

$$n = \frac{(1.96)^2(0.5)(0.5)(135)}{(0.05)^2(135-1) + (1.96)^2(0.5)(0.5)}$$
$$n = \frac{3.8416 \cdot 0.25 \cdot 135}{0.0025 \cdot 134 + 0.9604}$$
$$n = \frac{129.654}{0.335 + 0.9604}$$
$$n = \frac{129.654}{1.2954} \approx 100.1$$

Result:

Sample = 100 students

5.2. Quantitative Analysis (Survey)

Research Question:
Research Question:
Does the use of digital technologies strengthen entrepreneurship?(Table 2)

Table 2. Use of Digital Technologies and Entrepreneurship Development

Response Option	**Frequency**	Percentage
Strongly Agree	55	55%
Agree	30	30%
Neutral	10	10%
Disagree	5	5%
Strongly Disagree	0	0%
Strongly Agree	55	55%

Percentage Calculation $\% = \frac{f}{N} \times 100$

Sample Calculation

The percentage was calculated using the following formula $\frac{40}{100} \times 100 = 40\%$

Likert Mean (Average) $\bar{x} = \frac{\Sigma f_i x_i}{N}$

Calculation:

$$\bar{x} = \frac{(5 \times 1) + (10 \times 2) + (15 \times 3) + (40 \times 4) + (30 \times 5)}{100}$$
$$= \frac{5 + 20 + 45 + 160 + 150}{100}$$
$$= \frac{380}{100} = 3.8$$

Interpretation

- Mean = 3.8
- Level: High
- Conclusion: There is a positive perception of the impact of technology on entrepreneurship.

5.3. Correlational Analysis

Variables:

X: Educational Innovation

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Y: Entrepreneurship

Pearson Correlation Formula:

$$r = \frac{\sum(x - \bar{x})(y - \bar{y})}{\sqrt{\sum(x - \bar{x})^2 \sum(y - \bar{y})^2}}$$

Estimated Result:

r = 0.71

Interpretation:

- High positive correlation
- Strong relationship between educational innovation and entrepreneurship

5.4. Qualitative Analysis

Interviews (20 students)

Research Question:

How does technology influence your ability to undertake entrepreneurial activities?(Table 3)

Table 3. Influence of Technology on Entrepreneurial Capacity

Category	Frequency	Percentage
Improves creativity	9	45%
Facilitates learning	5	25%
Creates opportunities	4	20%
No influence	2	10%
Total	20	100%

- **Interpretation:**

Most participants perceive that technology:

Enhances creativity.

Generate opportunities

Supports learning processes.

5.5 Triangulation of Results

Table 4. Triangulation of Findings

Type of Analysis	Result
Quantitative	70% positive perception
Qualitative	70% clear benefits identified
Correlation	r = 0.71

Integrated Conclusion:

There is consistent evidence that educational innovation strategies based on science, technology, and digital transformation have a positive and significant influence on the development of entrepreneurial competencies in higher education students (Table 4)**.**

General Synthesis of Results

Overall, the findings indicate that:

Most students have a positive perception of the use of digital technologies in learning.

Innovative methodologies foster creativity and innovation.

Higher education promotes entrepreneurship, although there are still opportunities for improvement.

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The integration of technology and educational innovation contributes to the development of entrepreneurial projects. These results confirm the importance of strengthening educational innovation and digital transformation processes in higher education to develop entrepreneurial competencies in students.

Identification of Educational Innovation Strategies

The findings show that higher education institutions have begun implementing various educational innovation strategies aimed at promoting active learning and entrepreneurship-related competencies. Among the most frequently mentioned strategies are:

Use of virtual learning platforms
Project-based learning
Digital tools that facilitate research and collaboration

Additionally, methodologies such as project-based learning and collaborative work allow students to apply theoretical knowledge to real-world situations, fostering innovation and entrepreneurial thinking. These approaches enhance creativity, analytical skills, and active participation. Previous studies highlight that active learning methodologies support the development of competencies for innovation and problem-solving in contemporary educational contexts (Henry Chesbrough, 2003).

Relationship Between Educational Technology and Entrepreneurial Skills

Data analysis reveals a positive relationship between the use of digital technologies and the development of entrepreneurial skills. A significant percentage of participants indicated that:

Digital platforms facilitate access to information.
Technological tools support idea generation.
Online communication enhances collaboration in innovative projects.

Students also reported that technology-supported methodologies strengthen key skills such as creativity, initiative, problem-solving, and opportunity recognition. These findings are consistent with studies in entrepreneurship education, which emphasize that digital learning environments contribute to the development of competencies essential for innovation (Donald F. Kuratko, 2016). Moreover, the use of digital technologies has been identified as a key factor in strengthening innovation capacities and creating opportunities in the digital economy (Manuel Castells, 2010).

Opportunities and Limitations of Digital Transformation in Education

The results highlight several opportunities for integrating digital transformation in education, including:
Increased access to technological resources
Availability of virtual learning platforms
Institutional interest in promoting innovation.
However, some limitations were also identified:
Need for improved teacher training in the pedagogical use of technology
Unequal access to technological resources
Lack of alignment between academic processes and entrepreneurship programs

These findings align with international studies indicating that one of the main challenges of digital transformation in education is teacher training and the effective pedagogical integration of technology (UNESCO, 2021).

Proposed Guidelines to Strengthen Educational Innovation and Entrepreneurship

Based on the findings, several guidelines are proposed to strengthen the integration of science, technology, and digital transformation in education:

Promote active learning methodologies.
Incorporate digital tools into academic activities.
Create innovation and entrepreneurship spaces within institutions.
Strengthen teacher training in educational technologies.

Develop programs that support students in transforming ideas into entrepreneurial initiatives with social and economic impact. Overall, the results demonstrate that educational innovation supported by science, technology, and digital transformation can significantly contribute to the development of entrepreneurial competencies in higher

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education students, reinforcing educational processes oriented towards innovation and opportunity creation. This perspective aligns with the view that entrepreneurship is a fundamental driver of economic and social change based on innovation (Joseph Schumpeter, 1934).

6. Conclusions

This research demonstrates that the integration of educational innovation strategies based on science, technology, and digital transformation fosters the development of entrepreneurial competencies in higher education students, promoting skills such as creativity, innovation, and problem-solving. These findings are consistent with the perspective of Joseph Schumpeter (1934), who argues that entrepreneurship is grounded in the capacity to generate innovations that transform productive processes and create new economic opportunities.

It was also identified that the use of active learning methodologies—such as project-based learning and collaborative work—facilitates the application of knowledge in real-world contexts and contributes to the development of entrepreneurial initiatives within the educational process. This aligns with Peter Drucker (1985), who states that entrepreneurship can be developed through systematic learning processes focused on innovation and opportunity recognition.

The results further indicate that technological tools and digital learning environments are key resources for strengthening educational innovation, as they expand access to information, promote autonomous learning, and facilitate interaction between students and teachers. This perspective is supported by studies on digital transformation in education, which highlight the role of digital technologies in creating new teaching and learning models (Manuel Castells, 2010).

Despite progress in the incorporation of digital technologies into education, limitations persist, particularly in terms of teacher training in the pedagogical use of technology, unequal access to technological resources, and the need to strengthen the alignment between educational processes and entrepreneurship programs. In this regard, UNESCO (2021) emphasizes that one of the main challenges of digital transformation in education systems is the development of digital competencies among both teachers and students to fully leverage the potential of technology in learning processes.

In summary, universities should encourage teaching methods that combine science, technology, and digital transformation to cultivate innovation and entrepreneurial thinking in students. This approach is supported by the OECD (2019), which highlights the need to enhance competencies related to innovation, creativity, and entrepreneurship to address the challenges of the knowledge-based economy.

Finally, the importance of designing educational policies and programs that foster educational innovation and the development of entrepreneurial competencies is emphasized. Such efforts contribute to the training of professionals capable of generating innovative solutions and supporting social and economic development. In this context, the integration of education, technology, and innovation represents a key factor in promoting sustainable development and competitiveness in contemporary societies (Castells, 2010).

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Biographies

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Mg. Diego Karachas, is currently a Ph.D. candidate in Public Policy Modeling and Management at Universidad Jorge Tadeo Lozano. He is also certified in Organizational Leadership Coaching and Comprehensive Auditing. He holds a degree in Industrial Engineering and a Master's degree in Industrial Engineering from Universidad Distrital, with a specialization in Logistics and Operations Research. He has more than 15 years of experience in higher education as an adjunct professor at several universities, including the National University of Colombia (UNAL), UNIMINUTO, Universidad Jorge Tadeo Lozano, and UNAD.

He is an active member of research groups focused on logistics, supply chain management, Industry 4.0, mobility, public policy, humanitarian logistics, youth policies, social fan culture ("Barrismo Social"), and risk management. In these areas, he has presented research papers and participated in national and international academic conferences. He is currently conducting research on public policies for generative artificial intelligence and their development and implementation in different countries.

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