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Potential Research Impact in a Colombian Systems Engineering Programme: A Mixed Descriptive Analysis of Thematic and Policy Alignment

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ABSTRACT

This study analyzes the impact of research produced by the Systems Engineering program on technological, social, productive, and territorial development by examining its contribution to innovation, public policy, and sustainable development. A mixed descriptive approach combining quantitative and qualitative analysis was used to examine 20 unique articles reported by the programme. The quantitative component summarized the research portfolio through frequencies and percentages, while the qualitative component examined thematic orientation, areas of application, and alignment with national, regional, and international policy frameworks. The findings indicate that the program's research is primarily focused on strategic areas such as artificial intelligence, Big Data, software engineering, digital transformation, information and communication technologies (ICT), entrepreneurship, blockchain, fintech, and digital inclusion. These research areas contribute to strengthening technological innovation, organizational competitiveness, digital education, evidence-based

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decision-making, and knowledge transfer while addressing societal challenges related to sustainability, inclusion, and regional development. Furthermore, the results highlight the program's role in promoting innovation ecosystems and fostering collaboration among academia, industry, government, and society, thereby supporting regional competitiveness and sustainable growth. The study also demonstrates the relevance of aligning academic research with public policy priorities and emerging technological challenges. Finally, it recommends strengthening research impact assessment through systematic monitoring of knowledge transfer, stakeholder engagement, applied research projects, and the social appropriation of scientific knowledge to maximize the contribution of research to sustainable territorial development.

Keywords: Systems Engineering; Research Impact; Digital Transformation; Technological Innovation; Sustainable Development

1. Introduction

The research conducted within Systems Engineering programmes is a strategic pillar for understanding how knowledge generation contributes to the technological, productive, social and institutional transformation of the environment. In a context characterised by the acceleration of digital transformation, the expansion of artificial intelligence, the intensive use of data, process automation, cybersecurity, software development, and the consolidation of innovation ecosystems, academic research acquires a function that transcends scientific production. It facilitates the provision of solutions, the guidance of decisions, the strengthening of capacities, and the response to real-world problems in society and the productive sector.

Assessing the relevance of research requires looking beyond academic production and considering how scientific knowledge relates to technological, productive, social, and institutional needs. The programme's publications address areas such as artificial intelligence, data analytics, software development, digital transformation, ICT-mediated education, entrepreneurship, and technological inclusion, all of which reflect current challenges faced by organisations, communities, and territories. This orientation is consistent with the programme's foundational document, which links academic production with curriculum development, quality, research, teaching, and community outreach. From this perspective, the analysis also considers how these research areas connect with public policies, development agendas, productive needs, and territorial innovation.

Recent studies indicate that university–industry collaboration can strengthen digital transformation and innovation by connecting academic knowledge, technological capabilities, and organizational needs. These collaborative

relationships facilitate the identification of real-world problems, the development of applied research projects, and the transfer of scientific results to productive and social contexts. However, their effectiveness depends on the existence of institutional mechanisms that support communication, trust, joint planning, and sustained interaction among universities, companies, public institutions, and other stakeholders. In this regard, Knowledge Transfer Offices and similar institutional structures play a relevant role in identifying transferable results, promoting collaborative opportunities, supporting intellectual property management, and facilitating the practical application of research. Long-term cooperation models can also strengthen the participation of small and medium-sized enterprises in innovation ecosystems, allowing academic knowledge to contribute more directly to technological modernization, organizational competitiveness, and territorial development^[1–3].

The present study aims to assess the potential contribution of the Systems Engineering programme's research to its surrounding environment by examining the alignment of its scientific production with development plans, the Sustainable Development Goals, and strategic priorities in science, technology, and innovation.

Based on this objective, the study addresses the following research questions:

- RQ1. What thematic areas characterize the scientific production of the Systems Engineering programme, and how is this production quantitatively distributed across the identified research areas?
- RQ2. How does the programme's scientific production align with public policy priorities, territorial development agendas, and the Sustainable Development Goals, and what potential pathways of contribution can be identi-

fied from this alignment?

RQ3. How does the thematic profile of the programme's research compare with patterns reported for other Information Systems programmes in international contexts?

2. Analytical Framework

In order to analyse the impact of research on the environment, it is necessary to establish a coherent understanding between the programme's scientific output and the main public policy frameworks that guide national, departmental, district and global development^[4].

In this study, research impact is understood as the contribution of scientific knowledge to changes, benefits, or developments beyond academic publication, including effects on public policy, organisational or productive practices, social conditions, technological capabilities, and institutional decision-making. This understanding is consistent with research impact frameworks that distinguish the production of knowledge from its demonstrable use or influence outside academia^[4,5]. Accordingly, a distinction is made between potential impact and realized impact. Potential impact refers to the relevance and plausible contribution of research outputs to external needs, priorities, or challenges, whereas realized impact requires evidence that research knowledge has been used, adopted, implemented, or has contributed to observable changes among external stakeholders.

In the Colombian case, the 2022–2026 National Development Plan, “Colombia, a World Power for Life,” identifies connectivity and digital transformation as strategic drivers of opportunity, wealth, and equality, as well as science, technology, and innovation for productive transformation, addressing social, economic, and environmental challenges, and building a knowledge society^[6,7]. These priorities are directly related to research in Systems Engineering, especially when it focuses on emerging technologies, data analysis, the development of digital solutions, automation, technological education, and strengthening digital capabilities^[8].

Moreover, the National Development Plan acknowledges the significance of enhancing the physical and technological infrastructure of higher education, in addition to information systems and human talent in strategic sectors^[9]. This underscores the significance of university research out-

put as a crucial input for innovation, knowledge transfer, and evidence-based decision-making^[7,10]. Furthermore, the same plan proposes strengthening basic and applied research, scientific ecosystems, talent development in emerging and convergent digital technologies, and the integration of knowledge, technology, society, and the productive sector—aspects that connect with the applied focus of research in Systems Engineering.

At the territorial level, the 2024–2027 Departmental Development Plan, “For a Strong Antioquia,” underscores the imperative to establish physical and digital connections between people and markets in the subregions, enhance local technical and institutional capacities, and foster alliance-based territorial development strategies^[11]. This vision enables us to comprehend the program's research as an academic resource with the capacity to contribute to the reduction of the digital divide, the enhancement of information systems, the management of data, the augmentation of regional productivity, and the modernisation of processes in public and private organisations. The departmental plan incorporates a logic of monitoring, evaluation, and generating public value, an aspect that is relevant for analysing the impact of research not only through its academic outputs but also through its contribution to solving problems in the region.

At the district level, the 2024–2027 District Development Plan, “Medellín Loves You,” formally recognises Medellín as a Special District of Science, Technology, and Innovation, underscoring the pivotal role of science, technology, and innovation as pivotal mechanisms for catalysing the region's economic, social, and environmental transformation. This orientation underscores the significance of university research in technological domains, particularly in light of Medellín's emergence as a nexus of innovation, the knowledge economy, technological entrepreneurship, and the integration of novel technologies into production and service processes^[12,13]. In this particular context, the program's research output gains territorial relevance by connecting with the city's initiatives in digital innovation, Industry 4.0, organisational transformation, technology adoption, and sustainable development^[14].

From a global perspective, the Sustainable Development Goals (SDGs) provide a framework for assessing the social contribution of research, especially in relation to SDG

4, quality education; SDG 8, decent work and economic growth; SDG 9, industry, innovation, and infrastructure; SDG 10, reduced inequalities; SDG 11, sustainable cities and communities; and SDG 17, partnerships for the goals^[15]. The correlation between research, technological development, and sustainability enables the interpretation of the articles reported by the programme as prospective contributions to environmental transformation, particularly when their outcomes are oriented towards the generation of applied knowledge, the enhancement of processes, digital inclusion, business innovation, and the fortification of societal capacities^[16].

Within higher education, sustainable digital transformation cannot be understood exclusively as the adoption of technological tools or the digitization of academic and administrative processes. It also involves changes in institutional strategies, organizational culture, teaching practices, research capacities, infrastructure, governance, and relationships with external stakeholders. From this perspective, technological transformation should contribute not only to institutional efficiency but also to educational quality, equitable access, social inclusion, environmental responsibility, and the development of competencies required by contemporary societies. These considerations are particularly relevant in developing countries, where universities frequently face limitations related to infrastructure, connectivity, financing, digital competencies, and unequal access to technological resources. Consequently, research in Systems Engineering can support sustainable digital transformation by generating context-sensitive solutions, strengthening institutional capacities, promoting digital inclusion, and addressing educational, productive, social, and environmental challenges through interdisciplinary and applied approaches^[17,18].

3. Methodology

The study used a mixed descriptive approach combining quantitative analysis with qualitative interpretation. Data collection and analysis were conducted using the institutional repository of Corporación Universitaria Americana as the source of academic production associated with the Systems Engineering programme. The study included eligible articles published since 2018. Articles were included when they were registered as published outputs under the institutional

affiliation, contained sufficient bibliographic information for identification, and provided enough information to determine their primary theme and area of application. Duplicate records, outputs not classified as published articles, records not directly associated with the programme, and publications with insufficient information for thematic coding were excluded. After removing one duplicate, the final dataset consisted of 20 unique articles. For each article, the analysis recorded title, authorship, year of publication, primary research theme, area of application, relevant population or sector, contribution to the environment, associated public policy, and related Sustainable Development Goals. Frequencies and percentages were used to describe the thematic composition of the portfolio, while qualitative interpretation was used to examine its relationship with technological, productive, educational, social, and territorial needs.

A characterisation matrix was developed to identify the predominant thematic areas and their relationship with problems or needs in the environment^[19]. Each article was assigned a primary thematic category according to its main research problem, technological domain, and stated application. When a publication addressed more than one topic, classification was based on the theme most closely related to its research objective and principal contribution. This procedure allowed the portfolio to be organised into mutually exclusive primary categories and interpreted in relation to the professional profile and contemporary technological demands^[20].

The external alignment analysis compared the topics identified in the articles with key public policy references^[21]. These included the National Development Plan 2022–2026, the Antioquia Departmental Development Plan 2024–2027, the Medellín District Development Plan 2024–2027, CONPES documents on science, technology, innovation, and digital transformation, and the Sustainable Development Goals^[22–24]. The comparison examined the extent to which the research portfolio corresponded with priorities related to digital transformation, innovation, productivity, higher education, digital talent, social appropriation of knowledge, business development, inclusion, and sustainability.

A second external comparison was used to place the programme's thematic profile in the context of Information Systems education. The benchmark included evidence from 127 AACSB-accredited Information Systems programmes

in the United States^[25], undergraduate programmes in Sweden compared with Australian and US counterparts^[26], and 74 master's programmes in Information Systems offered by AACSB-accredited business schools in the United States^[27]. The comparison focused on areas such as data and information management, systems and software development, analytics, organisational applications of information technologies, and systems management. Because these studies describe curricular and programme profiles rather than comparable research productivity or societal impact indicators, the benchmark was used to establish thematic positioning rather than an institutional performance ranking.

The interpretive stage examined the potential impact of the research portfolio^[28]. Four criteria guided this analysis: alignment with national or territorial policy priorities; relevance to identifiable productive, technological, educational, or social needs; correspondence with the Sustainable Development Goals; and the presence of a plausible pathway through which the research could support knowledge application, technological development, capacity building, or decision-making. These criteria capture research relevance and potential pathways of contribution rather than verified downstream impact. Demonstrating realized impact would require additional evidence of policy uptake, implementation of research-derived solutions, organisational adoption, formal knowledge transfer, changes in professional or institutional practice, or measurable benefits among external users. Such evidence was not available in the documentary dataset and was therefore not treated as an outcome of the study. Based on the findings, strategic recommendations were for-

mulated around knowledge transfer, collaboration with external stakeholders, visibility of results, and connections between research, curriculum, and community outreach^[29].

Citation-based indicators were not included because citation counts had not been collected from a single bibliographic database using a common cut-off date for all publications. Combining counts from different sources would reduce comparability. The quantitative analysis was therefore limited to publication output, publication status, thematic distribution, and portfolio concentration.

4. Results

4.1. General Characterization of the Reported Articles

The analysis of the 20 unique articles reported by the Systems Engineering programme reveals a research portfolio distributed across several areas of relevance to the current technological environment (**Table 1**). The works are primarily related to artificial intelligence, Big Data, data analytics, software development, information technologies, digital transformation, ICT-mediated education, management, entrepreneurship, digital marketing, blockchain, fintech, digital inclusion, the gender gap, social technology, and technology law. This thematic diversity demonstrates that the programme's research is not confined to a purely technical dimension but rather incorporates an applied and interdisciplinary perspective on the role of technology in society, organisations, and territories^[30].

Table 1. List of articles reported by the program and their contribution to the environment.

Product Title	State	Journal or Editorial	Contribution to the Environment
Artificial Intelligence (AI) and learning management systems (LMS): A Bibliometric Analysis	Published	Journal of Infrastructure, Policy and Development	It contributes to understanding the integration of artificial intelligence in LMS platforms, contributing to the strengthening of digital education, the personalization of learning and innovation in virtual environments.
Percepción de habilidades en el uso de tecnologías de información y comunicación (TIC) para el aprendizaje en el contexto universitario: Estudio de caso [Perception of skills in the use of information and communication technologies (ICT) for learning in the university context: A case study]	Published	Formación Universitaria	It provides evidence on the ICT skills of university students, promoting the design of digital literacy strategies, strengthening technological skills and improving training processes.
Tendencias en tecnologías convergentes en la industria 4.0: Una revisión de literatura [Trends in converging technologies in Industry 4.0: A literature review]	Published	ION	It helps to identify trends in converging technologies associated with Industry 4.0, providing input for productive innovation, industrial modernization, and business digital transformation.

Table 1. *Cont.*

Product Title	State	Journal or Editorial	Contribution to the Environment
Aplicaciones de Realidad Mixta en la industria del entretenimiento: Evolución temática y agenda investigativa [Mixed reality applications in the entertainment industry: Thematic evolution and research agenda]	Published	RISTI Revista Ibérica de Sistemas e Tecnologias de Informação	It contributes to the analysis of the use of mixed reality in the entertainment industry, contributing to innovation in digital experiences, creative industries, tourism, culture and new models of technological interaction.
Herramientas de automatización en el desarrollo de software: Un análisis de tendencias [Automation tools in software development: A trend analysis]	Published	RISTI Revista Ibérica de Sistemas e Tecnologias de Informação	It helps to identify automation tools and trends in software development, contributing to the efficiency of technological processes, improved productivity and quality in the software industry.
Tendencias investigativas en el uso de tecnologías de Big Data en sistemas de ciberseguridad [Research trends in the use of Big Data technologies in cybersecurity systems]	Published	RISTI Revista Ibérica de Sistemas e Tecnologias de Informação	It contributes to the analysis of Big Data applied to cybersecurity, helping to strengthen capabilities for information protection, prevention of digital risks and organizational security.
Research Trends on the Role of Big Data in Artificial Intelligence: A Bibliometric Analysis	Published	Recent Innovations in Artificial Intelligence and Smart Applications	It contributes to understanding the relationship between Big Data and artificial intelligence, providing input for the development of data-based solutions, advanced analytics, and technological innovation.
Uso de inteligencia artificial en gestión de la información: Una revisión bibliométrica [Use of artificial intelligence in information management: A bibliometric review]	Published	RISTI Revista Ibérica de Sistemas e Tecnologias de Informação	It contributes to the analysis of artificial intelligence applied to information management, promoting the optimization of documentary, organizational and data-driven decision-making processes.
Factores asociados al uso de tecnologías de la información y la comunicación (TIC) en los procesos de aprendizaje de estudiantes de ingeniería [Factors associated with the use of information and communication technologies (ICT) in the learning processes of engineering students]	Published	Formación Universitaria	It helps to identify factors that influence the use of ICT in engineering students, contributing to the strengthening of pedagogical strategies, digital skills and educational quality.
Tendencias investigativas en el desarrollo ágil de software: Un enfoque bibliométrico [Research trends in agile software development: A bibliometric approach]	Published	RISTI Revista Ibérica de Sistemas e Tecnologias de Informação	It contributes to knowledge about agile methodologies in software development, contributing to the improvement of technological management processes, team productivity and organizational adaptation.
Tendencias en el desarrollo de software libre: Un análisis bibliométrico [Trends in free software development: A bibliometric analysis]	Published	LEIRD Conference	It contributes to understanding the evolution of free software, contributing to technological appropriation, open collaboration, digital innovation and access to computer solutions in diverse contexts.
Determinants of entrepreneurial intention among engineering students based on structural equation modeling	Published	Pertanika Journal of Social Sciences and Humanities	It provides evidence on the factors that influence the entrepreneurial intention of engineering students, contributing to the strengthening of technological entrepreneurship, innovation and business training.
Redes neuronales para identificar factores asociados al diseño de una propuesta de formación en línea de artesanos en marketing digital [Neural networks to identify factors associated with the design of an online training proposal for artisans in digital marketing]	Published	RISTI Revista Ibérica de Sistemas e Tecnologias de Informação	It contributes to the design of online training processes for artisans through the use of neural networks, contributing to digital inclusion, commercial strengthening and productive transformation of communities.
Análisis de la existencia de lógica abductiva en el desarrollo de software: Estudio de caso [Analysis of the existence of abductive logic in software development: A case study]	Published	RISTI Revista Ibérica de Sistemas e Tecnologias de Informação	It contributes to the analysis of reasoning processes in software development, contributing to methodological strengthening, decision making and the improvement of practices in software engineering.
Modelo para la Adopción de Cloud Computing en las Pequeñas y Medianas Empresas del Sector Servicios en Medellín, Colombia [Model for Cloud Computing adoption in small and medium-sized enterprises in the service sector in Medellín, Colombia]	Published	Información Tecnológica	It contributes to the digital transformation of SMEs in the service sector through a cloud computing adoption model, with potential impact on productivity, efficiency and business competitiveness.
Reconocimiento de la innovación disruptiva en entornos industriales de desarrollo de software [Recognition of disruptive innovation in industrial software development environments]	Published	Etic Net. Revista Científica Electrónica de Educación y Comunicación en la Sociedad del Conocimiento	It contributes to the recognition of disruptive innovation processes in the software industry, promoting the identification of capabilities for technological transformation and business competitiveness.

Table 1. *Cont.*

Product Title	State	Journal or Editorial	Contribution to the Environment
Proceso de extracción y almacenaje de características a partir de imágenes de huellas de mordida en el desarrollo de un software para la identificación de personas mediante procesamiento digital de imágenes [Process for extracting and storing features from bite mark images in the development of software for person identification using digital image processing]	Published	Espacios	It contributes to the development of technological solutions for the identification of people through digital image processing, with possible application in forensic contexts, security, judicial investigation and biometric analysis.
Analysis Project Integrator “Mano Robótica” from Levels Discursive Connection by Systems Engineering Students of Corporacion University Americana	Published	Social Sciences	It contributes to the strengthening of integrative training experiences in systems engineering through applied projects, promoting the development of technical, communicative, research and problem-solving skills.
Multidisciplinariedad, Interdisciplinariedad y Transdisciplinariedad en la formación para la investigación en Ingeniería [Multidisciplinarity, interdisciplinarity, and transdisciplinarity in research training in engineering]	Published	Revista Lasallista de Investigación	It contributes to strengthening research training in engineering from multidisciplinary and interdisciplinary approaches, contributing to a more comprehensive, contextualized education oriented towards complex problems.
Aprendizaje ubicuo en los programas de Ingeniería: Aproximaciones iniciales [Ubiquitous learning in engineering programmes: Initial approaches]	Published	Journal of Engineering and Technology	It contributes to the analysis of ubiquitous learning in engineering programs, contributing to educational innovation, training flexibility and the use of technologies to expand learning scenarios.

A close examination of the systematization of the articles reveals that several of the research projects connect with problems in the productive and social environment, as they address topics related to process automation, data-driven decision-making, business innovation, digital education, technology adoption, inclusion, information management, and organisational transformation. This orientation serves to reinforce the programme’s relevance, particularly in light of the projected importance of Systems Engineering as a fundamental disci-

pline for the development of technological solutions that are applicable across a range of sectors^[31]. Moreover, the integration of research in education, management, entrepreneurship, and inclusion serves to expand the social reach of academic output by establishing a nexus between technological knowledge and human, institutional, and territorial needs^[32].

The 20 articles were grouped into five primary thematic areas according to their dominant research focus, as shown in **Table 2**.

Table 2. Quantitative distribution of the research portfolio by primary thematic area.

Primary Thematic Area	Number of Articles	Percentage
Digital education and engineering training	6	30%
Software engineering and development	5	25%
Digital transformation and emerging technologies	4	20%
Artificial intelligence, data and cybersecurity	3	15%
Entrepreneurship and socially oriented digital applications	2	10%
Total	20	100%

The distribution shows a clear concentration in technology-intensive research, which accounts for 60% of the portfolio. At the same time, the 30% devoted to digital education and engineering training shows that the programme maintains a substantial educational line alongside its technological orientation. These figures describe the composition of the research portfolio and should not be interpreted as measures of citation or societal impact.

4.2. Contribution to Digital Transformation and the Knowledge Economy

The publications examined in this area reveal different dimensions through which the programme’s research is connected to digital transformation. Research on artificial intelligence, Big Data, and data analytics is mainly associated with the generation and use of information for

decision-making, whereas studies on software development and related technological processes address opportunities for improving organisational and productive activities. Other research concerning information technologies and technology adoption contributes to understanding the development of digital capabilities in different contexts. This differentiation provides a more specific interpretation of the programme's scientific production and shows that digital transformation is not represented by a single research trajectory, but by different technological and organisational applications. In this regard, the strategic use of digital technologies and information for decision-making has been associated with organisational performance and sustainable transformation^[33].

This technological orientation is consistent with national and local priorities that place digital transformation, science, and technological innovation at the centre of development strategies^[7,12,34]. In this context, the relevance of the portfolio lies in its alignment with areas associated with data-informed decision-making, technological process improvement, and the development of digital capabilities. Such alignment reflects the strategic relevance of the research agenda, while the evidence available does not allow these relationships to be interpreted as demonstrated transformations in policy, industry, or society.

4.3. Contribution to the Productive Sector, Innovation and Competitiveness

The programme's research has the potential to impact the productive sector by addressing topics related to technological development, innovation, management, entrepreneurship, digital marketing, blockchain, and fintech^[35]. These areas allow for responding to business needs associated with process digitisation, productivity improvement, the generation of new business models, service optimisation, information management, and the incorporation of emerging technologies in various economic sectors. In this sense, academic production not only strengthens the disciplinary field of Systems Engineering but also contributes useful knowledge for organisational transformation and value creation in the surrounding environment.

This contribution is congruent with the priorities of the National Development Plan with regard to sustainable productive transformation, the knowledge economy, technology-based entrepreneurship, and knowledge transfer to the pro-

ductive sector. The subject under discussion is also related to the vision of the Antioquia Departmental Development Plan, which recognises the importance of connecting people and markets, strengthening technical and institutional capacities, and consolidating alliances to improve the region's productivity and competitiveness^[11].

4.4. Social, Educational and Inclusive Impact of the Research

The presence of articles related to ICT and education, digital inclusion, the gender gap, social technology, and technology appropriation highlights a relevant social dimension within the programme's research. The aforementioned themes contribute to a comprehensive understanding of how technology can support teaching and learning processes, reduce inequalities, expand access to knowledge, strengthen digital skills, and promote the participation of diverse populations in technological settings. In this manner, the programme's research endeavours are intertwined with the community, fostering not only productive innovation but also inclusivity, training, and social transformation.

This approach is consistent with the National Development Plan's priorities concerning quality education, digital connectivity, digital literacy, and digital appropriation as drivers of opportunities for equality. The programme's alignment with the Sustainable Development Goals (SDGs) is also noteworthy. Specifically, it intersects with SDG 4, which emphasises the quality of education, SDG 9, which pertains to industry, innovation, and infrastructure, and SDG 10, which seeks to reduce inequalities^[15]. The significance of research in ICT-mediated education and social technology lies in its potential to influence communities, educational institutions, social organisations, and civic education processes.

4.5. Relevance to Public Policies and Territorial Development

The analysis of the reported articles establishes that the research of the Systems Engineering programme is highly relevant to current public policies, especially those related to digital transformation, science, technology and innovation, higher education, productive development, connectivity, the knowledge economy, inclusion, and sustainability. The relevance of this research is evidenced by its alignment with the

research topics and priorities established in the National Development Plan, the Antioquia Departmental Development Plan, and the Medellín District Development Plan.

At the national level, the programme's research is aligned with the need to strengthen human talent in emerging technologies, energise scientific ecosystems, promote applied research, and increase the impact of knowledge on society. At the departmental level, this commitment is connected with the endeavour to strengthen information systems, data culture, territorial capacities, digital connectivity, and evidence-based decision-making. At the district level, this initiative is consistent with Medellín's designation as a Science, Technology, and Innovation District, as well as with the establishment of innovation ecosystems that integrate academia, entrepreneurship, the productive sector, and public stakeholders.

4.6. Comparative Positioning against Information Systems Programmes

The comparison with Information Systems programmes in other institutional and international settings provides an external reference for interpreting the thematic orientation of the research portfolio. Mills et al.^[25], based on 127 AACSB-accredited Information Systems programmes, identified different programme profiles, demonstrating that Information Systems education combines common disciplinary foundations with substantial variation in programme structure and emphasis. Against this background, the portfolio analysed in the present study shows a marked orientation toward technologically intensive topics, including Big Data, artificial intelligence, information management, cybersecurity, software development, automation, cloud computing, and digital transformation.

International comparison provides further context for this positioning. Steen and Pierce^[26] identified Foundations of Information Systems, Data and Information Management, and Systems Analysis and Design as relevant common areas across Swedish, Australian, and US undergraduate Information Systems programmes, while Swedish programmes demonstrated comparatively greater emphasis on enterprise architecture and application development. The programme analysed in the present study shows clear thematic correspondence with data and information management and application-oriented technological development through its

research on Big Data, artificial intelligence, software automation, agile development, cloud computing, and information management. In contrast, enterprise architecture and formal systems analysis and design are less explicitly represented within the reported research portfolio.

A more recent benchmark is provided by Yang^[27], who identified 74 Information Systems master's programmes among AACSB-accredited business schools in the United States. Data, Information, and Content Management; Systems Development and Deployment; and Project and Change Management were among the most frequently required core areas, while Business Intelligence, Analytics, and Data Mining also occupied a prominent position. In comparison, the research portfolio examined here demonstrates strong correspondence with data-intensive and technological development domains, particularly through research related to Big Data, artificial intelligence, information management, software, and digital technologies. However, project and change management appear less explicitly represented. Therefore, the comparison suggests convergence with several internationally established Information Systems domains while also identifying opportunities to diversify the research portfolio toward managerial and systems-oriented areas. These findings represent relative thematic positioning and should not be interpreted as evidence of superior research performance.

5. Discussion

The findings place the programme's research within areas closely connected to digital transformation, innovation, competitiveness, inclusion, and sustainable development. This thematic relevance should not, however, be confused with demonstrated impact on policy, industry, or society. The evidence identifies pathways through which research may contribute to decision-making, technological processes, organisational practices, or digital capabilities, but establishing realized impact would require showing that these outputs were transferred, adopted, or implemented by external stakeholders. The distinction is important for interpreting the results: scientific relevance indicates where research may contribute, whereas realized impact requires observable evidence of use and change in productive, institutional, or social settings.

The comparative analysis broadens the interpretation of these findings by situating the programme within patterns observed across other Information Systems programmes. The prominence of data-intensive technologies and software-related research is consistent with areas emphasized in international Information Systems education, particularly data and information management, systems development, and analytics^[26,27]. At the same time, the diversity identified among Information Systems programme profiles suggests that thematic specialization is an inherent characteristic of the field rather than evidence of deficiency by itself^[25]. From this perspective, the programme demonstrates convergence with internationally visible technological domains while maintaining opportunities to broaden its research activity in areas such as enterprise architecture, systems analysis, and project and change management. This comparison provides an external benchmark for interpreting the programme's thematic position without equating curricular correspondence with research productivity or realized societal impact.

Furthermore, the incorporation of research in the fields of ICT and education, digital inclusion, gender disparity, and social technology serves to expand the program's scope, thereby encompassing both social and educational dimensions. This focus enables the programme's research to extend beyond technical development to incorporate concerns related to access, equity, capacity building, and the social appropriation of knowledge. In this sense, research output can be used to strengthen educational processes, support digital literacy strategies, and contribute to reducing the technological divide.

The distinction identified in this study between thematic relevance and realized impact is consistent with research impact assessment literature that emphasizes the need to trace observable connections between research activities and subsequent changes beyond academia. Budtz Pedersen and Hvidtfeldt^[36] argue that interactions between researchers and external actors constitute important links in the pathways through which research may contribute to broader societal change, while Woolley and Molas-Gallart^[37] emphasize that impact assessment should incorporate the perspective of research users and the processes through which knowledge is translated, applied, and valorized. From this perspective, the findings of the present study suggest that thematic alignment can serve as an initial indicator of where research may con-

tribute, but it cannot substitute for evidence of uptake or use. This interpretation also complements evidence from Colombian universities, where research and knowledge transfer performance has been assessed through measurable outputs and efficiency indicators^[38]. In contrast, the present analysis operates at the programme level and focuses on the thematic composition of scientific production and its potential pathways of contribution. Research on university–industry knowledge transfer further shows that external value depends on sustained interaction, institutional mechanisms, and collaboration among universities, firms, public institutions, and other actors^[2,3,39]. The contribution of this study therefore lies in combining portfolio characterization, policy and SDG alignment, and external benchmarking as a programme-level analytical approach for identifying potential pathways of research contribution while explicitly distinguishing them from evidence of realized impact.

This study should be interpreted in light of several limitations. The analysis focuses on the research portfolio of a single Systems Engineering programme at one Colombian higher education institution. Rather than seeking statistical generalization, this context-specific analysis provides an initial reference for understanding how programme-level scientific production can be examined in relation to technological, social, productive, and territorial priorities, and it offers a basis for future comparative or multi-institutional studies. The findings are also based primarily on thematic alignment and plausible pathways of contribution rather than on direct evidence of realized impact; consequently, they do not demonstrate that the analysed publications produced observable changes in policy, organisational practice, or society. In addition, the qualitative classification and interpretive assessment involve researcher judgment, which introduces an inherent degree of subjectivity into the analysis. Although the study incorporates frequencies and percentages to describe the composition of the research portfolio, these indicators remain descriptive and do not capture citation impact, longitudinal effects, stakeholder uptake, or measurable outcomes derived from the research. Future studies could extend this analytical approach to other programmes and institutions and combine documentary analysis with stakeholder evidence, longitudinal monitoring, and standardized impact indicators to assess realized research impact more comprehensively.

6. Conclusions

The analysis of the 20 articles shows that the programme's research portfolio is concentrated in digital education and engineering training (30%), software engineering and development (25%), digital transformation and emerging technologies (20%), artificial intelligence, data and cybersecurity (15%), and entrepreneurship and socially oriented digital applications (10%). Overall, 60% of the portfolio is concentrated in technology-intensive areas, while the substantial presence of educational research reflects an additional orientation toward training and digital learning. The correspondence identified between these research areas and national, departmental, district, and Sustainable Development Goal priorities indicates potential areas of contribution to technological, productive, social, and territorial challenges. However, these findings represent thematic and strategic alignment and should not be interpreted as evidence that the analysed publications have produced observable changes in policy, organisational practice, or society.

The external comparison also shows that the programme converges with internationally visible Information Systems domains, particularly data and information management, software development, analytics, and digital technologies. At the same time, enterprise architecture, formal systems analysis and design, and project and change management are less explicitly represented in the research portfolio. These findings provide a more specific basis for interpreting the programme's current research profile and the areas in which its scientific production could be further diversified.

Based on these results, future actions should respond to two needs identified in the analysis. The programme could broaden its research portfolio toward the managerial and systems-oriented areas that were less visible in the external comparison, while maintaining its existing strengths in technological and educational research. It should also complement publication monitoring with evidence of research use, including stakeholder uptake, applied projects, institutional or technological adoption, and other documented forms of knowledge transfer. These measures would allow future assessments to determine whether the potential pathways identified in this study translate into realized impact.

Author Contributions

Conceptualization, A.V.-A.; methodology, A.V.-A. and S.C.-A.; formal analysis, S.C.-A.; investigation, J.E.C.F.; data curation, M.C.B.-G.; writing—original draft preparation, A.V.-A.; writing—review and editing, A.V.-A., S.C.-A., J.E.C.F., M.C.B.-G. and J.C.R.H.; supervision, A.V.-A.; project administration, A.V.-A. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

AI Use Statement

The authors declare that no artificial intelligence (AI) tools were used in the preparation of this manuscript.

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