INDUSTRIAL ENGINEERING AND RELATED FIELDS IN THE XXI CENTURY: APPLIED CASE FOR STUDENTS ACOFI - ANTIOQUIA NODE*

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Abstract

The Network of Industrial Engineering and Related Fields (REDIN) - Antioquia Node consolidates an Industrial Engineering and related fields academic community in Colombia as a working group. One of these strategies is a REDIN - Antioquia Node Student Assembly that is held once a year. This paper aims to present analyses of competencies, graduate profiles, relevance, and trends in Industrial Engineering and related fields as a contribution to building a country in this discipline as a result of this assembly. This study presents a conceptual framework and the details to develop the assembly. It is centered on five stations of focused questions. Then, results, discussion, and conclusions are made evident. The assembly highlighted differences and similarities between differentiating factors, fields of action, performance sectors, technology trends, capabilities, skills, and a vision of the program in two working groups. Group 1 is made up of 1st to 5th-semester students, and Group 2

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is made up of 6th to 10th-semester students of Industrial Engineering and related fields. These types of scenarios represent opportunities for various fields of engineering, which, in context with the actors involved in curricular improvement processes, allow researchers to evidence and document research that serves as a reference to strengthen future professionals' relevance.

Keywords: student employment, professional competence, skills development, production engineering, educational prospection.

INGENIERÍA INDUSTRIAL Y CAMPOS AFINES EN EL SIGLO XXI: CASO APLICADO PARA ESTUDIANTES ACOFI - NODO ANTIOQUIA

Resumen

La Red de Ingeniería Industrial y Campos Afines (REDIN) - Nodo Antioquia consolida una comunidad académica de Ingeniería Industrial y campos afines en Colombia como grupo de trabajo. Una de sus estrategias es la Asamblea de Estudiantes REDIN - Nodo Antioquia, que se realiza una vez al año. Este artículo tiene como objetivo presentar análisis sobre competencias, perfiles de egreso, pertinencia y tendencias en Ingeniería Industrial y campos afines como aporte a la construcción de país en esta disciplina, como resultado de dicha asamblea. Este estudio presenta un marco conceptual y los detalles para el desarrollo de la asamblea. Está centrado en cinco estaciones con preguntas focalizadas. Posteriormente, se exponen los resultados, la discusión y las conclusiones. La asamblea destacó diferencias y similitudes entre factores diferenciadores, campos de acción, sectores de desempeño, tendencias tecnológicas, capacidades, habilidades y una visión del programa en dos grupos de trabajo. El Grupo 1 está conformado por estudiantes de 1.º a 5.º semestre, y el Grupo 2 por estudiantes de 6.º a 10.º semestre de Ingeniería Industrial y campos afines. Este tipo de escenarios representa oportunidades para diversos campos de la ingeniería que, en contexto con los actores involucrados en procesos de mejora curricular, permiten a los investigadores evidenciar y documentar investigaciones que sirvan como referencia para fortalecer la pertinencia de los futuros profesionales.

Palabras clave: empleabilidad estudiantil, competencia profesional, desarrollo de habilidades, ingeniería de producción, prospectiva educativa.

INTRODUCTION

Per the Statutes of ACOFI (Colombian Association of Schools of Engineering), the Board of Directors approved the formation of an Industrial Engineering Chapter. Since March 2019, regional leadership has been responsibly assumed to consolidate REDIN, which seeks to promote collective construction, propitiate integration spaces, and generate discussion scenarios concerning training in Industrial Engineering and related fields.

For this case study, we consider the REDIN - Antioquia Node student assembly held at the Universidad de Medellín with the support of Institución Universitaria de Envigado, Politécnico Colombiano Jaime Isaza Cadavid and the Universidad de Antioquia, bringing together students from 13 of the 22 Higher Education Institutions (HEI) that make up the Antioquia Chapter: Universidad de Medellín, Institución Universitaria de Envigado, Politécnico Colombiano Jaime Isaza Cadavid, Universidad de Antioquia, Institución Universitaria Pascual Bravo, Corporación Universitaria Adventista, Universidad Luis Amigó, Institución Universitaria Salazar y Herrera, Politécnico Grancolombiano, Universidad Nacional Abierta y a Distancia, Universidad San Buenaventura, Instituto Tecnológico Metropolitano, Universidad EIA.

As in [1]'s proposal where a comparative study is carried out among student groups, aiming to evidence strategies to support the teaching-learning process in engineering fields. This study analyzes trends (educational prospectives), a sense of belonging, competencies (professional competence and skills development), and graduation profiles (student employment) of Industrial Engineering (production engineering) and related fields in Antioquia. The methodology used to develop this study is different from those reported in the literature and is based on the perception of two groups of students as main actors, responding to questions focused on five workstations to collect information related to:

- Station 1 (E1): Knowing the most important factors of students' graduation profiles, in addition to what they consider a differentiating factor of their program.
- Station 2 (E2): Knowing the fields of action or areas in which they believe they can perform professionally, in addition to their favorite work sector and references concerning program selection.
- Station 3 (E3): Knowing opinions about the contributions of innovation, entrepreneurship, and research to the program and trends.
- Station 4 (E4): Knowing the capacities and skills they deem necessary for comprehensive performance.

- Station 5 (E5): Knowing student body aspirations and their vision of the program in 2030.

To respond to previous approaches, this article includes the following sections. Section 1 presents a theoretical framework that allows the generation of context and trends in the course topics. Section 2 presents materials and methods and defines the objective of the assembly, the assembly structure, and a development and analysis of the results of the assembly. Section 3 presents results and discussions. Finally, section 4 includes conclusions about the findings generated in the focused questions.

1. THEORETICAL FRAMEWORK

1.1 Basic concepts

[2] defines a graduate profile as a condensed presentation of professionals and the personal characteristics of graduates. In Colombia, academic programs are focusing their curricular design on the construction of graduate profiles; based on [2], a graduate profile presents the description of basic generic specific skills, knowledge, and competencies that a student is expected to acquire at the end of an academic program or major. This profile establishes the educational goals and characteristics that graduates must have to perform competently in their professional field.

According to [3], academic competencies are associated with the basic conditions of school learning and begin to develop in our first years of life, guided by educational institutions. At a university level, competencies refer to specific skills and knowledge that students must acquire during their professional training. These competencies may include cognitive, research, problem-solving, critical thinking, and effective communication, among others. Academic competencies are fundamental to intellectual development and the acquisition of knowledge in a field of study. In the Secretary's Commission report on Achieving Necessary Skills [SCANS] (1993), cited by [3], they state that academic competencies "are associated with fundamental general education knowledge." [3]. [4]'s study states that the concept of competencies is broad and encompasses different approaches, but from a technological and engineering perspective, it refers to the behaviors, knowledge, skills, and abilities that a professional must have to achieve optimal performance and attain organizational objectives.

Academic competencies are aimed at developing work competencies associated with the skills, knowledge, and attitudes that a person must have to perform successfully in a workplace. These competencies may vary according to a profession or field of work. This agrees with what [5] stated. Labor competencies include not only the basic competencies adopted in academic institutions but also a great diversity of attitudes, habits, and values for the correct functioning of a society that is increasingly demanding and influenced by new technologies, productivity, and competitiveness. The above is an indicator that some universities currently wish to foster an independent entrepreneurial spirit in their engineering students, as [6] presents it.

1.2 Trends in Industrial Engineering

In the field of Industrial Engineering and related areas, there have been relevant trends in recent years. Some of these include the application of artificial intelligence and machine learning in process optimization, focusing on sustainability and energy efficiency in production systems, developing advanced manufacturing technologies such as 3D printing and collaborative robotics, using data analytics and evidence-based decision-making, and implementing supply chain management strategies and smart logistics. [7] corroborated this by explaining that current technological trends focus on intelligent environments, combining physical and virtual systems, characteristic of the era of the fourth industrial revolution or Industry 4.0.

A search in Scopus for the terms competences AND industrial AND engineering AND trends OR profile yields an obvious list of keywords:

- **Engineering education:** This is the word with the greatest weight and maintains relationships with many other keywords, such as students, education, higher education, curriculum, teaching, e-learning, professional aspects, and competencies. These are natural and understandable relationships; however, some other relationships are found with contextual aspects such as digital technologies and risk assessment, and others with people-related factors such as motivation, competencies, decision-making, problem-solving, planning, and product design. The results found in [8]'s work highlight the continued relevance of strategic positions or roles in the context of shifts toward services and digitization.

- **Student:** This term has relationships that coincide with the previous concept, such as planning, decision making, motivation, curriculum, professional development, etc., but other interesting ones appear, such as science and technology, life cycle, knowledge, and system.

- **Teaching:** This has relationships with educational modalities such as e-learning and distance education (digital technologies). In [9]'s work, the importance of digitalization in the transformation of values and fields of activity in existing industries is highlighted.

- **Professional competence:** Researchers observed relationships with curriculum, accreditation, professional development, motivation, education, students, professional aspects, and distance education. Some other relationships that attract attention are knowledge management, digitization, journal priority, male, female, adult, methodology, human engineering, and ergonomics.

- **Computing or educational informatics:** appears as one of the most recent, it is linked to elements such as software engineering, decision making, computer, knowledge management, planning, product design, product application, and engineering. [10] highlight the need to enhance competencies to achieve a long-term sustainable competitive advantage in a global business environment. More relationships were found, the most significant are as follows (Figure 1).

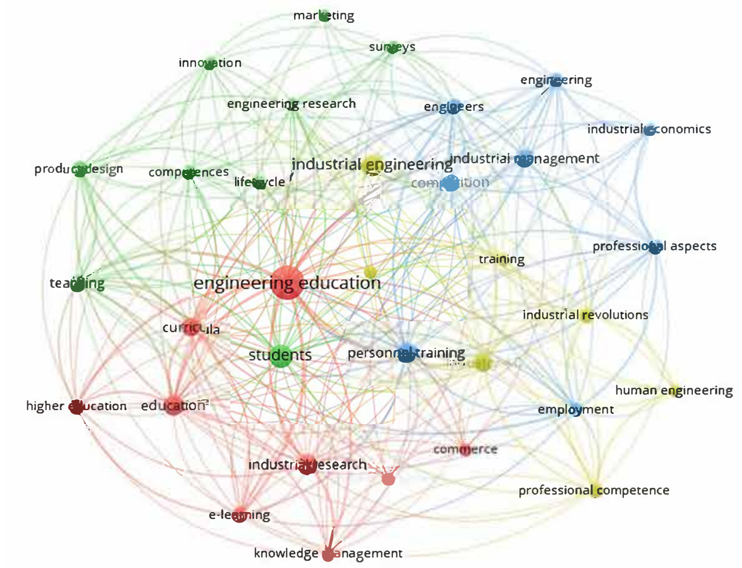

Figure 1. Keywords

Source: Authors' compilation using VOSviewer

- **Digital technologies and educational processes, industry 4.0, technology and evaluation:** there are other relationships with educational concepts such as education, engineering education, students, teaching, e-learning, competence, and learning. There is evidence of an increase in the number of documents related to these topics since 2004, considering the importance of developing engineering competencies to strengthen productive sector capabilities and trends, as shown in Figure 2.

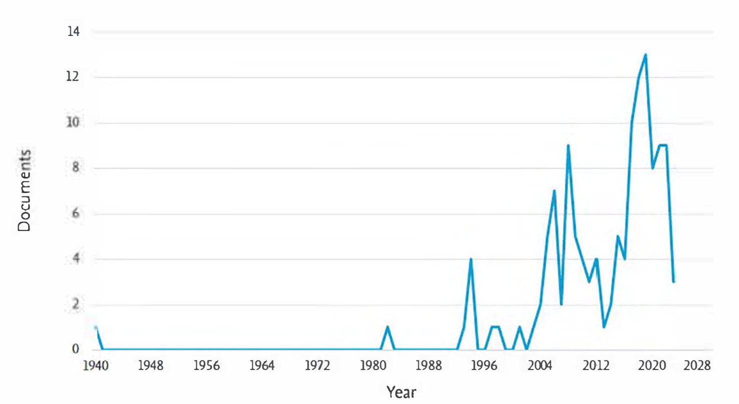

Figure 2. Documents by year

Source: Scopus, 2023

As seen in the bibliographic review, studies on competencies in engineering education have been carried out mainly at an international level. In Colombia, the concepts of competency and graduate profile have been determined in different works, such as those [7], [3] and [11] carried out.

To analyze the trend in Engineering, particularly in Industrial Engineering and related fields, and the competencies required by professionals, several methodologies have been used in studies. These methodologies include job bank selection with keyword searches for the roles of interest, the application of additional filters using inclusion and exclusion criteria, and data mining for the analysis of role changes associated with strategic positions, such as the one [8] used, [10] carried out multiple case studies in subsidiaries to determine the creation of competencies in business renewal. Systematic reviews of the literature have also been used, such as [9]'s work, to answer questions related to Education 4.0. Also, [11]'s research was initially based on a literature review and later on a test with its respective statistical analysis on project management competencies in Engineering programs and Generation Z students' personality traits. Another study based on a literature review is the one [12] proposed to determine future competencies in smart factories. An inductive method has been used to construct profiles of the Industrial Engineering program and related fields, such as in [13]'s study.

2. MATERIALS AND METHODS

This study proposes four phases for the methodological process. In phase I, the objective of the assembly is defined to characterize Industrial Engineering and related fields of REDIN-Antioquia Node comparatively, using an exploratory method in the HEIs attached to Antioquia Node-REDIN. To do so, students from the different academic semesters of the Industrial Engineering program and related fields are summoned to participate in a discussion scenario guided by questions. The call is made through REDIN-Antioquia Node's institutional representatives. In phase II, the structure of the assembly is generated, defining the logistics (date, place, duration), participants, materials, and instruments to gather information (forms in *Google Forms*, flip charts). The method applied in this phase is descriptive. In phase III, the development of the assembly is documented. Initial instructions, team formation, passing through workstations, socialization of results, and closure where fieldwork is applied as a method in this phase. In this phase, the segmentation of the participants into two work groups stands out. Group 1 is made up of students from 1st to 5th semester, and Group 2 is made up of students from 6th to 10th semester of Industrial Engineering and related fields, who had to go through five workstations to answer seven questions in terms of differentiating factors. Fields of action, sectors of performance, technology trends, capabilities, skills, and vision of the program (some of these questions were designed based on the methodology [11] proposed). Finally, in phase IV, the analysis of results is generated by taking the digital instrument and flip charts of the stations so that through the comparative method of mixed nature (qualitative and quantitative), conclusions and evaluation of the assembly are generated.

The phases (Figure 3) that were executed and the methods used to carry out this work are explained below [14], [15]:

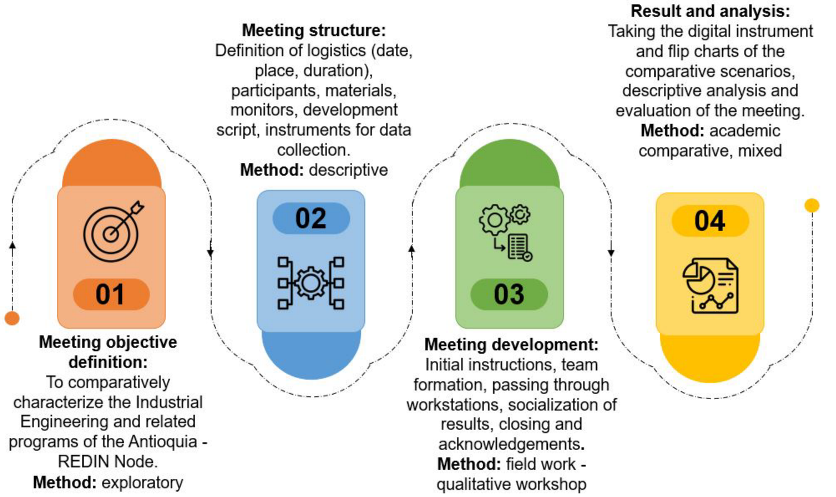

Figure 3. Methodology used

Source: Author's compilation

3. RESULTS AND DISCUSSION

3.1 Phase I. Definition of the objective of the assembly

According to sources from [16] in Colombia there are 181 Industrial Engineering and related fields, 17.13% in official HEIs and 82.87% in private HEIs. For the year 2022-2, there is a record of 68177 enrolled in the program, evidencing an increase compared to the same period of the immediately previous year, 66878, where 57.45% were men and 42.55% were women. As for graduate students in Industrial Engineering and related fields for the year 2022-2, there were 7447. As for Industrial Engineering and related fields by departments, Antioquia has 12.71% of the total, in second place with the highest number of programs in Colombia. In this context, it is established as this Student assembly's objective to characterize comparatively the Industrial Engineering and related fields of the REDIN-Antioquia Node, considering aspects related to graduation profiles, fields of action, program trends, training processes, and academic competencies, among others relevant to this case study, which allow determining relevance, actions and disciplinary opportunity of future professionals aligned in context with a socio-productive environment.

3.2 Phase II. Generation of the assembly structure

Table 1 shows a technical sheet of the assembly, which illustrates the logistics and structure considered to develop this Student assembly.

Table 1. Technical sheet of the Student Assembly

item	Description
Name of the Student Assembly	Workshop- 1st Assembly of REDIN students – Antioquia Node "Industrial Engineering and related fields in the XXI Century"
Location	Universidad de Medellín, Block 18 - Héctor Ospina Botero Auditorium
Date	October 12, 2022
Time	8.00am to 10.00am
Modality	Face-to-face with prior registration (limited places)
HEIs that organize	Universidad de Medellín, Institución Universitaria de Envigado, Politécnico Colombiano Jaime Isaza Cadavid, Universidad de Antioquia
Number of participating HEIs	13 HEIs
Number of participants	35 students
Number of monitors	10 students from the various organizing HEIs
Number of teachers	7

item	Description
Number of questions	E1: 2 E2: 3 E3: 2 E4: 1 E5: 1
Instruments used for the collection of information	Google forms (scenarios and evaluation of the assembly), photographic record, flip charts, attendance lists
Materials	10 flip charts, 10 Post-It blocks, 20 colored markers, 20 colored pens

Source: Author's compilation

3.3 Phase III. Development of the assembly

Table 2 summarizes each of the activities developed during the Student Assembly, considering the details of execution, the duration of the process, and the evidence.

Table 2. Development of the Student Assembly

Activity	Duration	Record
Reception and accommodation	10 min	
Explanation of the activity	10 min	
Group formation	10 min	

Activity	Duration	Record
Workstation Assignment	40 min	
Opening recreation activity	15 min	
Socialization of results	20 min	
Closing and evaluation of the assembly	10 min	

Source: Author's compilation

3.4 Phase IV. Analysis of results

The information from the digital instrument that the monitors filled out at each workstation is collected. It is also complemented by what was documented by the students in the flip charts of the comparative scenarios (workstations) to carry out a descriptive comparative analysis as the main objective of this Student assembly. Finally, the attendees evaluated the assembly through the projection of the QR that refers to *Google Forms* obtaining an average evaluation of 4.76, on a scale of 1 – 5, and 1 being the lowest rating and 5 being the highest:

For the presentation of the results and their respective discussion, the names Group 1 (G1) and Group 2 (G2) will be taken into account. G1 refers to students from the various HEIs between semesters 1 and 5, while G2 considers students participating from semesters 6 and 10.

3.4.1 E1

In E1, two questions were addressed. One of them was divided into two parts as follows: E1-P1, E1-P2.1, and E1-P2.2. E1-P1 asks *What are the most important factors of your graduation profile for your professional training?* Figure 4 shows that both groups highlight soft skills (ability to adapt, communicate, and work in a team) as their most important factor. Correspondence can be observed between factors presented by G1 and G2, such as soft skills, analytical capacity, new trends, optimization, and knowledge. In G1, observation skills, creativity, innovation, and versatility were also mentioned. Notice that this group focuses on more general factors, where there is evidence of a lack of specific knowledge of their professional training, and cross-cutting generalities of different areas of training are noted. On the other hand, G2 proposed additional factors in which greater knowledge of the program is observed, such as continuous improvement, project management, plant management, research, and experience. This shows that indeed, with the progress in the training plan, students are acquiring greater knowledge of an Industrial Engineer's work and the fields in which they feel they can perform in the future.

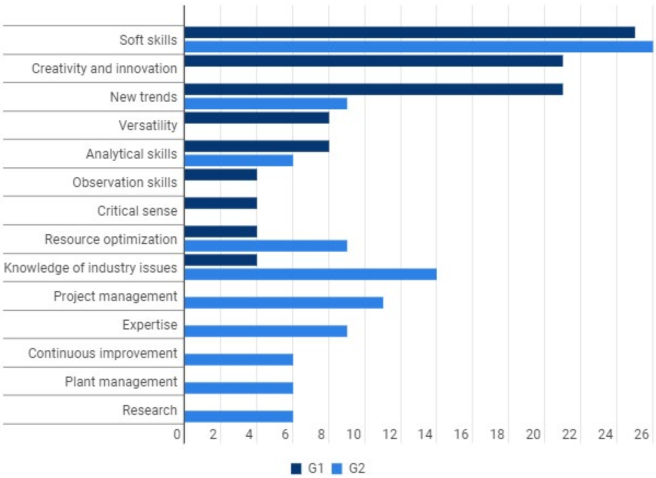

Figure 4. The most important factors of a graduate profile

Source: Author's compilation

Figure 5 shows the results of E1-P2.1 *What do you think is its differentiating factor?* In this case, there is no coincidence between G1 and G2 and it can be noted how the two groups were separated. There is evidence of greater knowledge in G2, and G1 stands out as differentiating factors, some similar to those selected as the most important of their professional profile. In this response, as in the previous one, cross-cutting factors are observed in different trainings such as soft skills, program management, programming, logic, and analytical capacity, among others. G2's response to E1-P2.1 is related to the ability to generate alternatives and comprehensive solutions, focus on the production process, and management of consulting projects.

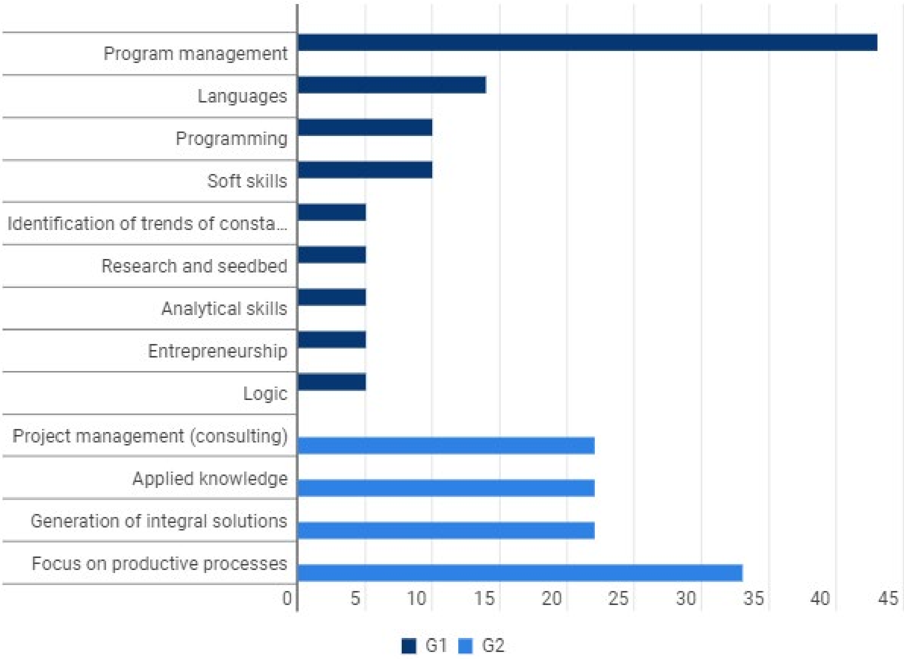

Figure 5. Differentiating factor

Source: Author's compilation

Figure 6 presents the answer to E1-P2.2, which was only for G2 *How do you think your differentiating factors can influence your professional life?* The largest percentage of G1 wrote something general for any university program: application to the workplace. Following this factor, those only trained in Industrial Engineering and related fields appear with 25%, which corresponds to continuous improvement, subsequently, and with equal percentages, three factors appear transversal to different professional training such as project leader, influencing others, and research.

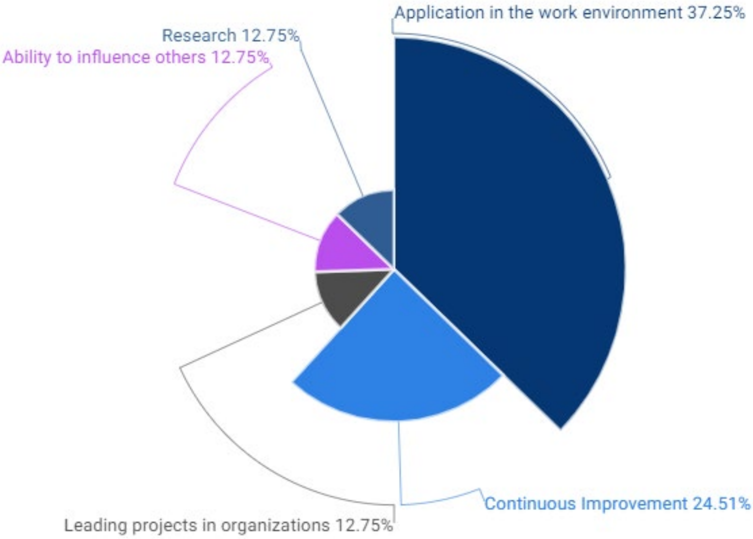

Figure 6. Influence on a graduate profile's professional life

Source: Author's compilation

The authors [11] and [13] present a profile of competencies for education in Industrial Engineering and related fields, which has been systematically designed through the discussion of the professional and cross-cutting competencies needed in the subfields of input, production, and output logistics, considering the current literature. They pointed out that this proposal for a competency profile serves as a starting point for the professionalization of engineering education in the field of industrial logistics, but that it must be perfected by incorporating current requirements from the perspectives of science, business, and society.

3.4.2 E2

In E2, three questions were addressed like this: E2-P1, E2-P2, E2-P3. To start with E2-P1*, what do you think are the fields of action, areas, disciplines, and sectors in which you can work professionally?* Figure 7 shows differences between G1 and G2 in design fields, plant management, and industrial design. G1 considers it important in 11.9% and G2 in 0.9%, as well as agro-industrial production, which is relevant for G1 in 16.7% and for G2 in 1.8%, and the automotive sector G1 considers it in 7.10% and G2 in 0.9%. In production and manufacturing, it was found that it was important for 7.2% of G1 and 12.2% of G2. In administration, finance, and resource management, 4.5% of G1 considers it a field of action, while this value increases to 8.5% in G2. Quality is considered a field of professional performance of interest in 4.8% for G1 and

7.5% for G2. Other fields such as human talent, data analytics, and the textile sector are mentioned, but in smaller percentages.

Concerning E2-P2, the question arises: *In which sectors would you like to work?* G1 highlights the food sector at 7.1%, inventories at 4.8%, operations coordination at 4.8%, modeling, and process simulation at 2.4%, and other sectors at 7.10%. On the other hand, for G2, they consider the services and health sector to be of greater interest at 7.5% and technology and systems at 5.6%.

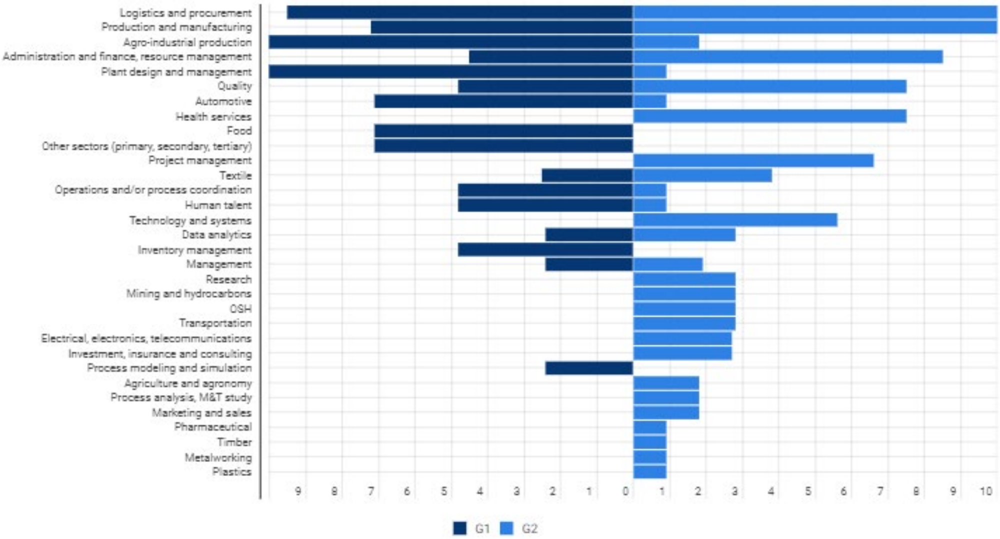

Figure 7. Fields of action, areas, disciplines, and sectors for professional performance

Source: Author's compilation

Figure 8 presents the results of E2-P3. *Do you have any references about the selection of a program?* Family, academic, and company management references had a ratio of 63% in G1 and 37% in G2. 18% of G1 considered the Industrial Engineering curriculum and reading of topics, while for G2 it is 25%, and Academic fairs and events for 18% of G1, and no reference for 37% of G2.

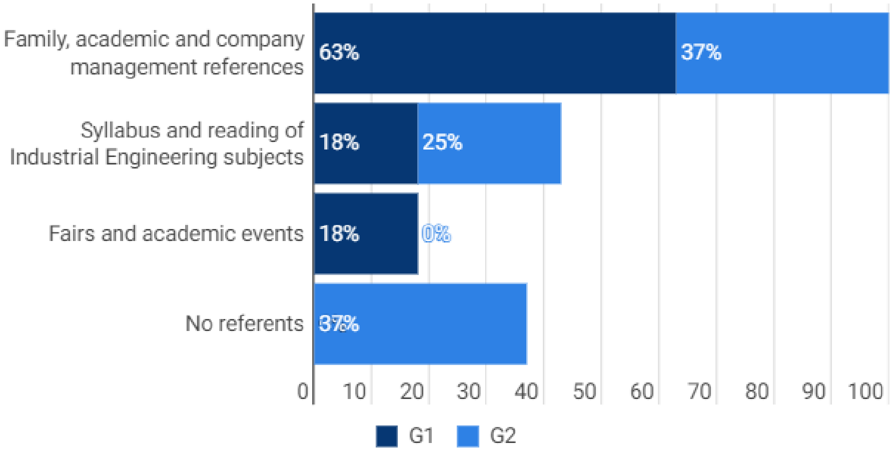

Figure 8. References for program selection

Source: Author's compilation

Taking into account [17], HEI representatives highlight that fundamental tools or competencies should be strengthened at the curricular level to comply with the learning outcomes required in the graduate profile. Thus, 20% highlight the importance of the lines in Industry 4.0 and digital transformation, 18% seek to strengthen social skills as a necessity for an integral professional, 18% seek to strengthen process improvement from a curricular level, and 13% focus efforts on the need for adequate learning environments. At the same time, HEIs face great challenges in updating Industrial Engineering curricula to meet training needs in quality conditions such as curriculum internationalization (15%), curricula updating adapted to Industrial Engineering and related program trends (12%), strengthening University-Company-State relationships (12%), creating short specialized virtual and distance programs (9%), having budget availability to increase the capacity to produce and generate knowledge (9%) and searching for high-quality accreditation models (9%).

On the other hand, [12] identify and classify future competencies in smart factories, in categories such as technical, methodological, social, and personal competencies. Some competencies to highlight are creative problem-solving, continuous learning, complex challenge analysis, leadership skills, knowledge transfer, and adaptation to change, among others.

3.4.3 E3

In E3, two questions were addressed, one of them adjusted according to the group that would answer as follows: E3-P1, E3-P2.1, E3-P2.2. Regarding E3-P1*, how do you think innovation, entrepreneurship, and research contribute to your study program?* within the categories highlighted by G1, the creation of a business idea 21.9%, technology, programming, and social networks 28.1%, problem-solving and challenges 28.1%, continuous improvement 15.6% and process improvement with innovation 6.3%.

For G2, the creation of a business idea represents 21.4%. The use of technology 2.4% is proposed using social networks for advertising and *e-commerce*, also the solution of business problems and challenges 9.5%, continuous improvement 47.6%, and the improvement of processes with innovation 19%.

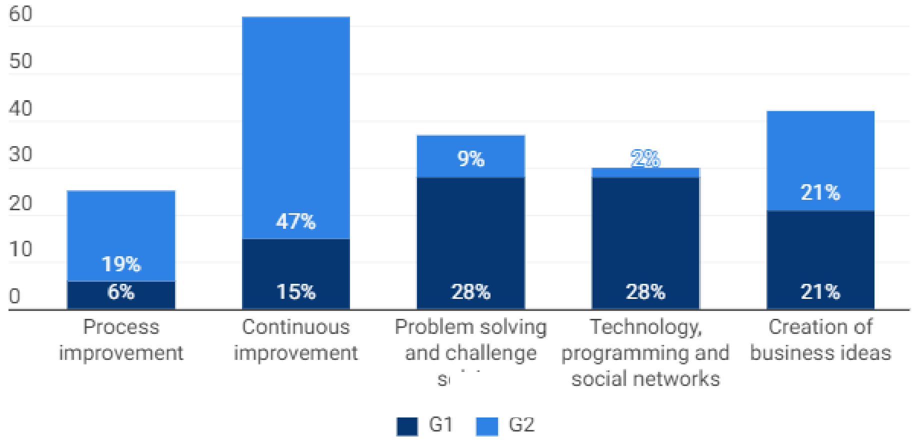

Figure 9. Contribution of innovation, entrepreneurship, and research
Source: Author's compilation

Concerning E3-P2.1 only addressed by G1*, what should be the trends in technology applicable to your training?* They observed that they affirm the management of social networks and the use of podcasts with a 20% representation. In addition, regarding the use of new technologies, they define it as the management of programming languages, software, and data analysis with a 76.7% representation. They also mentioned that these technologies help improve the fields of industrial engineering with a 3.3% share (Figure 10). In E3-P2.2, *How would you apply trends in technology in your professional development?* G2 only solved it and analyzed that greater priority was given to the use of new technologies related to the development of Industry 4.0 tools, used for data analysis, modeling, and simulation, as well as technology training for the organization's employees with a 90% participation. Another item mentioned would be machinery innovation to be used using *hardware* or *software* with hard or soft technology with a 10% representation (Figure 10).

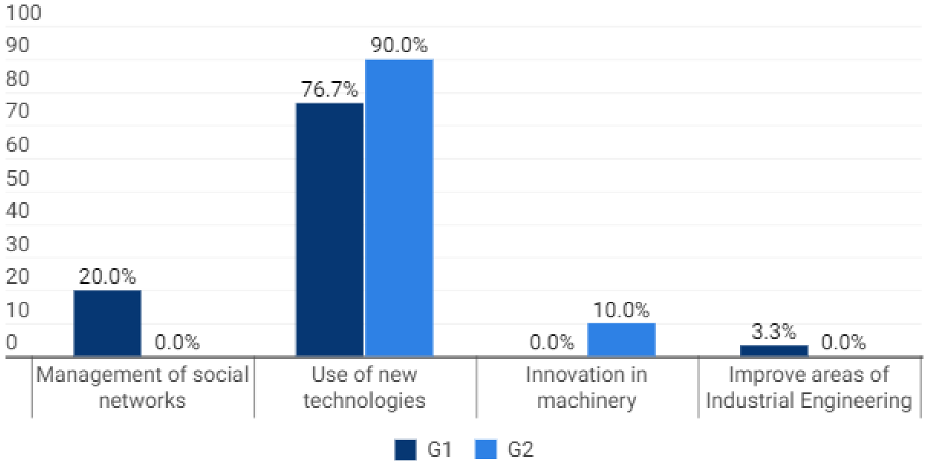

Figure 10. Technology trends in your professional development

Source: Author's compilation

In a study, [17] proposed it is possible to show how HEIs are joining forces in promoting strategies to adapt the graduate profile of Industrial Engineers and related fields to future needs. It is done considering the importance of in-depth study lines in Industry 4.0 and digital transformation. Complementing what [18] presented, it is necessary to implement advanced training processes for ICT use in the classroom, transforming their practices in a reflexive way and following national education plans. [6] concluded that to maintain continuous innovation and thus contribute to sustainable organizational development, some competencies had been identified that could be fostered in engineering students through entrepreneurship programs. Among these competencies, analytical and creative skills, management, and research skills stand out. This is an indicator that currently, some HEIs want to promote an independent entrepreneurial spirit in their Industrial Engineering and related program students.

3.4.4 E4

In E4, a question like this was addressed: E4-P1. As far as capacities and skills are concerned, in the profiles and study plan, while at G1 the question asked was *What do you think are the capacities and skills that a professional should have for comprehensive performance in the near future?* G2 is asked to find out *what capacities and skills they have developed in their study plan for comprehensive performance in the near future?*, next, as main findings (Figure 11) soft skills such as communication, listening, teamwork, resilience, risk-taking, proactivity, critical thinking, problem-solving in G1 stand out at 53.2%. In G2, adaptation and learning, leadership, socialization, and assertive communication stand out, at 40.4%.

Disciplinary competencies in G1 are also highlighted, such as process optimization, logical reasoning, analytical capacity, profile flexibility, and quantification of business situations at 12.8%; while in G2, distribution and planning of production spaces, technological management, metrology, administration and project management, calibration of measurement equipment, process optimization and improvement, decision-making and idea generation, logistics and production, quality control, quality management (standards and auditing) are more representative, at 37.2%.

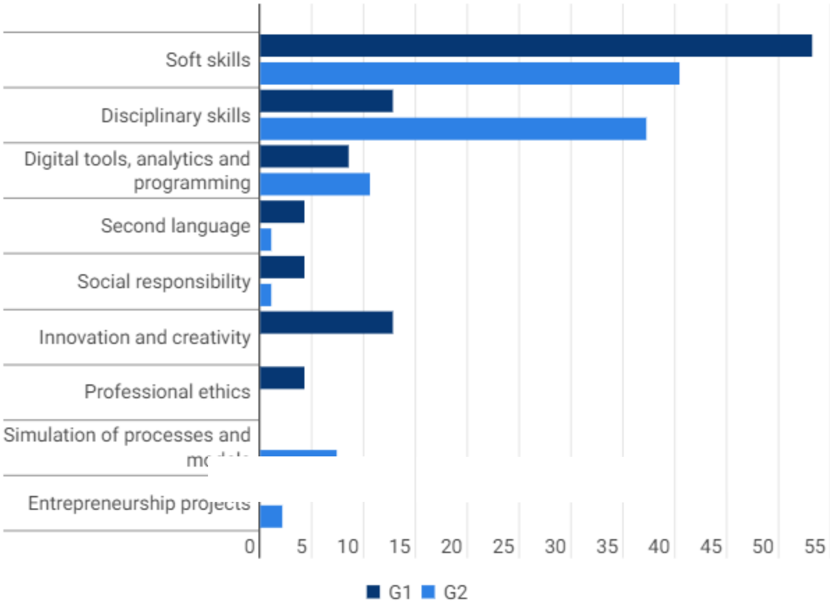

Figure 11. Capacities and skills in the profiles and study plan

Source: Author's compilation

Taking as a reference the study [17] conducted, Industrial Engineering and related fields highlight overall patterns and specific competencies related to applied engineering (23%), innovation (20%), basic and socio-humanistic sciences (15% each), basic engineering and economic-administrative sciences (14% each) in terms of general competencies. This allows the generation of analogies concerning what students in both groups expect to develop throughout their curriculum. The Antioquia Node-REDIN study also frames a series of the most representative and common specific competencies such as a comprehensive vision of organizations, modeling systems and processes, and increasing productivity.

According to [17] communication and self-development are presented as key competencies in the profiles studied. In addition, there is a high demand for analysis and decision-making tasks, so a new trend is intuited in organizations, to see some roles as active partners in business, which transcends a vision of simple executors. Likewise, a need to balance technical knowledge and soft skills in these profiles is detected.

3.4.5 E5

In E5, a question like E5-P1 was addressed for both groups*: How do professionals in Industrial Engineering or related fields see themselves in 2030?* The differences are significant (Figure 19). G1 places special emphasis on possible engineering fields such as Industry 4.0 (*Big Data*, IoT, process automation), sustainability (circular economy, alternative energies), research, innovation, and technological adaptation (52.2%). For this group, in addition, external relationships, particularly in terms of possible needs for program curricular reform and evolution, as well as synergy in government processes to advance in the regions (30.4%). Finally, required soft skills such as resourcefulness, leadership, autonomy, originality and agility stand out in the development of human beings (17.4%).

On the other hand, G2 does not consider any of these aspects. Their emphasis was on the occupational profile in fields such as *Big Data* consultant, logistics areas with technological applications, managers in metrology, quality, simulation, automation, and/or programming, giving other people opportunities with entrepreneurs' roles (85.0%). Innovation and research (10.0%) were additional skills and future challenges such as internationalization (5.0%) were also complementary.

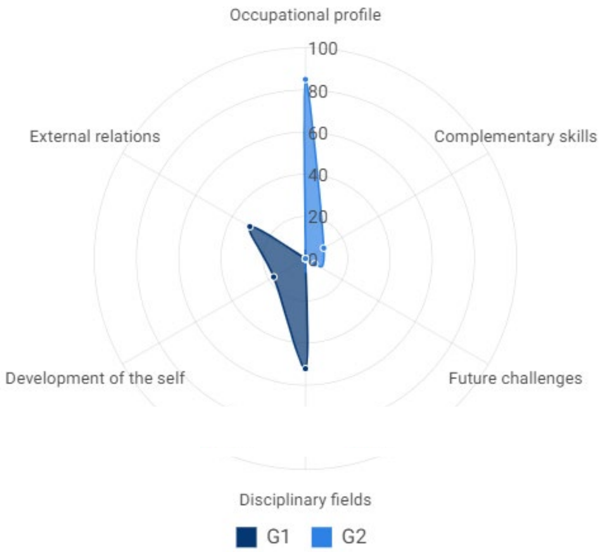

Figure 12. Professional in Industrial Engineering or related fields in 2030

Source: Author's compilation

In [11], the importance of recognizing the personalities of the new generations in Industrial Engineering and related fields graduates' profiles is highlighted. Some strengths were identified such as high resilience, high emotional stability and a tendency to be result-oriented. Likewise, results scored high in kindness and empathy and low in openness. In addition, [19] emphasizes that an academic manager's main responsibilities to ensure relevant programs are to promote internationalization, extension, and research, and increase the potential, quality, and recognition of the program.

CONCLUSIONS

In E1, it is possible to conclude in the face of the most important factors of a graduate profile mentioned by both student groups, that the impact the various HEIs participating in this assembly want to give in training is not only for Industrial Engineering and related fields professionals but also for comprehensive human beings, who can perform in different activities, in local Industry's diverse needs. This becomes evident when you notice the importance that students give to soft skills, analytical capacity, and the ability to develop skills in new trends (using different *software* and programming tools).

As for the program's differentiating factor, it is important to analyze students' answers given in light of the information HEIs reported in [17]'s work. The study determined that the most relevant differentiating factors are design and improvement at 17%, development of productive sectors at 14%, integrated productive and logistics systems at 11%, diagnosis, and optimization at 8%, management tools at 8%, evaluation and measurement of processes at 8%, technological innovation at 8%, productivity, and competitiveness 8% and in cross-section integrality, ethics, and project-based approaches. It is noted students are not internalizing the differentiating factors HEIs had presented. Here, it is striking that students who are a maximum of two years away from starting their professional practice have so little specific vision about their work and its differentiating factors.

In E2, the conclusion is that the fields of action, areas, or disciplines in which they believe both study groups can perform professionally are logistics, supply, production, manufacturing processes, and agro-industrial production. For G1, plant design and management, inventories, operations coordination, and human talent stand out, while for G2, the fields that stand out are quality, administration, finance, project management, technology, and systems.

The sectors of preference to work for G1 are automotive and food, while for G2, they are services and health.

Both student groups mentioned as references about program selection, family members, academics, company directors, readings of the study plan, and topics related to the disciplinary field.

In E3, both groups' opinions about the contributions of innovation, entrepreneurship, and research to the program are creation and business ideas. In particular, for G1, problem-solving, and challenges stand out, in addition to technology, programming, and social networks, while for G2, contribution is given for continuous improvement.

As far as trends in technological applications are concerned, both groups register the importance of using new technologies. For G1, its application is in managing social networks, while for G2, it is in machinery innovation.

In E4, it is possible to show in terms of the capacities and skills that they consider necessary for comprehensive performance, how digital tools, analytics, and programming are part of the analysis, going from 8.5% in G1 to 10.6% in G2. Both groups also mentioned second language and social responsibility, both showing a 4.3% decrease in participation in G1 to 1.1% in G2. For G1, participants mentioned innovation and creativity have 12.8%, while professional ethics only 4.3%. However, these are characteristics that were not considered by G2. Finally, G2 referred to 7.4% for processes and model simulation and 2.1% of them referred to entrepreneurship projects. However, G1 did not consider any of these aspects.

In E5, seeking to know the student body's aspirations and their vision of the program in 2030, this study based itself on [17]'s study, where participating HEIs' representatives highlight some fundamental tools or competencies that are expected to be strengthened at the curricular level to meet the learning outcomes required in a graduation profile. "20% highlight the importance of the lines in Industry 4.0 and digital transformation. 18% seek to strengthen social skills as a necessity for an integral professional. 18% seek to strengthen process improvement from the curricular, and 13% focus efforts on the need for adequate learning environments" [17]. Compared to what was expressed by both groups, students value digital transformation, a comprehensive professional profile, and adapting to the environment.

The following future exercises can be derived from this study:

- Review of curricular plans by HEIs, which allow students to meet their interests, without losing the rigor and fundamental focus of Industrial Engineering and related fields.
- To replicate in a similar future scenario this case applied to determine interest, evolution, and trends of Industrial Engineering and related fields.

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