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# Sequential Triadic Methodology for the Conception and Self-Assessment of a Study Plan

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***Abstract***

*The results of the article demonstrate that graduates of the Computer and Systems Engineering program have transitioned from developing scientific aptitude skills to planning during their professional careers. This finding suggests that the study plan should emphasize the development of managerial skills, leveraging the logical competencies that characterize engineering students, while simultaneously improving their learning outcomes in innovation and information technology. The article proposes a triadic self-assessment model based on the Triadic Mental Quotient Revealer test proposed by Waldemar De Gregori, utilizing a sequential triadic methodology for the conception and self-assessment of a study plan. This self-assessment process has allowed for the identification and reduction of the gap that exists between industry and the university. Accordingly, the syllabus serves as a control variable that adapts to the industry's requirements to reduce this gap. The article presents a curriculum for the Systems and Computer Engineering program that is considered within the government regulations and the national qualifications framework in the Colombian social context.*

***Keywords:*** *competencies; curriculum; triadic brain; self-assessment; triadic methodology*

## Introduction

Colombia currently boasts a well-established IT software and services industry that is rapidly growing and thriving in the development of specialized IT solutions for various sectors, including Fintech, healthcare, agribusiness, petrochemicals, energy, telecommunications, logistics, government, digital marketing, virtual and augmented reality, business, big data, among others. The government is committed to digital transformation as a catalyst for technology-based services in the region in the coming years (Belousova Veronika. and Chichkanov, 2022; Medina Baquero, 2022).

Currently, the technological trends in the IT industry have a strong relationship with information systems, particularly with Systems Engineering, which is referred to by different names in various countries such as Information Technology Engineering, Computer Engineering, Software Engineering, and Computer Science, among others. However, the objective and the skills or competencies acquired are similar, including planning, design, implementation, and maintenance of computer and technological systems, which are common to all these programs.

According to Gartner, the development of IT competencies is a crucial element for an organization's success in a constantly evolving digital environment, which requires adaptability to technological disruptions and improving the efficiency and effectiveness of business processes through the development of digital strategies with a degree of innovation (Hubschmid-Vierheilig

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Elena. and Rohrer, 2020). This highlights the need for IT engineers in the country, which has prompted university programs to carry out continuous curriculum updates.

Figure 1 depicts job offers made during the annual periods from 2017 to 2022 (observation time window), which were extracted from various job portals and employment exchanges, including Computrabajo Colombia, elempleo.com, Konzerta, Trabajando.com Colombia, Universia empleo, Buscojobs Colombia, Acciontrabajo Colombia, Empleate, EmpleosLatino.com, and EmpleoListo.com. The information available for free web consultation was obtained through web scraping. We have selected the four areas with the highest labor demand and identified the top five most in-demand jobs in each area from 2017 to 2022.

It's worth noting that the data shown in Figure 2 is derived from the Colombian labor observatory, a governmental information system that analyzes the situation of occupations and the job market in the country. This entity is attached to the Ministry of National Education.

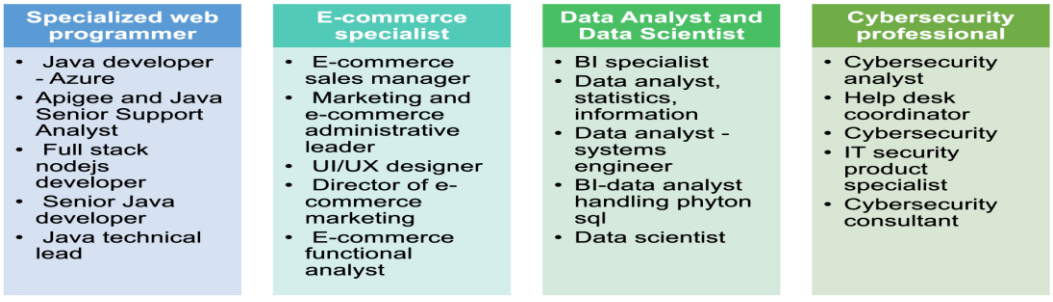


**Figure 1:** Areas of Jobs with the Highest Demand in Colombia in the it.

The most in-demand positions in the field of Systems Engineering are development engineers, service engineers, support engineers, and project managers, across companies of all sizes. Micro and small companies tend to demand more purely operational positions, while larger companies require commercial and project managers. Figure 2 describes the demand for professionals according to the Labor Observatory for Education (OLE), the National Information System for Higher Education (SNIES), and IT Industry Observatory of the Ministry of Information and Communication Technologies (Observatorio-TIC, 2022; OLE, 2022; SNIES, 2022).

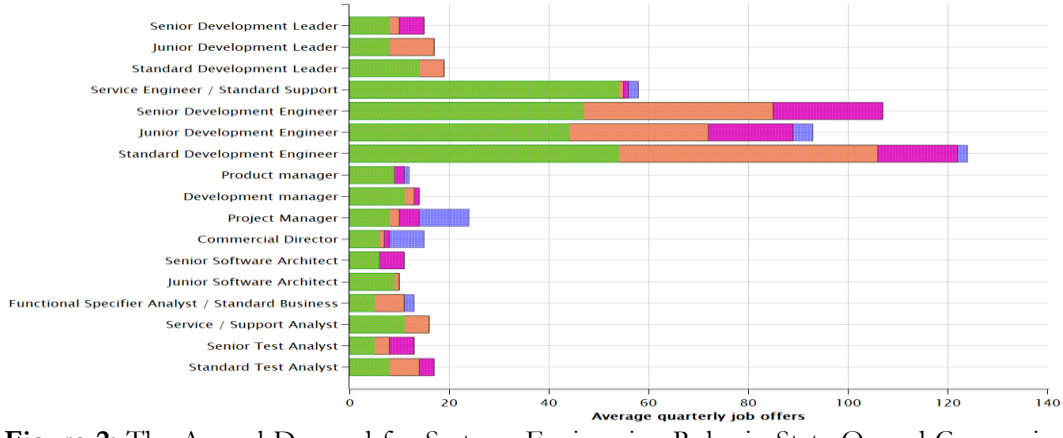


**Figure 2:** The Annual Demand for Systems Engineering Roles in State-Owned Companies, 2021-2022.

Colombian universities need to adjust their curricula and training routes to the needs of the

market based on the demand for IT skills and competencies, while also interpreting the social processes that allow for the development of ethically acceptable technologies to tackle the challenges and opportunities that arise from the interaction between technology and society.

Furthermore, the SWEBOK project (Software Engineering Body of Knowledge) provides essential knowledge that software engineers must possess, compiled in a guide for their training, evaluation, and certification across 15 knowledge areas. These areas include the specification of requirements, software design, coding, testing, software quality, and software project management. This guide serves as a valuable tool for software engineers, companies, and universities seeking to establish a framework for training and professional development in the field of software engineering.

Another aspect recommended by Gartner (Chai et al., 2019; Gartner, 2022) to universities regarding technology integration in their curricula is adopting innovative technologies to improve efficiency and enhance the student experience. This involves promoting collaboration among different faculties (e.g., medicine, economics, engineering) and connecting with external stakeholders, such as companies and institutions. By doing so, academic programs can ensure their syllabus is up to date with the latest emerging IT technology skills that are in high demand (Lim et al., 2023).

Moreover, recognizing the training needs of graduates, reflecting on their experiences, and gathering feedback from employers during internship periods can lead to valuable recommendations. These inputs can then be used in the process of updating study plans, curricula, and syllabi of any program.

As a consequence of the Covid-19 pandemic, traditional processes of internationalization for the dissemination of science, such as meetings, presentations, and congresses, which were mostly carried out in person, have now changed to a hybrid mode. Similarly, teleworking has been consolidated and IT professionals have adapted to an acceleration of digitization in many sectors, leading to a greater demand for information technology (IT) skills and abilities than the current training of systems engineers can replace, generating a gap between the skills and competencies that companies require and those that their workers currently have.

To address this gap, some companies are investing in the training and development of their current employees, while others are hiring external experts or adopting third-party technology and automation solutions to make up for in-house skills gaps, as the training acquired in universities is insufficient, becoming a problem.

The inclusion of IT skills has become a challenge for both the industry and universities, presenting an opportunity to include necessary skills and competencies in curricula with a projection towards a constantly evolving, connected, and globalized digital environment. In this context, where polyglotism and the opening of work visas demand professionals with specific skills, such as the ability to work independently with efficient time management, as well as establish and maintain remote connections and collaborations, these professionals are currently considered digital nomads.

One of the problems observed in Latin American universities is the continued conception of monadic curricula focused on the development of mathematical logic, when they should be restructured to deploy critical thinking in students, enabling them to mature in the skills of knowing, doing, and being. This should be based on required skills and contextualized in the needs of the productive sector.

The objective of this article is to present the procedure and analysis used to conceive

a curricular proposal for the Systems and Computing Engineering degree within the National Qualifications Framework (MNC). The basis of this proposal relies on triadic thinking and its relationship with employability, proposing the curriculum as a dependent variable on external factors that include computer skills and competencies demanded by the industry and labor demands in the Colombian social context. As a controlled variable, factors associated with the curriculum, such as academic programs, contribute differently to an individual's employability depending on their personality and learning style.

The presented curricular proposal supports the learning style model based on triadic thinking developed by Waldemar De Gregori (Garbinato Junior, 2018; Ortiz, 2020), who focuses on the management of the triadic manifestation of the human being from social cybernetics. From this point, the curriculum is considered as a set of formal and informal agendas to train the unitary brain of people in self-direction, self-sustenance, and self-education so that they can be socially integrated as protagonists in a post-pandemic "*new reality*" (Organización de Estados Iberoamericanos, 2021).

The curriculum has four levels of performance in its mental functions, which range from the simplest to the most complex, going through the levels of execution, management, advice, and leadership, recognizing the logical, operational, and emotional functions, and promoting talents and skills.

For this case, the research objective for the MNC has been defined as the restructuring of the traditional curriculum of Systems and Computing Engineering, with the implementation of a self-assessment model and a competency integrator supported by the style identification model of learning based on the triadic model of thought proposed by Waldemar De Gregori.

## Method

The methodology used in the curricular proposal presented in this article is based on Waldemar De Gregori's Triadic Mental Quotient Revealer (TMQR), which he developed to measure creativity and problem-solving abilities (Grégori, 2014). The test is used to identify the learning style and adapt IT content through a self-assessment process throughout the curriculum of the Systems and Computing Engineering program, providing feedback on the demand for IT skills and competencies.

The TMQR test was applied in three stages: an initial stage to characterize the type of student entering the program, an intermediate test to determine variation and make intermediate adjustments through the syllabus, and a final test applied to recently graduated individuals and those with up to more than 16 years of experience, in order to determine their evolution in society and the identification of IT skills and competencies acquired.

These moments of self-evaluation and iterative feedback, applied mostly to the program's graduates, allowed the identification and formulation of academic spaces that helped to understand the interrelationship and plan the inclusion of academic spaces in the program's curriculum based on the evolution of IT skills and competencies. For this reason, this process was developed in the following phases:

- Analysis of society: Before formulating a curriculum, Colombian society and its context

were analyzed, considering factors such as culture, economy, politics, technology, and current and future social needs. This analysis makes it possible to determine a profile for admission to the program.

- Identification of the objectives and competences: Based on the results of the analysis of the society, the objectives and competences that are to be developed in the students were identified, in terms of the graduation profile, which must be aligned with the needs and demands of the society.
- Selection of academic spaces: Once the objectives and competences have been defined, the academic spaces must be selected that allow the integration of the objectives and competences with the analysis of society to be in tune with the social reality of the environment.
- Design of activities: With the selected academic spaces, we proceed to integrate activities that allow students to develop the skills and objectives set for the fulfillment of the professional profile. These activities must make the most of the potential of technology, the digital tools available and the demanded employability requirements.
- Self-assessment: This phase corresponds to a continuous process and forms an integral part of the curriculum, allowing for the measurement of the integration process, adjusting, and identifying opportunities for improvement.

**Analysis of Society (Population)**

The Systems and Computing Engineering program has 1987 graduates. For the target sample during the period of 2013 to 2022-1, there have been follow-up and frequent contact with 730 of them in the last five years, which becomes the size of the target population (N). The desired confidence level (Z) is 1.96 for a 95% confidence level with a margin of error (E) of 5% (0.05), and an expected proportion (p) with a given opinion of 50% (0.5). From these conditions, the appropriate sample size (n) is determined as shown in equation (1):

$$n = \frac{\frac{Z^2 p(1-p)}{E^2}}{1 + \frac{1 + Z^2 p(1-p)}{E^2 N}} \tag{1}$$

In that case, the sample size (n) is calculated in (2):

$$n = \frac{\frac{1.96^2 \cdot 0.5 \cdot (1-0.5)}{0.05^2}}{1 + \frac{1 + 1.96^2 \cdot 0.5 \cdot (1-0.5)}{0.05^2 \cdot 730}} = 251.702 \tag{2}$$

Rounding n requires a minimum sample of 252 people to obtain a reliable estimate of the opinion of the target population of 730 individuals.

Regarding the results presented, a sample of 274 respondents was reached. Among them, 218 were men and 56 were women, with an age range from 22 to 58 years old, and an average labor productivity between 28 and 45 years of age, with salaries greater than $2,200 USD for 23% of the respondents, who occupied positions such as senior programmers, project managers, and data analysts. Junior programmers, database administrators, support engineers, and network technicians, between 23 and 35 years old, represented 61% of respondents, with a salary range from $300 USD to $1150 USD. Also, 11% of them worked in the telecommunications sector in mobile cellular telephone companies, support in fiber optic networks, and security in computer

networks, with an age range between 27 and 58 years. Finally, only 6% of those surveyed declared themselves as independent workers, providing support and sales in technology centers and freelance activities without declaring their monthly income, and aged between 23 and 29 years.

Likewise, information was collected from 20 professionals directly related to education, including professors, coordinators, and university deans, who considered relevant aspects between industry and academia and their representation of relationships in a curriculum. These interviews were not added to the target population (274), since the sampling was intentional in order to link elements of the academy, the institution, and the current regulation of the Colombian National Ministry of Education.

The other phases, such as the identification of objectives and competencies, the selection of academic spaces, the design of activities, and the self-assessment, are closely related in the context of learning and education and are presented in the Proposal section as a triadic self-assessment model.

## Results

The De Gregori triadic mental quotient in the terminal stage allowed us to measure the cohesion of the social group of graduates, applied in the different work contexts in which they work. We obtained results through triadic methodologies (Kim & Bae, 2017; Nätti et al., 2014; Wang et al., 2021) applied to studies of markets, using a sequence of a survey, an interview, and the TMQR test. This section describes and explains the results obtained in each of these sequences.

### Survey Data

The application of surveys allowed for the identification of social cohesion, relating to the membership of socio-emotional, intellectual, and business competencies. The results show the number of closed triads divided by the number of possible triads for greater cohesion in the group of graduates. Figure 3 shows that the Systems and Computing Engineering program should project (consolidate) the development of logical, operational, and affective competencies in its curriculum.

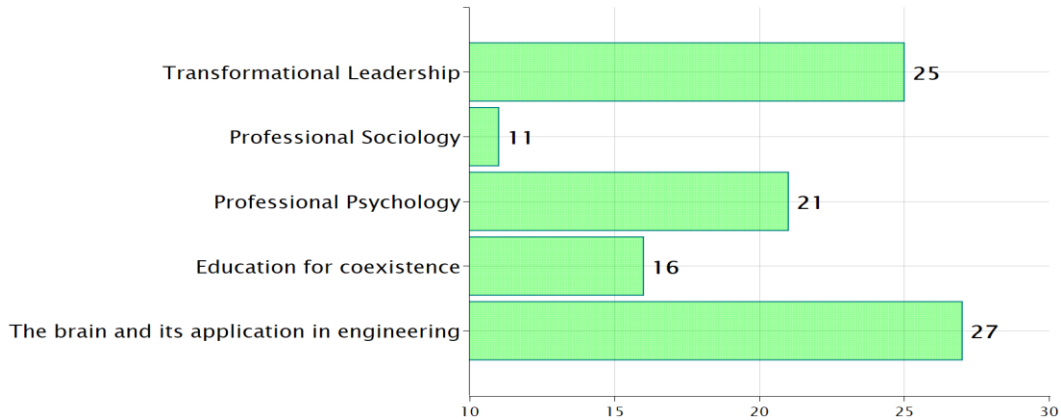


**Figure 3:** Percentage and Classification of Subjects for the Development of Socio-Emotional Skills.

The survey grouped triads that encompass "the brain and its application in engineering", viewed from the identification of trends in IT related to society. Artificial Intelligence (AI) and Machine Learning (ML) emerged as the leading transformative technology for businesses, with the highest perception of favorability for job performance among the respondents, followed by Cloud Computing and Cybersecurity. On the other hand, the triad with the highest perception of unfavourability for job

performance includes Robotic Process Automation (RPA), Internet of Things (IoT), and Virtual and Augmented Reality. The perspective gained from the interview sequence shows that RPA is not a recurring topic, as companies implement it and take years to modify it. Similarly, interviewees expressed that Colombia is an emerging country in smart cities, therefore distributed sensing has a very low demand for job positions, as well as virtual and augmented reality.

The psychosocial triads link aspects of "education for coexistence", "professional psychology and sociology", and "transformational leadership" with the development of IT professions in society. These aspects are further expanded upon in the information collected from the interviews, which are presented in the Interview Data section.

As a result of the survey, Figure 4 displays the top five academic areas most favorable and proposed for reducing the gap between academia and social life (perceived unfavourability), selected by 25% of a triad of transformational leadership, as shown in Figure 3.

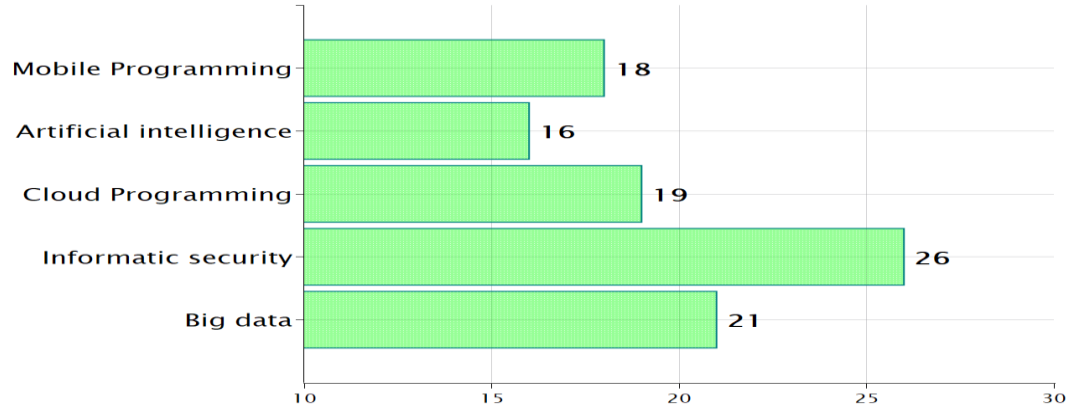


**Figure 4:** Percentage and Classification of Subjects for the Development of Intellectual Competences.

Another aspect identified in 'transformational leadership' is related to business competencies as a focus of personal and professional development, marking innovation as a significant driver of change in organizations and society. Graduates indicate that the academic areas that contribute the most to understanding both local and global economies are Project Evaluation and Development, followed by Business Engineering and Macroeconomics within the predominant triad that projects the relationship of systems and computer engineering with the markets, as shown in Figure 5.

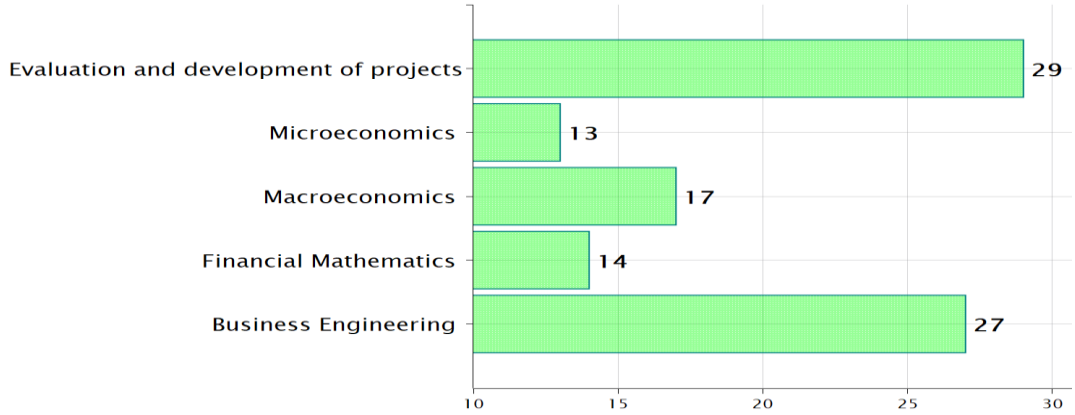


**Figure 5:** Percentage and Classification of Subjects for the Development of Intellectual Competences.

### Interview Data

In the context of the interviews, the triadic quotient was applied in survey format to identify triads that relate the data of the interviewees with the data of the surveyed, expanding the perception of obtained responses, obtaining

70% of the interviewees state that their undergraduate education lacked the development of emotional competencies, such as "self-awareness" to become aware of a self-taught, professional and competitive performance. The lack of "emotional management," as this 70% declares that there were few tools that provide the ability to manage stress, pressure and deal with conflict situations effectively. On the other hand, they state that it is necessary to develop "empathy" to understand and feel the emotions of others and, in turn, understand the needs of users, clients, and colleagues, and design tailored solutions adjusted to the needs of clients. Finally, "effective communication" must be strengthened since, in their post-university environment, they require the ability to communicate their ideas and knowledge clearly, effectively, and in a two-way manner, develop the ability to listen and respond appropriately. The interviewees declare that these emotional competencies have been developed in their work stage and with the passage of time, they have improved collaborative work and their leadership. With the above, the interviewees justified the socio-emotional competencies shown in Figure 3, which cannot be included as academic spaces due to their transversal nature and post-learning nature after graduation.

The triad of "the brain and its application in engineering" and "transformational leadership" allowed identifying academic areas of perceived improvement in response to the absence of consolidation of intellectual and business competencies, in response to the difficulties faced by graduates when obtaining a job or starting their own business.

The collection of information from the 20 professionals with a direct relationship with education was established under the National Qualifications System (SNC), which is responsible for compiling the set of competencies necessary to perform a specific job function. Regarding the qualifications related to IT, the SNC contemplates areas such as software and application development, database management, cybersecurity, and networks and communications (MIN, 2022), confirmed by thematic correlation in more than 60% of the syllabi of big data, computer security, cloud programming, artificial intelligence, and mobile device programming, as shown in Figure 4.

### TMQR Data

When using the TMQR test as a nonverbal intelligence test to measure the ability to solve abstract and complex problems through the identification of patterns and relationships between geometric figures, using the triadic mental quotient test (Carrero et al., 2015), graduates selected a figure that completes a series of correlated patterns, in order to classify abstract, perceptual, and analytical reasoning skills used in the IT industry. The results of this test show that the dominant brain among the graduate population was the central (operational) with 39%, followed by the left brain (logical) with 32% and the right brain (creative) dominates with 29%. The data corresponding to the initial and intermediate tests within the observation window are presented and discussed in the next section.

## Discussion

Contrary to the expected results (dominance of logical competence) (Carrero et al., 2015), it is observed in the graduates that their creative abilities are more developed. This characteristic favors the proposal of a curriculum plan oriented towards the development of competencies

for the three brains, seeking to encourage the logical brain and taking advantage of creative competencies for better learning, since the right brain develops creative, emotional, mystical, ethical, and aesthetic abilities. This strengthens creativity and technological innovation, a sense of belonging, and interpersonal relationships.

It is equally important to infuse the syllabus with competencies in innovation and their application analogies to encourage the student's vocation, enrich study options, research, and professional practice. In this way, graduates can apply solutions to similar situations that may arise in the early years of their professional development, based on experiences acquired through analogies in undergraduate programs.

These analogies, as innovation case analyses, can be functionally similar to the case studies used by legal professionals who may choose to implement solutions from past use cases, without guaranteeing their success, but with the acquisition of socio-economic logic in their context.

On the other hand, current curricula have defined training alternatives for engineers only within the scope of the professional cycle areas of the program. However, the continuous changes to which organizations are subjected and the diversity of technological alternatives that emerge daily demand particular training profiles within each branch of engineering that are not within the scope of the professional cycle areas defined at the time of the curricular model's conception. This causes dissatisfaction among organizations that hire program graduates, as they must invest in additional training for their employees.

Within the framework established by the MNC, special attention must be paid to the current social problems and needs that engineering addresses in the national context. This attention must translate into defining the training objectives of the future Systems and Computing Engineer, not only as a professional but also as a person and citizen.

As a result of the interviews, the interviewees suggested improvements for the curriculum, including managing it through project-based learning that connects students with industry. While the classroom is one among many methods or techniques, it is not recommended to eliminate it entirely. Instead, students should be able to choose when to use it, alternating between online learning to manage their own time and pace, and personalized education to clarify doubts.

On the other hand, graduates suggest consolidating a competency-based teaching approach that emphasizes practical skills development and the application of knowledge in real-life situations. They propose the alternative of obtaining technology certifications or digital badges, which allow them to demonstrate their ability to apply what they have learned in a practical, business-oriented context.

Graduates state that the lack of innovation skills is due to the need for experiential education, which involves learning through the direct experience of successful individuals who may not have much theoretical knowledge, but whose transmission of their experience could pave the way for knowing how to begin in future scenarios.

Therefore, the development of a pedagogical proposal based on Social Cybernetics is proposed for the restructuring and implementation of a curriculum that enhances the development of logical, operational, and creative skills in the formulation of a program within the National Qualifications Framework (MNC). The objective of this proposal is to meet the needs, profiles, and performance requirements of IT companies based on the guidelines established by the Ministry of National Education through Decree 1330 of 2019 (Presidencia de la República de Colombia, 2019).

## Proposal

The proposal developed for the curricular transformation of the Systems and Computing Engineering degree aims to enhance logical, creative, and operational competencies from a tri-cerebral approach supported by Social Cybernetics, integrating socio-emotional and intellectual aspects, as well as business competencies through the training pathway, synthesized by the academic spaces shown in Figure 6.

The curricular transformation proposal for the Systems and Computing Engineering degree in the MNC was developed to enhance logical, creative, and operational competencies through a tri-brain approach supported by Social Cybernetics, integrating socio-emotional, intellectual, and business competencies through the training pathway depicted in Figure 7.

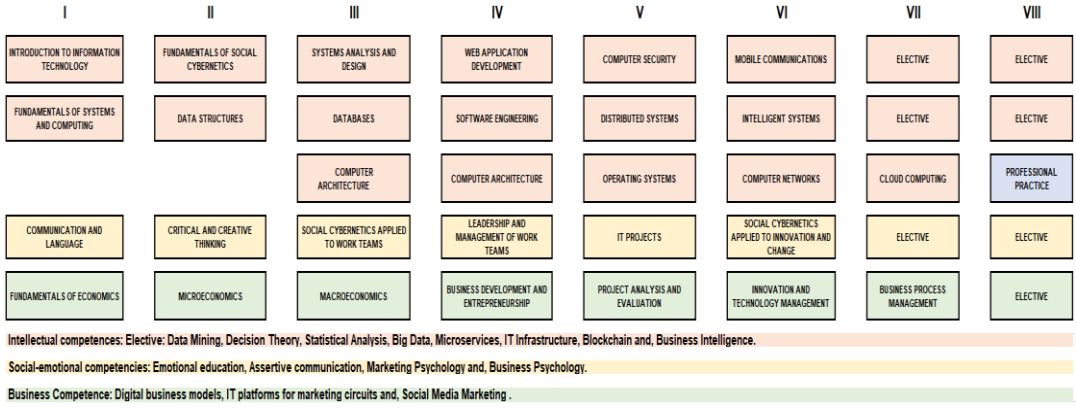


**Figure 6:** Curriculum Obtained.

The curriculum shown in Figure 7 is in line with the Educational Program of the Program (PEP) that presents a competency-based curricular model and allows defining educational goals and learning outcomes that students must achieve at the end of the program. Disciplinary competencies encompass the disciplinary field by articulating in their syllabi the praxis with micro-practices developed in the industry revolving around a holistic and comprehensive understanding of a real problematic situation. The final stage is the academic space for professional practice, which is aimed at the capacity to act critically, creatively, and effectively in various scenarios of their professional performance.

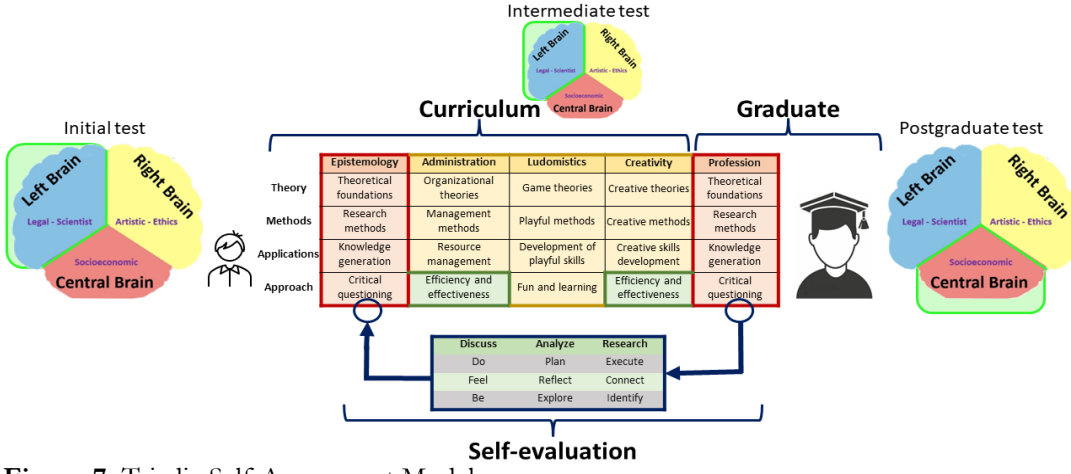


**Figure 7:** Triadic Self-Assessment Model.

The proposed curricular matrix shown in Figure 7 (feedback given by the self-assessment process) was designed based on the TMQR test, which, according to Social Cybernetics Theory, is based on communication as an exchange of information in feedback loops through self-evaluation processes. Self-evaluation allows for the adjustment and improvement of the quality of an academic program since it enables the actors involved (teachers, students, graduates, employers, etc.) to reflect on the performance of students and graduates and take measures to improve it. The TMQR test allowed us to identify that the majority of entering students had developed the left-brain region, highlighting that this population is characterized by the development of analytical and logical skills necessary to solve complex problems. The initial evaluation found a 35% development of the surveyed population in the first semester, averaged over the observation time window.

A second midterm assessment was conducted on sixth, seventh, and eighth-semester students (with an average population of 38 students), revealing that 42% of the program's students had a predominantly left-brain region development. This percentage increased compared to the initial evaluation (67 students surveyed on average in the first semester). The aforementioned results correspond to the average of annual tests conducted from 2017 to 2019, followed by the years 2021 and 2022. The 2020 test was not carried out due to the pandemic.

The evaluation in the final stage of the model in Figure 7 was only carried out at a time corresponding to the year 2022 and resulted in a novel finding that 39% of the graduates have developed a predominant central brain. This leads to changes in learning and thinking styles due to the shift in roles and acquisition of responsibilities.

The model presented in Figure 7 shows two initial epistemological stages, one at the beginning of university life and another at the beginning of their professional career, so that the knowledge acquired is validated and utilized at the beginning of each stage. The administration, ludomistics, and creativity components strengthened competencies that need to be reinforced in the professional stage.

The three variables identified in the TMQR test feedback are communication (Discuss), logic (Analyze), and creativity (Research), which cross the curriculum matrix materialized in the syllabus structure with the functional relationship between theory, method, and application. These are closely related to research and the development of any academic space, discipline, or field of study. Theory provides a conceptual framework and an explanation of observed phenomena, the method provides a set of systematic and rigorous procedures for data collection and analysis, and application refers to the practical use of research results to solve problems and improve understanding.

The approaches aim to develop critical thinking through self-formulation of questions (Critical questioning), self-performance measures (Efficiency and Effectiveness), and fun learning by focusing on making the learning process engaging, enjoyable, and exciting for the student, with the aim of increasing their motivation and commitment to learning.

## Conclusions

The triadic methodology allowed for the collection of information in three sequences: survey, interview, and TMQR test, identifying trends, perceptions, and styles, respectively, in both students and mainly program graduates. With the results from this sequential methodology, a curricular proposal was obtained, as well as the conception of a self-evaluation model based on the identification of the Waldemar De Gregori learning style.

The evolution and adaptation of thinking and learning styles were identified, given by a change in academic context to professional. The TMQR test allowed for a relationship to be established between how the sense of responsibility, through direct leadership roles or when graduates begin to have personnel under their supervision, transforms their thinking, moving from logical development to the creative, innovative, and leadership thinking proposed by Waldemar De Gregori in the central brain classification.

The collection of data using the triad of survey, interview, and TMQR test presents advantages for contrasting information through structured, closed, pre-defined, and anonymous questions obtained in the survey, expanded in detail and deeper understanding of the interviewee's perspectives and experiences, and correlated with the thinking style obtained by the TMQR test, which as a whole provides a good tool in self-evaluation processes.

However, it is important to consider that the triadic methodology has some limitations, such as the fact that only three options are evaluated, which may not be sufficient to obtain a complete understanding of the evaluated context (development of a curriculum based on IT), leaving out some social variables that are not contemplated in the slow temporal variation that the formulation and adaptability of a curriculum presents. Therefore, this item remains as a reflection and development for future work.

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