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A Thematic Analysis of Trends in Engineering Education Conferences Congresses in Latin America and the Caribbean: An Insight into Future Innovations and Developments in Higher Education

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A Thematic Analysis of Trends in Engineering Education Conferences Congresses in Latin America and the Caribbean: An Insight into Future Innovations and Developments in Higher Education

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Abstract: Education is a fundamental element of social development as it stimulates economic growth and promotes social equality. It is well documented that high-quality higher education fosters the development of critical and informed citizens who are capable of making well-informed decisions and actively contributing to the construction of a higher society. However, in light of the potential changes in technology, science, and society, it is imperative to prioritize research in education to ensure a prosperous and sustainable future. The objective of this study was to gain insight into the emerging issues that shape the engineering education landscape. To understand the current scope and nature of research, both globally and within specific nations and regions, with respect to trends in accreditations; digitalization of education; integration of active, immersive, and collaborative learning methodologies; and emphasis on the development of transversal competencies. This study analyzed the corpus derived from 12 conferences distributed in two engineering education events in Latin America and the Caribbean from 2017 to 2024. A corpus of 4530 articles with DOI was taken, of which 1690 was the final sample for the specific thematic categories of education. A thematic approach was used to identify recurring, variable, and emerging themes, using a classifier that resulted in nine thematic categories. The most notable results show that there are three recurring themes: international accreditation and evaluation, online and remote laboratories, and technologies for teaching and learning. The most variable themes were related to the Government, Industry, and University and Recruitment and Retention in Engineering. Undoubtedly, these recurrences coincide with an era marked by increasing digitalization, immersive technologies, artificial intelligence, and the need for engineering programs aligned with the social and economic demands of the time. In conclusion, engineering training conferences in Latin America and the Caribbean play crucial roles in identifying and promoting innovative practices that define the future of higher education in the region.

Keywords: Thematic, Engineering, Education, Trends, Conferences

Introduction

Education is an essential pillar of social progress as it drives economic development and fosters social equity. It has been widely demonstrated that high-quality higher education fosters the development of critical and well-informed citizens who are capable of making sound decisions and contributing significantly to the creation of a better society. In this context, the increasing complexity of new high-tech solutions and innovations is generating a demand from employers for new ways of thinking and skill sets [1]. In addition to the above, and considering the potential changes in technology, science, and society, it is crucial to prioritize research in the field of education to ensure a prosperous and sustainable future. Adaptability and innovation in educational methods are necessary to prepare future generations for emerging challenges and take advantage of the opportunities that arise in a constantly evolving world.

We must acknowledge how quickly technology is developing and the extent to which the conventional model restricts access to higher education. According to experts [2], education should be less regimented and allow greater variation. As a direct consequence of the social distancing measures imposed by COVID 19 and the changing needs of employers, universities have undergone a large-scale transition [3], [4]. From then on, learning at all levels of education can be done in more active, collaborative, digital or hybrid, adaptive, experiential, and individualized ways [5], [6]. The additional virtual environments in the blended model accelerated everything [7].

Despite the current trends, it is important to critically study the most recent developments in learning theory, didactics, and digital education technology in light of the increasing digitalization of higher education.

The higher education landscape is expected to be altered, taking into account the technological advancements in society, in this new and dynamic approach, universities today are increasingly becoming like entrepreneurial non-profit organizations where higher education specifically in engineering serves several objectives for society by preparing students for their further personal and professional development, which is further subject to considerable evolution and dynamics [8], [9].

Emerging Challenges in Engineering Education

Engineering applies scientific and mathematical principles to the design, development, construction, and maintenance of structures, machines, systems and processes. It uses technical knowledge and skills to solve complex problems and to create innovative solutions in a variety of fields. Although diverse, engineering has a common goal of creating solutions that meet specific needs. Engineering education refers to the process of acquiring knowledge, skills, and competencies in various fields of engineering. This involves formal study and training that prepares individuals to become professional engineers. Engineering education is typically provided at universities or institutions that follow a structured curriculum [10], [11], [12].

Over the past two decades, profound technological changes have occurred driven by disruptive advances. Beyond classroom learning, engineering education often includes internships in industry, allowing students to gain practical experience and apply their skills to real-world environments. These changes have not only transformed the way engineering is taught but also the way engineers approach and solve complex problems in today's world. It is of utmost importance that higher engineering education institutions go beyond knowledge transfer and technical qualification in Information Technology, also promoting a comprehensive education that incorporates personal development objectives, with a focus on the development of social and emotional skills. A well-trained engineering workforce in all these aspects can enhance innovation and technological development, increasing competitiveness in the global market and the development of new products, processes, and services necessary for sustainable economic growth [1], [13], [14], [15].

However, it is well known that engineering education institutions face several challenges when preparing students for the workforce. In today's dynamic job market, engineering graduates face challenges, including the changing nature of the industry, the need to keep up with the latest technological advancements, and the lack of collaboration between industry and academia. To overcome these challenges, engineering education institutions must develop and implement programs focused on experiential learning, interdisciplinary collaboration, industry partnerships, and innovative teaching tools [16].

Therefore, the engineering education system must incorporate lifelong learning opportunities into the curriculum to ensure that graduates are prepared to meet the demands of an ever-changing technological landscape [17], [18]. Figure 1 shows the key areas of labor market demand for engineering graduates.

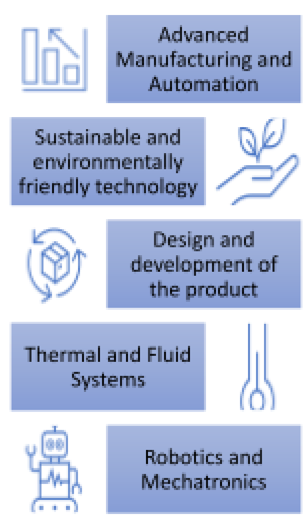

Figure 1. The main areas of demand in the labor market for engineering. Edited from [15].

In addition to the aforementioned technological changes, there is a fusion of information, communication, artificial intelligence (AI), big data, metamaterials, electromobility, and cybersecurity, among others, which has led to the integration of various concepts. These changes drive what is commonly known as digital transformation, which represents a challenge and new paradigm in education, heralding a new era of research, teaching, and learning for engineering education institutions. In addition to disciplinary topics, topics such as lifelong learning, transdisciplinary education, sustainability, the importance of diversity and inclusion, resilience and human-centered design, and data management skills are becoming increasingly important in engineering training. This evolution highlights the need to adapt engineering education to prepare future professionals to face the challenges of today's world [19], [20], [21].

However, disciplinary conferences are an excellent forum for the dissemination of innovative trends by researchers, as they facilitate the convergence of experts in specific areas of knowledge and promote the exchange of ideas and experiences. From a scientific perspective, these events represent the ideal context for positioning emerging topics and disseminating advances in knowledge in a timely manner, given that the evolution of the field is conditioned by critical time windows [22]. These windows directly influence the average citation rate and are manifested through the citation half-life indicator (Cited-Half Life), in which the processes of innovation and consolidation of information develop at an accelerated pace [22].

Therefore, the objective of this study was to understand the emerging issues shaping the engineering education landscape in Latin American and Caribbean countries and the current scope and nature of research, both globally and in specific countries and regions, on trends in accreditation, digitalization of education, integration of active, immersive, and collaborative learning methodologies, and emphasis on the development of transversal competencies. We analyzed trends in topics addressed in research papers presented at two international conferences that are peer-reviewed and indexed in databases such as Scopus. The research question to be answered is: What emerging issues shape the engineering education landscape in research presented at peer-reviewed conferences in Latin America and the Caribe?

Methodology

a) Selection and collection of corpus

For this research, papers presented at 12 international conferences distributed across two events were selected. The selection criteria were as follows: they are held annually; they are international in scope; they have a blind refereeing process; they accept papers in Spanish, English, French, and Portuguese; and they have tracks directly linked to engineering education and are indexed in Scopus. To guarantee the anonymity of the publications analyzed, events were coded as Event A and Event B.

Event A is a multi-conference that currently employs a hybrid format[1], facilitating the convergence of research in diverse areas of engineering. It boasts a history spanning more than 15 consecutive events and attracts over 1,500 authors. For this study, works published from 2017 to 2024 were extracted from Event A. Event B was an international congress aimed at disseminating research on entrepreneurship, innovation, education, and technology in engineering. The event was established in 2021 in an exclusively virtual format. For this article, publications from 2021 to 2024 were examined.

Table 1 shows the topics of both events in which we collected a total of 4530 articles, of which 3796 correspond to event A and 734 to event B.

[1] Event A was held in person from its inception until 2020. In 2020 it was exclusively virtual and from then on it has a hybrid format.

Table 1. Topics presented at engineering education conferences in Event A and Event B.

Topics presented at the LACCEI Multiconference.	Topics presented at the LEIRD Multiconference.
1. Accreditation, Assessment, Dual Degree, Certificate Programs, and Degree Equivalency of Engineering 2. Chemistry, Mathematics, and Physics in Engineering Education 3. Enhancing Undergraduate Education and Curriculum Improvement 4. Ethics and Society in Engineering Education 5. Government, Industry, and University 6. Management of Engineering Education 7. Online and Remote Laboratories 8. Recruitment and Retention in Engineering 9. Technology for Teaching and Learning, E-Learning, and Distance Education 10. Women and Diversity in Engineering 11. Aerospace and Aeronautical Science 12. Agriculture, Food, and Farming 13. Biochemistry 14. Biomedical/Health 15. Biotechnology, Bioinformatics and Nanotechnology 16. Chemical and Materials 17. Civil, Infrastructure, and Construction 18. Computer Science, Computer Engineering, Data Science, AI, and Software 19. Cybersecurity and Digital Forensics 20. Electrical and Electronics 21. Energy and Water 22. Entrepreneurship and Innovation 23. Green and Environmental Engineering 24. Humanitarian, Peace, and Service-Learning Engineering 25. Information Technology 26. IoT, Industry 5.0 and Society 6.0 27. Logistics and Transportation 28. Mechanical and Electromechanical 29. Natural Hazards 30. Oceanography and Marine Sciences 31. Project and Product Life Management in Engineering 32. Production Engineering 33. Sustainable Development in Engineering 34. Technology Management 35. Telecommunications	1. Circular economy innovation and Frugal innovation 2. Communication strategies and Social Networks in entrepreneurship and innovation 3. Design thinking-driven innovation 4. Digital transformation and artificial intelligence 5. Enabling regional initiatives in entrepreneurship and innovation 6. Entrepreneurship and innovation to overcome the economic and financial crisis 7. Equal rights, opportunities and spaces for women in Latin America and the Caribbean in the professional field 8. Incubators, accelerators, and other support programs 9. Intellectual property and open innovation 10. International innovation and entrepreneurship 11. Intrapreneurship and business model innovation 12. Market and financial impacts of entrepreneurship and innovation 13. Open innovation systems 14. Social innovation and entrepreneurship 15. Strategies, policies, and management practices in R&D, innovation, and entrepreneurship 16. Sustainable Innovation and Entrepreneurship 17. University-Industry technology transfer and knowledge exchange 18. Venture formation processes, funding, and strategies 19. Work in Progress

In this article, we selected publications that are linked to engineering education. To do this, we have 1690 articles distributed in different categories (see section c, in which the categorical process is detailed). Table 2 shows the number of articles per year for each event. We note that for event A from 2017 to 2021, the papers ranged between 90 and 150; in the years 2022 and 2023, they exceeded 200 papers, and in 2024, they reached more than 300 publications. For event B in the years 2021 and 2022, there were between 15 and 47 papers, and for 2023 and 2024, there were up to 130 papers.

Event A has a greater number of papers (1389 articles) because it is an event with a longer history.

Table 2. Number of papers published each year for events A and B.

YEAR	EVENT A	EVENT B	Total
2017	96	The event did not exist	96
2018	141	The event did not exist	141
2019	113	The event did not exist	113
2020	127	The event did not exist	127
2021	142	15	157
2022	204	47	251
2023	245	109	354
2024	321	130	451
Total	1389	301	1690

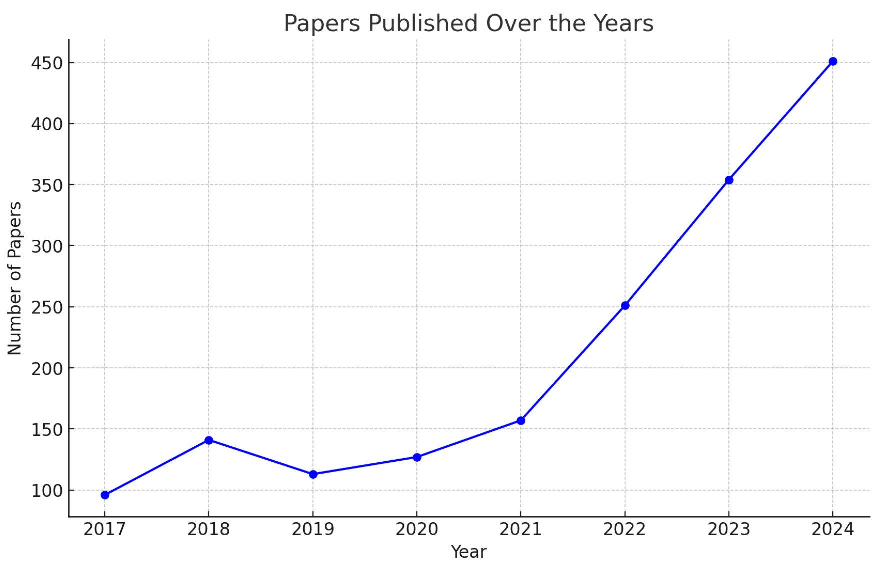

Figure 2. Growth of published papers 2017-2024

Figure 2 shows the growth of papers on engineering education at these conferences. Although there were fewer papers published in 2019 and 2020, we must remember that this was the time of the COVID pandemic. This undoubtedly impacted all spheres of social life in countries, and scientific events were no exception [23], [24], [25].

In this article, the analysis is not detailed by region, but we think it is relevant to mention the countries that have the greatest presence in these events. The 15 countries with the greatest presence at the events are named (in alphabetical order) Argentina, Brazil, Chile, Colombia, Costa Rica, Cuba, Ecuador, Honduras, Mexico, Panama, Peru, Puerto Rico, Spain, the United States, and Venezuela.

On the other hand, only three of the four languages have been published on engineering education topics (see Figure 3):

- English: 865 (51.18%)
- Spanish: 817 (48.34%)
- Portuguese: 8 (0.47%)

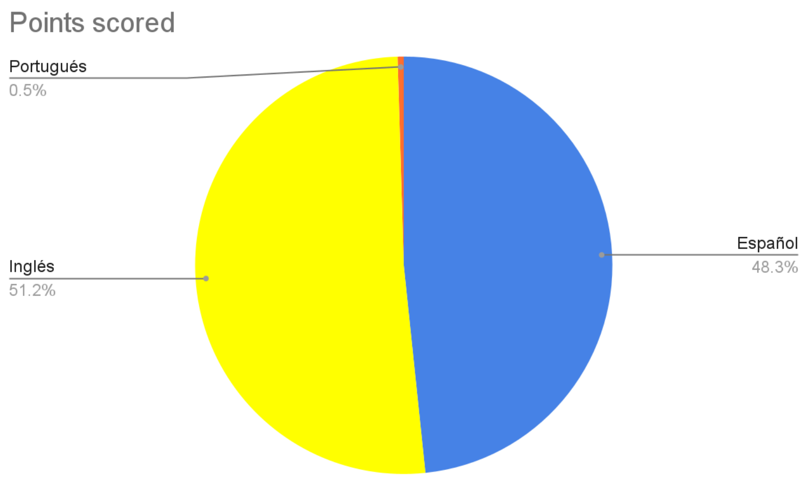

Figure 3. Languages of publications

b) Analysis tools and strategies

To ensure consistent categorization, a semantic classifier based on embedding (BERT) was applied to the abstracts, titles, and keywords. Thus, the prevalence of different topics in the articles was semantically determined. This quantification identified areas with the highest number of publications in the selected events.

Subsequently, the trends identified in Latin America and the Caribbean are compared. This analysis not only allowed us to identify the similarities and divergences in the topics addressed in the congresses of Latin American and Caribbean countries, but also highlighted the temporal evolution of these topics. To do so, the differences and transformations between 2017 and 2024 were examined, highlighting significant changes in the areas of interest. This longitudinal approach provides a broader view on how priorities and concerns have evolved in the fields of engineering, education, technology, entrepreneurship, innovation, and development in Latin America.

In this way, it was possible to determine which areas have gained greater relevance over time and which have seen a decrease in their prevalence, thus providing important insights into emerging research and how engineering education is being configured in Latin America and the Caribbean.

In the present study, a script developed in Python using Google Colab was used to perform an exhaustive thematic analysis on a corpus composed of 4530 papers: title, abstract, and keywords [26]. The purpose of this analysis was to identify and classify emerging themes in the texts in a standard way. The process was structured into three stages, starting with the preprocessing of the texts, followed by the application of advanced topic modeling and semantic classification techniques.

The first step in the classifier process, preprocessing of the texts, consists of cleaning and preparing the texts, which is essential to guarantee the quality of the results in the analysis model. A series of steps was implemented to preprocess the titles, abstracts, and keywords of the documents. This preprocessing included the removal of stop words, tokenization of the texts into relevant lexical units, and lemmatization of the words to reduce them to their base form. These tasks were carried out using the spaCy library, which provides powerful natural language processing tools for four languages: Spanish, English, Portuguese, and French. The automatic detection of the language of each text was performed using the LangDetect library, which allowed the preprocessing to be adjusted to the linguistic characteristics of each fragment.

Once the texts were preprocessed, the Latent Dirichlet Allocation (LDA) model was applied, which is an unsupervised learning algorithm widely used to discover underlying topics (the second step) in large volumes of text. The Gensim library was used to implement the model. LDA assumes that each document is a mixture of several topics and that each topic is a probabilistic distribution over words. By applying LDA, documents were classified based on their relationship to specific topics identified by the distribution of associated words.

In addition to topic analysis, a semantic embedding-based approach was implemented using the Sentence-BERT model to classify documents based on their semantic similarity to predefined categories (the third step). These categories include event tracks and UNESCO SKOS Science and Technology nomenclature categories [27]. This allowed the documents to be aligned with specific thematic areas within engineering education and research.

To calculate the semantic similarity, embeddings were generated for each abstract in the corpus and for each reference category (event tracks and UNESCO nomenclature) using the BERT model. Subsequently, the cosine similarity between document embeddings and categories is calculated, allowing the identification of the most relevant documents for each category. This approach, based on deep learning, has been shown to be effective in classifying documents in specific subject areas, providing accurate and robust classification. This matching was manually validated with an effectiveness of 94.62% (from the papers in the education-only tracks).

c) Definition of categories

Based on the mixed coding system, the thematic categories were 9. Table 3 presents the coding for each category, name of the category with the largest number of descriptors, and description of each category to guide the understanding and breadth of each category.

Results

a) General thematic distribution

As noted in Table 3, nine categories were determined in the classifier for 1690 works related to engineering education. We will see in Table 4 the distribution of the categories by year. For the first analysis, only the three topics with the highest recurrence for each year were considered and grouped by category.

Table 3. Thematic categories and description

Codification	Categories	Description
Theme 1	Accreditation, Assessment, Dual Degree, Certificate Programs, and Degree Equivalency of Engineering	This category addresses the process of standardizing and assessing engineering programs to ensure their quality. It includes frameworks for accreditation, the design of dual-degree and certificate programs, and strategies for international degree equivalency.
Theme 2	Chemistry, Mathematics, and Physics in Engineering Education	Explore the integration of fundamental sciences into engineering curricula. This highlights innovative teaching approaches, interdisciplinary applications, and the importance of these disciplines in solving engineering problems.
Theme 3	Enhancing Undergraduate Education and Curriculum Improvement	Focuses on educational reforms to adapt engineering education to current industrial needs. It includes curriculum redesign, project-based learning, and the development of skills, such as teamwork and communication.
Theme 4	Ethics and Society in Engineering Education	Analyze how to train engineers from an ethical perspective to make responsible decisions. It includes the integration of ethical frameworks into programs and the analysis of the social impact of engineering solutions.
Theme 5	Government, Industry, and University	Collaboration between governments, industry, and academic institutions drives innovation in engineering education. It includes policy development, funding, and alignment of curricula with labor market demands.
Theme 6	Management of Engineering Education	Administrative and Strategic Aspects of Engineering Program Management. It includes faculty development, resource allocation, and program sustainability in a competitive academic environment.
Theme 7	Online and Remote Laboratories	Explore the use of virtual and remote laboratories to enrich hands-on engineering instructions. These technologies increase access to and enable students to conduct experiments in resource-limited or remote environments.
Theme 8	Recruitment and Retention in Engineering	Focuses on strategies to attract and retain diverse talent in engineering programs. It includes outreach initiatives, mentoring programs, and creating inclusive environments to reduce dropout rates.
Theme 9	Technology for Teaching and Learning, E-Learning, and Distance Education	Addresses the use of technology to transform engineering education through virtual learning platforms, virtual classrooms, and distance education. Personalized learning and global accessibility were also emphasized.

In general, it can be said that thematic category 1 related to the "Accreditation and evaluation processes of engineering programs" occupies the first place in recurrences between 2017 and 2021. In second place, three categories appear: "Online and Remote Laboratories" (2018, 2019, 2021 and 2022), “Management of Engineering Education” (2017 and 2020) and “Government, Industry, and University” (2020). Third, the predominant categories from 2017 to 2021 and in 2023 were “Technology for Teaching and Learning, E-Learning, and Distance Education” and “Accreditation” (2022 and 2024).

It can also be noted that in the last two years (2023-2024) the “Management of Engineering Education” topic occupies the first place; in second and third place, the “Accreditation” topics are reversed with that of “Technology for Teaching”.

On the other hand, we note that the topics “Chemistry, Mathematics, and Physics in Engineering Education”, “Ethics and Society in Engineering Education”, and “Enhancing Undergraduate Education and Curriculum Improvement” have the least recurrences in the analyzed data.

Regarding the topics of “Government, Industry, and University” and “Recruitment and Retention in Engineering”, it is observed that they have a greater variability of recurrences. For topic 5, the greatest amount was in 2022, and for topic 8, it was in 2024.

Table 4. Distribution of thematic categories by year

	Theme 1	Theme 2	Theme 3	Theme 4	Theme 5	Theme 6	Theme 7	Theme 8	Theme 9
2017	35	5	15	7	17	31	19	16	22
2018	60	12	20	6	14	28	49	16	42
2019	49	6	11	5	16	17	31	11	30
2020	59	4	12	10	31	31	29	16	30
2021	66	6	18	9	35	36	48	14	41
2022	52	6	11	21	98	42	56	14	48
2023	91	14	68	31	62	108	49	59	85
2024	109	22	97	38	68	152	56	94	119

The overall thematic distribution reflects a significant shift in engineering education priorities. While the initial years (2017-2020) focused on traditional aspects such as accreditation and assessment (Theme 1), recent years (2023-2024) show a growing interest in technological and digital areas, such as online laboratories (Theme 7) and technology for teaching (Theme 9). This suggests that the engineering education system is in the process of adapting to the challenges of digitalization and remote teaching.

Furthermore, the growth of themes such as recruitment and retention (Theme 8) indicates an emerging concern for attracting and maintaining talent in engineering careers, which is a key factor for the sustainable development of the sector.

b) Evolution of trends over time

If we delve into the data shown in Table 4, which are graphically represented in Figure 4, we notice the category of accreditation and evaluation as a dominant recurrence, which reflects a sustained concern for the quality and standardization of engineering programs [28], [29], [30].

This could be explained by the increasing globalization of education, which demands international standards for student mobility and competitiveness of graduates [31], [32], [33], [34], [35].

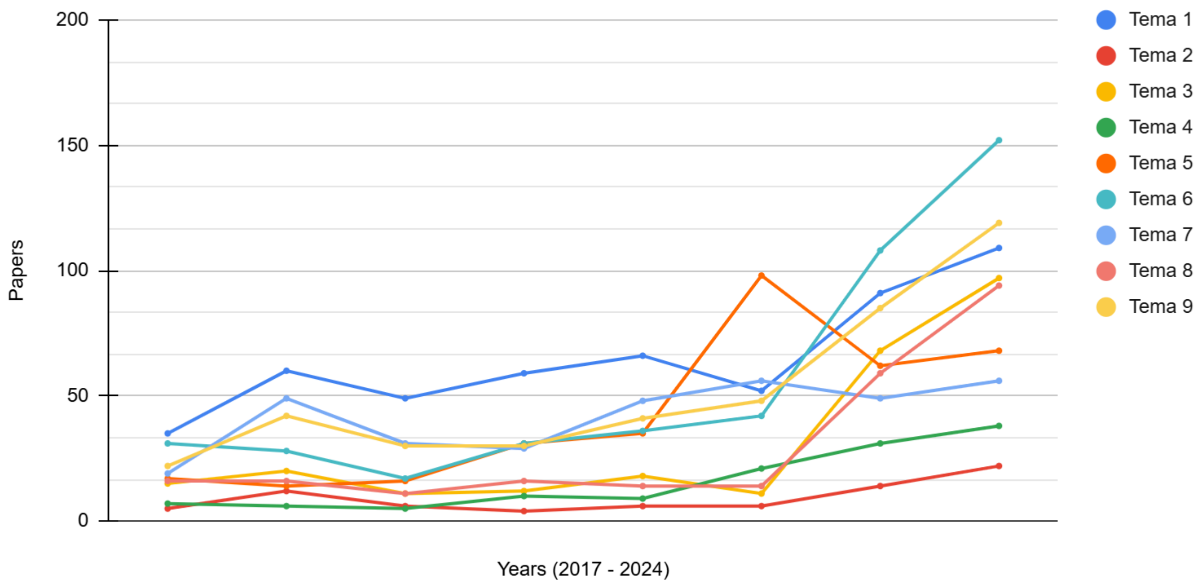

Figure 4. Trends in topics over time

However, the emergence of remote laboratories and online education coincides with the impact of the COVID-19 pandemic, as the health crisis drove an accelerated digital transformation, forcing educational institutions to adopt technological tools and virtual methodologies to ensure the continuity of practical and theoretical teaching [3], [4], [7]. In the case of engineering education, the pandemic catalyzed a transformation and highlighted the need for digital literacy and adaptability. While online learning presents challenges such as reduced interaction and disparities in access to resources, it also offers opportunities for innovation in teaching and assessment methods [16], [36]. However, we believe that there is a lack of studies that combine approaches that allow us to address these challenges. We wonder whether practices that include technologies in teaching are really innovative, or whether it is enough to include some strategies with the use of technologies for universities, specifically engineering programs, to be considered innovative.

Likewise, Figure 4 demonstrates variability in the topic related to government, industry, and University (2020-2024). This observation may lead to several potential conclusions. Firstly, it may indicate a reactive response to economic and technological changes during specific years. For instance, the digitalization accelerated by the COVID-19 pandemic precipitated a significant transition to remote work, e-commerce, and digital services, as well as the adoption of technologies such as cloud computing and collaborative software. Additionally, the renewable energy market experienced growth between 2020 and 2024 as governments and corporations increased investments in solar, wind, and green hydrogen energy, driven by climate commitments such as carbon neutrality agreements. Further examples likely pertain to advancements in artificial intelligence (AI), the implementation of 5G technology that enhanced mobile connectivity, and enabled sophisticated applications in the Internet of Things (IoT), smart cities, and augmented reality.

From the dimension that brings us together in the university environment, we refer to the triple helix models [37], [38], [39] and Industry 4.0 [40], [41], [42], who propose collaboration between universities, industries, and governments to promote innovation and economic development. However, we wonder how universities in this era of such rapid changes will be able to adapt to the demands and challenges of the industry or society.

The most prevalent theme in the last two years, Management of Engineering Education (2023-2024) depicted in Figure 4, indicates an increasing focus on efficient resource management, faculty development, and program sustainability in a post-pandemic and more competitive academic environment. It is evident that in recent years, the emphasis has been on reviewing or proposing programs within engineering curricula that are hypothesized to become teaching practices aligned with contemporary circumstances [43]. This suggests the possibility that these changes may occur not only from positions of authority (rectors, deans) but also from practices within programs or subjects, which would center these changes on the role of educators and students.

The topics “Chemistry, Mathematics, and Physics in Engineering Education” and “Ethics and Society in Engineering Education” appear with low priority or less recurrence, which may indicate an imbalance in curricular priorities, or these topics are overshadowed by the growing attention to technological and management issues. We know that these topics were on the research agenda in the 1990s and the early 2000s. The need for curricular integration, transversal competencies, the development of critical thinking, the inclusion of new teaching and learning strategies for the “hard” areas of the curriculum such as mathematics, physics and chemistry, among other pedagogical and didactic proposals [44], [45], [46], [47], has always been raised. However, in the data analyzed, they did not prevail as topics on the universities’ agenda.

The analysis of the thematic trends of the papers presented over the years at the events described reveals significant evolution and dynamism in academic production. From 2017 to 2024, a significant increase in the number of papers presented was observed, with certain activity peaks that coincided with specific events and contexts, such as the COVID pandemic starting with the 2020 Congress, where the event was entirely virtual. This pattern suggests an active response by the academic community to emerging needs and research opportunities, even with the challenges imposed by COVID.

c) Relationship between emerging and established topics

The emergence of topics such as "Recruitment and Retention in Engineering" (highlighted in 2024) indicates a growing interest in student diversity and retention. This underscores the necessity to address inclusion and access disparities, particularly in high-demand disciplines, such as engineering. The investment in accreditation and educational technology positions in recent years (2023-2024) may be interpreted as a shift in educational priorities, transitioning from a focus on traditional standards towards greater adoption of digital tools and innovative methodologies [2], [48], [49], [50].

The data reflect an evolution in educational priorities, influenced by external factors (pandemic, digitalization) and internal needs (quality and management). However, challenges persist in fundamental areas, such as basic sciences and ethics, which are essential for comprehensive engineering education.

Figures 5, 6, and 7 present word clouds generated from the titles of the analyzed data in the various languages represented at both events. While the most prominent words are "process, model, analysis or approach," typical of paper titles, or "education" and "engineering," directly related to the type of events analyzed, other words such as international, institutional, transfer, management, development, and company emerge. These findings align with the presented analyses and confirm the presence of emerging issues on the agenda. Notably, the words technology, laboratories, and virtuality were not observed, despite being one of the most recurrent categories in the analysis.

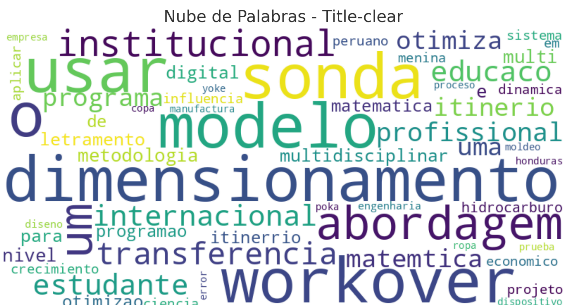

Figure 5. Word cloud Portuguese

Figure 6. Word cloud Spanish

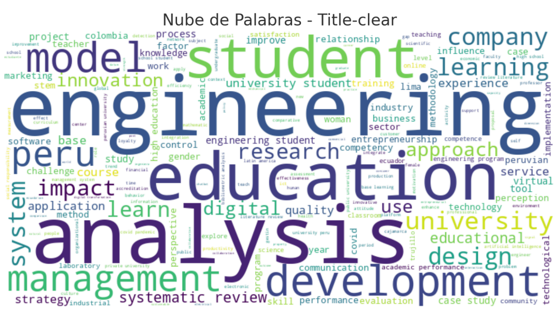

Figure 7. Word cloud English

In summary, the most recurrent topics are Theme 1 (Accreditation and evaluation), Theme 7 (Online laboratories), and Theme 9 (Educational technology), which indicates that these areas dominate the attention in engineering education. And the least recurrent topics: Theme 2 (Chemistry, Mathematics and Physics in engineering), 3 (Ethics and society), and 4 (Improving the undergraduate curriculum) have the lowest number of mentions throughout the period. This could indicate that these areas receive less attention, probably because they are considered consolidated or face less pressure for innovation.

Conclusions

The question that guided this research was: what emerging issues shape the engineering education landscape in research presented at peer-reviewed conferences in Latin America and the Caribbean? The first thing we can affirm is that the analyzed conferences have been increasing their production over the years and that they have been adapting to the new social conditions and formats (virtual, in-person, hybrid, synchronous, asynchronous, etc.) that digitalization and virtuality have brought to academic events.

On the other hand, the classifier allowed us a categorization that made it possible to determine the trends and distribution of the presented work. The 1690 papers focused on engineering education in these conferences with such thematic diversity is not a minor result [51]; on the contrary, it reflects the interest of the community of Latin American and Caribbean researchers who make their objects of analysis topics related to the training, evaluation, accreditation, and management of education in their engineering faculties.

Longitudinal analysis has revealed significant changes in areas of interest in recent years. The topics of accreditation and international evaluation have transitioned from priority status to the topic of education management. This shift demonstrates the necessity for universities to make visible their efforts in the training of their communities of teachers and students and the sustainability of the study programs in this immersive, digital, and complex era. Notably, certain topics are absent from the agenda of the publications, such as ethics or the teaching of physics, chemistry, and mathematics; however, further research is required to elucidate the relationship between these variables and the most prominent categories. The question arises as to whether these topics were not investigated or were not directly visible in the analyzed data.

Concurrently, it is noteworthy that the topic of teaching with the incorporation of technologies currently has a significant impact, as it is presumed that universities, in their pursuit of innovation and competitiveness in this era, manage the necessary tools for their teachers and students to innovate in proposals that transcend the instrumentality of technology. These findings highlight areas of potential growth and improvement. The necessity and value of fostering greater geographic and linguistic inclusion are acknowledged. Furthermore, comprehending the evolving trends in thematic areas can guide scholars and organizers to better align their projects and efforts with emerging needs and priorities.

It is important to note that the thematic analysis and semantic classification of the 4,530 papers constituted the technical foundation of the study, enabling the derivation of relevant conclusions regarding emerging trends in the corpus. The topics identified through LDA were interpreted based on the keywords that characterized them, and the papers were classified according to their semantic similarity (based on natural language processing and machine learning) to the defined categories. This methodology provided a deeper understanding of the topics covered in the papers and facilitated the detection of high-impact research areas, enabling their positioning within a global academic and scientific context.

The results suggest the necessity for a more balanced approach in curriculum design that integrates less-represented topics with the technological and management priorities of engineering education. It is also essential to foster interdisciplinary collaboration and promote inclusion initiatives, particularly in recruitment and retention strategies, to meet the demands of the workforce and social needs. Assessing the extent of innovation in engineering education in the region will require efforts and agreements that extend beyond individual and institutional initiatives, converging in global and community proposals that enable the overcoming of the greatest challenges in engineering education. Furthermore, understanding these evolving trends can guide academics and organizers to better align their projects and efforts with outstanding needs.

Future works

We believe that this type of corpus study allows us to approximate the research agenda and experience of engineering education. Without a doubt, knowing how thematic categories reflect reality helps us to think about what paths and decisions are being taken in engineering programs. Thus, new paths are open for further investigation:

- A qualitative comparative analysis of these themes in light of innovation in Latin America and the Caribbean would provide clues about what is happening with innovation in engineering training processes.
- It would also be interesting to understand how the issues of inclusion, equity, and diversity are outlined in the function of research in universities.
- A detailed study by region shows how these issues have been addressed, and from what dimensions they are positioned in teaching and innovation.
- An investigation examining the correlation between local trends and agendas from other geographical regions facilitates the comprehension of how the emphasis on research, innovation, education, and training in engineering influences regional development.

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