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Neutrosophic PEST-SWOT Analysis on the Impact of ICT on the Academic Training of Systems Engineering Students

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Abstract. The integration of Information and Communications Technologies (ICT) in the education of future systems engineers has generated a significant impact that deserves to be analyzed from multiple perspectives. This article explores these repercussions using the neutrosophic PEST-SWOT approach, a methodology that combines political, economic, social and technological (PEST) analysis with strengths, weaknesses, opportunities and threats (SWOT) within a framework of neutrosophic indeterminacy and complexity. The adoption of ICT in educational curricula has transformed not only the way in which students access information and knowledge, but also the way in which they interact and collaborate, promoting a more dynamic and adaptive education to contemporary market demands. labor. This analysis reveals both the benefits and challenges associated with this transformation, offering a comprehensive vision that ranges from opportunities for educational innovation to the structural barriers that still persist. In this context, profound changes are observed in pedagogy and teaching strategies, where ICT acts as catalysts for more active and personalized learning. The PEST-SWOT neutrosophic approach allows us to unravel the complexity of these changes, highlighting how political and economic forces influence the implementation of new technologies, while social and technological variables outline the horizon of possibilities and challenges. Thus, the article not only presents a detailed overview of the repercussions of ICT in the training of systems engineers, but also offers a critical reflection on the future implications of these technologies in the educational field. Ultimately, this research highlights the need for adaptive educational policies and a robust technological infrastructure to maximize the benefits of ICT, fostering a resilient and cutting-edge learning environment.

Keywords: Information and Communications Technologies, SWOT Analysis, PEST Analysis, Single Value Neutrosophic Numbers, PEST-SWOT Neutrosophic Analysis.

1 Introduction

Information and Communications Technologies (ICT) have disrupted all areas of modern society, re-configuring the way people interact, work and, crucially, learn. In the field of education, especially in the training of systems engineers, the incorporation of ICT has meant a true revolution, transforming methodologies, contents and pedagogical objectives [1]. This introduction focuses on exploring the various repercussions of ICT on the academic training of these future professionals, a topic of vital importance to understand current and future changes in higher education. One of the most notable aspects of the integration of ICT in the education of systems engineers is the improvement in access to information and educational resources [2]. Previously, students relied heavily on textbooks and physical libraries, but today they have a vast amount of information at their disposal online, accessible from anywhere and at any time. This accessibility not only facilitates autonomous learning, but also encourages the development of research and knowledge self-management skills, essential for systems engineers. ICT has also enhanced collaboration and teamwork, fundamental elements in the training of engineers. Tools such as online learning platforms, project management software and instant communication applications allow students to work together, even remotely, sharing ideas, developing projects and solving problems together. This ability to work in distributed teams is especially relevant in an increasingly globalized and connected world [3].

Furthermore, the implementation of ICT in education has led to the personalization of learning. Learning management systems and educational platforms can adapt to the individual needs of students, providing specific content according to their pace and learning style. This not only enhances the educational experience, but also helps identify and address each student's areas of difficulty, increasing their chances of academic success [4]. Another significant impact of ICT on the training of systems engineers is the introduction of new pedagogical methodologies. Project-based learning, flipped learning, and competency-based learning are approaches that have gained ground thanks to digital technologies. These methodologies promote more active and participatory learning, where students are not mere recipients of information, but protagonists of their own learning process. Learning assessment has also evolved with the help of ICT. Educational platforms allow for continuous and formative evaluation, offering immediate feedback to students. This not only helps educators monitor their students' progress more effectively, but also allows students to identify their strengths and weaknesses throughout the course, enabling continuous improvement [5].

However, the integration of ICT in the training of systems engineers is not without challenges. Among the most significant are technological barriers, such as the lack of adequate infrastructure and the digital divide that still persists in many regions. Furthermore, teacher training is crucial for the success of ICT implementation; Educators must be prepared and competent in using these tools in order to harness their full potential. The impact of ICT also extends to the development of new skills in students [6]. Digital literacy, the ability to work with large volumes of data and knowledge of cybersecurity are skills that are increasingly in demand in the labor market and that systems engineering programs must incorporate into their curricula. Thus, ICT not only changes the way of teaching, but also the content of what is taught. As ICT continues to evolve, it is essential that educational institutions constantly adapt and update their pedagogical strategies. The speed with which new technologies emerge means that both students and educators must be in a continuous process of learning and adaptation, ensuring that the education provided is aligned with the needs and demands of the real world [7].

The repercussions of ICT on the academic training of systems engineering students are profound and multifaceted. From access to information to personalization of learning and continuous assessment, ICT has transformed every aspect of the educational process. However, to maximize its benefits and overcome the challenges, a continuous commitment to updating and adaptation by all parties involved in the educational process is necessary.

2 Related Words.

2. 1 Academic training.

Academic training, in its essence, is the process through which individuals acquire knowledge, skills and competencies that allow them to develop both personally and professionally. This process, traditionally linked to formal educational institutions such as schools and universities, has evolved significantly in recent decades, influenced by technological, social and economic changes. However, beyond its formal definition, academic training is a complex and multifaceted phenomenon that deserves deep and critical reflection. From a historical perspective, academic training has been seen as the main route to social mobility and economic development. In the industrial era, for example, formal education was essential to prepare individuals for specific jobs that required technical skills and specialized knowledge. However, in the information age, the nature of work and the skills needed have changed dramatically [8]. The ability to adapt to new technologies, think critically and solve complex problems is now as important, if not more so, than specific technical knowledge.

One of the most controversial aspects of contemporary academic training is its accessibility. Despite advances in online education and efforts to democratize access to knowledge, significant disparities in access to quality education still persist. Economic, geographic, and social barriers continue to limit opportunities for many people, calling into question the equity of the current education system. How can we, as a society, ensure that all individuals have equal access to quality education?

The quality of academic training is also under constant scrutiny. Curricula and pedagogical methods must evolve to remain relevant in a rapidly changing world. However, many education systems are inflexible and slow to adapt to these changes. Competency-based education, personalized learning, and the use of advanced technologies in the classroom are just some of the innovations that could im-prove the quality of education, but their implementation is often met with resistance and logistical challenges. Another crucial aspect is teacher training. Teachers not only need to be well versed in their subject, but also in innovative pedagogical methodologies that encourage critical thinking and active learning [9]. Continuing training and professional development for educators is essential to ensure they can adapt to change and deliver high-quality education. However, investment in teacher training is often insufficient, limiting the positive impact these professionals can have on their students. The evaluation of learning is another topic of debate in academic training. Traditional assessment methods, such as standardized tests, often do not adequately reflect students' competencies and abilities. We need more holistic assessment approaches that consider a range of skills, from critical thinking to creativity and collaboration. This change will require a reevaluation of what we consider academic success and how we measure it. The relationship between education and the labor market is also constantly evolving. Educational institutions must work closely with industry to ensure that study programs are aligned with market needs. This not only improves the employability of graduates, but also ensures that companies can access a well-trained talent pool ready to meet the challenges of the future. However, this collaboration is often insufficient or non-existent, resulting in a significant skills gap [10].

Lifelong learning is another essential component of modern academic training. In a world where technologies and industries change rapidly, education cannot end with obtaining a degree. Individuals must be prepared to continue learning and adapting throughout their professional lives. Educational institutions must foster a mindset of continuous learning and provide the necessary tools and resources to support this type of education. Academic training also has a significant impact on personal development. Beyond technical and professional skills, education helps individuals develop values, ethics, and a critical understanding of the world around them. This humanistic aspect of education is often overlooked in debates focused on productivity and the economy, but it is fundamental to the development of responsible and engaged citizens. Finally, we must consider the future of academic training in a global context. The internationalization of education, driven by technology and student mobility, offers unprecedented opportunities for cultural exchange and global learning [11]. However, it also poses challenges in terms of quality and equity. Educational institutions must navigate these challenges carefully to ensure they can offer a high-quality education to all students, regardless of their background.

Academic training is a fundamental pillar of our society that faces multiple challenges and opportunities. From accessibility and quality to relevance and internationalization, every aspect of education needs to be carefully considered and improved. Only through a continued commitment to innovation and equity can we ensure that education delivers on its promise of preparing individuals for an uncertain and everchanging future [12].

2.2 SWOT Analysis

SWOT analysis is considered a fundamental tool in evaluating the current state of a company or project, adopting a structured approach that examines both its internal characteristics (strengths and weaknesses) and its external environment (opportunities and threats). This process unfolds in several well-defined phases: first, a thorough analysis of the external environment is performed, identifying opportunities that could drive the organization's growth and threats that could hinder its progress [13]. At the same time, the organization's internal factors are evaluated, such as its weaknesses that require internal management and strengths that must be optimized for maximum benefit.

Each of these components can be classified as positive or negative, depending on its impact on organizational development. Opportunities, for example, represent positive external factors that, once identified, can be strategically exploited to drive growth and competitiveness. On the other hand, threats constitute negative external influences that require effective tactics and strategies to be successfully mitigated and overcome. Internally, weaknesses are negative aspects that need to be addressed and improved through efficient management, while strengths represent areas of excellence that must be enhanced and used to the maximum [14]. The SWOT analysis delves into various critical areas such as the availability of financial resources, the organizational structure, the quality of the product or service offered, market perception and customer satisfaction. These results are organized and presented in a matrix that is then evaluated by experts, whose combined evaluation provides a clear and objective vision of the most viable and effective strategies for the organization or project in question.

2.3 PEST Analysis.

The PEST analysis is a strategic tool that examines the external factors that affect a company, covering the Political, Economic, Social and Technological components. This approach allows us to understand how legislative regulations, economic conditions, sociocultural trends and technological advances directly impact the organization. For example, political factors include environmental laws, antitrust regulations, and government stability, while economic factors address variables that influence market and financial stability. Sociocultural aspects, for their part, focus on the configuration and behavior of consumers, while technological factors consider the development and adoption of new technologies 15].

The PEST-SWOT methodology is developed in two fundamental stages that complement and strengthen the strategic analysis. Firstly, an exhaustive analysis of external factors is carried out from political, economic, social and technological perspectives. This phase provides a deep understanding of the environment in which the company operates, identifying emerging opportunities and potential threats that could influence its performance and future development. In the second stage, the principles of SWOT analysis are applied to evaluate the internal characteristics of the organization, such as its strengths and weaknesses. This internal analysis provides a critical view of available resources, organizational structure, product or service quality, and other key aspects that impact the company's ability to compete and prosper in its target market [16,17].

By combining both stages, the PEST-SWOT methodology offers a comprehensive and detailed view of the business situation. This allows business leaders and strategists to formulate more effective and holistic strategies that capitalize on identified external opportunities, while addressing internal weaknesses and mitigating potential threats. This integrated approach not only facilitates proactive adaptation to changes in the business environment, but also promotes longterm sustainability and continuous growth of the company in a dynamic and competitive context.

2.4 Basic concepts about neutrosophy

Unlike traditional PEST-SWOT methods, in this work the evaluations are carried out based on Triangular Neutrosophic Numbers of Single Value. Below are the fundamental explanations on this topic.

Definition 1 ([18]) : The neutrosophic set N is characterized by three membership functions, which are the truth membership function T_A, the indeterminacy membership functionI_A and membership function to falsehood F_A, where Uis the Universe of Discourse and $\forall x \in U$, $T_A(x), I_A(x), F_A(x) \subseteq]^-_T 0, 1^+[$, and $^-_T 0 \leq \inf T_A(x) + \inf I_A(x) + \inf F_A(x) \leq \sup T_A(x) + \sup I_A(x) + \sup F_A(x) \leq 3^+$.

See that by definition, $T_A(x), I_A(x)$and $F_A(x)$are standard or non-standard real subsets of $]^-_T 0, 1^+[$and, therefore, $T_A(x), I_A(x)$and $F_A(x)$can be subintervals of $[0, 1]$. $^-_T 0$and1^+ They belong to the set of hyperreal numbers.

Definition 2 ([19]) : The single-valued neutrosophic set $F_A: U \rightarrow [0, 1]$(SVN N) Ais U, $T_A: U \rightarrow [0, 1]$where $A = \{< x, T_A(x), I_A(x), F_A(x) > : x \in U\}$and $I_A: U \rightarrow [0, 1]$. $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$.

The single-valued neutrosophic number (SVN N) is symbolized by

$N = (t, i, f)$, such that $0 \leq t, i, f \leq 1$and $0 \leq t + i + f \leq 3$.

Definition 3 ([20]) : The single- $\tilde{a} = \langle (a_1, a_2. a_3); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$valued triangular neutrosophic number , , is a neutrosophic set in $\mathbb{R}$, whose membership functions of truth, indeterminacy and falsity are defined as follows:

$$T_{\tilde{a}}(x) = \begin{cases} \alpha_{\tilde{a}\left(\frac{x-a_1}{a_2-a_1}\right), a_1 \leq x \leq a_2} \\ \alpha_{\tilde{a}, x=a_2} \\ \alpha_{\tilde{a}\left(\frac{a_3-x}{a_3-a_2}\right), a_2 < x \leq a_3} \\ 0, \text{otherwise} \end{cases} \quad (1)$$

$$I_{\tilde{a}}(x) = \begin{cases} \frac{(a_2 - x + \beta_{\tilde{a}}(x - a_1))}{a_2 - a_1}, a_1 \leq x \leq a_2 \\ \beta_{\tilde{a},} \ x = a_2 \\ \frac{(x - a_2 + \beta_{\tilde{a}}(a_3 - x))}{a_3 - a_2}, \ a_2 < x \leq a_3 \\ 1, \text{otherwise} \end{cases} \quad (2)$$

$$F_{\tilde{a}}(x) = \begin{cases} \frac{(a_2 - x + \gamma_{\tilde{a}}(x - a_1))}{a_2 - a_1}, a_1 \leq x \leq a_2 \\ \gamma_{\tilde{a},} x = a_2 \\ \frac{(x - a_2 + \gamma_{\tilde{a}}(a_3 - x))}{a_3 - a_2}, \ a_2 < x \leq a_3 \\ 1, \text{otherwise} \end{cases} \quad (3)$$

Where $\alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \in [0, 1]$,$a_1, \ a_2, a_3 \in \mathbb{R}$ and $a_1 \leq a_2 \leq a_3$.

Definition 4 ([21]) : Given$\tilde{a} = \langle (a_1, a_2, a_3); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$ and$\tilde{b} = \langle (b_1, b_2, b_3); \alpha_{\tilde{b}}, \beta_{\tilde{b}}, \gamma_{\tilde{b}} \rangle$ two triangular neutrosophic numbers of a single value andλ any non-zero number on the real line. Then, the following operations are defined:

1. Addition: $\tilde{a} + \tilde{b} = \langle (a_1 + b_1, a_2 + b_2, a_3 + b_3); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$,
2. Subtraction: $\tilde{a} - \tilde{b} = \langle (a_1 - b_3, a_2 - b_2, a_3 - b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$,
3. Investment: $\tilde{a}^{-1} = \langle (a_3{}^{-1}, a_2{}^{-1}, a_1{}^{-1}); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, where $a_1, a_2, a_3 \neq 0$.
4. Multiplication by a scalar number:

$$\lambda\tilde{a} = \begin{cases} \langle (\lambda a_1, \lambda a_2, \lambda a_3); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle, \lambda > 0 \\ \langle (\lambda a_3, \lambda a_2, \lambda a_1); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle, \lambda < 0 \end{cases}$$

5. Division of two triangular neutrosophic numbers:

$$\frac{\tilde{a}}{\tilde{b}} = \begin{cases} \langle \left(\frac{a_1}{b_3}, \frac{a_2}{b_2}, \frac{a_3}{b_1} \right); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, a_3 > 0 \text{ and } b_3 > 0 \\ \langle \left(\frac{a_3}{b_3}, \frac{a_2}{b_2}, \frac{a_1}{b_1} \right); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, a_3 < 0 \text{ and } b_3 > 0 \\ \langle \left(\frac{a_3}{b_1}, \frac{a_2}{b_2}, \frac{a_1}{b_3} \right); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, a_3 < 0 \text{ and } b_3 < 0 \end{cases}$$

6. Multiplication of two triangular neutrosophic numbers:

$$\tilde{a}\tilde{b} = \begin{cases} \langle (a_1b_1, a_2b_2, a_3b_3); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, \ a_3 > 0 \text{ and } b_3 > 0 \\ \langle (a_1b_3, a_2b_2, a_3b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, a_3 < 0 \text{ and } b_3 > 0 \\ \langle (a_3b_3, a_2b_2, a_1b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, a_3 < 0 \text{ and } b_3 < 0 \end{cases}$$

Where,$\wedge$ It's a norm$\vee$ It is a conorm t [22].

3 Results and Discussion.

The study is carried out on the ICT factors that impact the Academic Training of Systems Engineering Students. For this purpose, experts on the subject and specialized literature were consulted. In this way the following factors were identified:

Access to educational resources: ICT provides instant access to a wide range of online educational resources, including e-books, academic articles, educational videos and interactive simulations, which enrich the learning of technical and theoretical concepts.

Online Learning Platforms: The availability of online learning platforms allows Systems Engineering students to participate in courses, carry out practical activities and collaborate with other students and teachers from anywhere and at any time.

Simulations and virtual laboratories: ICT facilitates the creation and access to simulations and virtual laboratories that allow students to experience and practice real situations safely and efficiently, improving their understanding of complex concepts.

Communication and collaboration: Tools such as emails, videoconferences and instant messaging platforms facilitate communication and collaboration between students, teachers and external experts, promoting collaborative learning and team problem solving.

Adaptive learning: ICT allows the personalization of learning through the use of algorithms that adapt the content and educational methodology according to the pace and learning style of each student, thus optimizing the effectiveness of the educational process.

Development of technical skills: Systems Engineering students can develop advanced technical skills through the use of specialized software, programming environments and computer-aided de-sign (CAD) tools, facilitating their preparation for the job market.

Access to experts and external resources: ICT allows students to access experts and external resources in real time, through professional social networks, discussion forums and online communities, thus expanding their network of contacts and learning opportunities.

Continuous updating: The rapid evolution of ICT ensures that Systems Engineering students are up to date with the latest trends and technological advances, preparing them to face technical challenges and adapt to changes in the field proactively.

Assessment and feedback: ICT-based educational platforms offer tools to evaluate student progress continuously and provide immediate feedback, allowing adjustments in learning and ensuring a better understanding of concepts.

Interaction with industry: ICT facilitates collaboration between educational institutions and industry, through joint projects, professional internships and mentoring programs, providing students with practical experiences and opportunities for real application of their knowledge.

The development of a strategy to guarantee a positive impact on the Academic Training of Systems Engineering Students may face several obstacles that require attention and consideration - The main obstacles to include are:

Unequal access to technology: Lack of equitable access to devices such as computers and internet connectivity can limit student participation and learning, especially in rural or economically disadvantaged areas.

Poor infrastructure: The quality and availability of technological infrastructure in some educational institutions may be insufficient to support the intensive use of ICT, affecting the learning experience and the effectiveness of educational tools.

Lack of adequate training: The lack of sufficient training for teachers and students in the effective use of ICT tools and platforms can limit their effective integration into the academic curriculum, reducing their educational impact.

Data security and privacy: Concerns about cybersecurity and personal data privacy can inhibit the full adoption of ICT in the educational environment, especially when sensitive information of students and teachers is involved.

High costs: The cost associated with the acquisition of software, licenses, hardware and maintenance of technological infrastructure can be prohibitive for some educational institutions, limiting their ability to implement ICT effectively and sustainably.

Digital disconnection: The digital divide between generations or groups of students can result in significant differences in familiarity and skills to use ICT effectively, affecting participation and academic performance.

Lack of curricular integration: Lack of coherent integration of ICT into the academic curriculum can lead to its fragmented and occasional use instead of continuous and meaningful application in learning and teaching.

Resistance to change: Resistance on the part of some teachers and educational administrators to adopt new technologies and teaching methods can limit innovation and the transformative potential of ICT in the educational process.

Connectivity issues: Frequent interruptions in internet connectivity or lack of reliable access to online services can hinder the effective use of web-based educational tools and resources.

Information overload: The excess of information available through ICT can overwhelm students and teachers, making it difficult to identify and select relevant and reliable content for academic learning. Overcoming these obstacles requires a multidisciplinary approach that includes diverse perspectives, fosters collaboration among multiple actors, and employs comprehensive data collection along with meticulous analysis of the complexity and uncertainty inherent in socioeconomic impact assessment.

Based on the PEST analysis, we can categorize the mentioned factors as threats and opportunities in relation to the four components of this analysis.

• **Threats**
○ **Political**
• **T 1: Changes in data protection and privacy regulations:** Evolution in data protection laws may require constant adjustments to educational institutions' internal policies to ensure compliance and security of student information.
• **T 2: Political instability and legislative changes in technological regulations:** Political uncertainty can influence the stability of investment policies in educational technological infrastructure, affecting long-term planning and implementation of educational projects based on ICT.
○ **Economic**
• **T 3: Fluctuations in application development and maintenance costs:** Changes in software development and maintenance costs can challenge the financial ability of educational institutions to keep their educational platforms up to date.
• **T 4: Increase in digital marketing and app promotion costs:** Increased costs for promoting online educational platforms may limit the reach and adoption of these technologies by students and educators.
○ **Social**
• **T 5: Resistance of some users to adopt new educational technologies:** The reluctance of some students and teachers to adopt new digital tools can hinder the effective integration of ICT in the educational process.
• **T 6: Impact on traditional educational culture and acceptance of digital platforms:** The introduction of educational technologies may face cultural resistance and require a process of adaptation and acceptance by the educational community.
○ **Technological**
• **T 7: Limitations in interoperability between educational systems and technological platforms:** Difficulties in achieving fluid integration between different educational systems and technological platforms can affect the user experience and learning efficiency.
• **T 8: Shortage of experts in the development of educational applications and learning platforms:** The lack of professionals trained in the development of educational technologies can limit the capacity for innovation and continuous improvement in ICT-based educational environments.
• **Opportunities**
• **2.1 Political**
• **O 1: Government support for educational digitalization initiatives:** Political support can provide additional funds and resources for the implementation and expansion of innovative educational technologies in the Systems Engineering curriculum.
• **2.2 Economic**
• **O 2: Creation of new learning models and markets through digital platforms:** Educational technologies can open new markets and opportunities for the development of personalized and adaptive educational content.

• **O 3: Increase in educational competitiveness through technological innovations:** The adoption of ICT can improve the educational quality and training offer of institutions, increasing their attractiveness for potential students and academic collaborators.
• **2.3 Social**
• **O 4: Local employment generation in urban and rural areas through the digital economy:** Educational technologies can promote job creation in the technological and educational sector, benefiting both urban and rural communities.
• **O 5: Contribution to educational accessibility and diversity for local and international students:** Online educational platforms can improve access to higher education and encourage cultural and linguistic diversity in the learning of Systems Engineering.
• **2.4 Technological**
• **O 6: Advances in technologies for personalization and adaptation of learning:** Technological innovations allow educational content to be adapted according to the individual needs of students, thus improving the effectiveness and personalization of the learning process.
• **O 7: Opportunities for research and development of new educational tools:** The integration of ICT in Systems Engineering education can boost the research and development of new educational methodologies and tools, continuously improving the academic experience.
• **Weaknesses**
• **W 1: Shortage of UX/UI specialists to design intuitive and attractive interfaces:** The lack of specialized user experience designers can limit the usability and acceptance of educational platforms by students and teachers.
• **W 2: Complexity in integration with existing management systems in educational institutions:** The difficulty in integrating online educational platforms with pre-existing academic management systems can generate compatibility and data redundancy problems.
• **Strengths**
• **S 1: Leveraging the growing popularity of online education and educational technology:** The growing demand for online education and educational technology offers opportunities to expand and diversify educational offerings in Systems Engineering.
• **S 2: Potential to improve operational efficiency and educational management:** ICT-based educational platforms can optimize academic administration, resource management and coordination between departments within educational institutions.
• **S 3: Improved student experience and loyalty through tracking and personalization tools:** Tracking and personalization tools can improve the student experience, increase academic retention, and promote student satisfaction.

This structured analysis allows us to visualize in a clear and organized manner the various factors that influence the effective implementation of ICT in the academic training of Systems Engineering students, as well as the opportunities and challenges that arise in this dynamic and technological context.

A team made up of eleven experts was in charge of analyzing various combinations between an external and an internal factor. Each of them was asked to carry out evaluations using the linguistic terms detailed in Table 1.

Table 1. Linguistic terms for evaluations and their associated SVTNNs. See [14-17].

Linguistic Terms	SVTNN
Very low (VL)	$\langle(0,0,1); 0.00, 1.00, 1.00\rangle$
Low (L)	$\langle(0,1,3); 0.17, 0.85, 0.83\rangle$
Medium Low (MDL)	$\langle(1,3,5); 0.33, 0.75, 0.67\rangle$
Medium (M)	$\langle(3,5,7); 0.50, 0.50, 0.50\rangle$
Medium High (MDH)	$\langle(5,7,9); 0.67, 0.25, 0.33\rangle$
Height (H)	$\langle(7,9,10); 0.83, 0.15, 0.17\rangle$
Very high (VH)	$\langle(9,10,10); 0.00, 1.00, 1.00\rangle$

Specifically, there are the following sets:
$W = \{W_1, W_2\}$ denotes the set of Weaknesses,
$S = \{S_1, S_2, S_3\}$denotes the set of Strengths,
$T = \{T_1, T_2, T_3, T_4, T_5, T_6, T_7\}$denotes the set of Threats,
$O = \{O_1, O_2, O_3, O_4, O_5\}$denotes the set of Opportunities.

The steps are the following:

1. Each expert was asked to evaluate the possible combinations between the elements of SO, ST, WO and WT. This evaluation is carried out in terms of how the development and implementation of a multi-platform mobile application in the gastronomic sector would have a socioeconomic impact.
2. Linguistic terms are replaced by the equivalent single-valued triangular neutrosophic numbers (SVTNN) in Table 1.
3. A single SVTNN is obtained by calculating the median of the SVTNNs of all experts for each pair of items.
4. The arithmetic mean of the SVTNN is calculated for each quadrant SO, ST, WO and WT.
5. The final result of each quadrant is converted to a crisp value using precision Equation 4. This con-verts them into values on a numerical scale out of 10 that allows the results to be compared [23, 24].

$$A(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} + \gamma_{\tilde{a}})$$

Tables 1, 2, 3 and 5 summarize the results obtained after applying the previous steps.

Table 2. Calculation results for the SW quadrant. The medians of all experts are shown.

		Opportunities				
		O_1	O_2	O_3	O_4	O_5
Strengths	S_1	V.H.	V.H.	V.H.	V.H.	H
	S_2	V.H.	H	V.H.	H	V.H.
	S_3	H	MDH	V.H.	V.H.	H

Table 3. Calculation results for the ST quadrant. The medians of all experts are shown.

		Threats						
		T_1	T_2	T_3	T_4	T_5	T_6	T_7
Strengths	S_1	MDVH	V.H.	MDVH	MDVH	V.H.	V.H.	VVH
	S_2	V.H.	VVVH	H	V.H.	VVH	VVH	H
	S_3	V.H.	MDH	H	V.H.	V.H.	MDH	H

Table 4. Calculation results for the WO quadrant. The medians of all experts are shown.

		Opportunities				
		O_1	O_2	O_3	O_4	O_5
Weaknesses	w_1	MDH	MDH	MDH	MDH	MDH
	w_2	MDH	MDH	MDH	MDH	MDH

Table 5. Calculation results for the WT quadrant. The medians of all experts are shown.

		Threats						
		T_1	T_2	T_3	T_4	T_5	T_6	T_7
Weaknesses	w_1	H	V.H.	V.H.	H	V.H.	H	V.H.
	w_2	MDVH	MDVH	MDVH	MDVH	MDVH	MDVH	MDVH

From Tables 1 to 5, we have the following results:

- ❖ Potentials (Opportunities+Strengths): $\langle(7.6467, 9.2637, 9.9813); 0.57, 0.55, 0.63\rangle$,
- ❖ Risks (Strengths+Threats): $\langle(5.5190, 6.5714, 9.7519); 0.57, 0.25, 0.33\rangle$,
- ❖ Challenges (Weaknesses+Opportunities) $\langle(6, 5, 9); 0.57, 0.35, 0.13\rangle$:
- ❖ Limitations (Weaknesses+Threats): $\langle(6.2, 7.0, 5.5); 0.55, 0.43, 0.51\rangle$.

As a last step, these values are converted into a neat scale with a maximum of 10 using Equation 4. From here we have the following results:

$$A(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} + \gamma_{\tilde{a}}) \quad (4)$$

	A	a1	a2	a3	α	β	γ
Potentials	**8.9079**	7.6467	9.2637	9.9813	0.5700	0.5500	0.6300
Risks	**7.2353**	5.5190	6.5714	9.7519	0.5700	0.2500	0.3300
Challenges	**5.8750**	6,0000	5,0000	9,0000	0.5700	0.3500	0.1300
Limitations	**6.1476**	6,2000	7,0000	5,5000	0.5500	0.4300	0.5100

1. Potentials (Opportunities+Strengths): 8.9079.
2. Risks (Strengths + Threats): 7.2353.
3. Challenges (Weaknesses + Opportunities): 5.8750.
4. Limitations (Weaknesses + Threats): 6.1476.

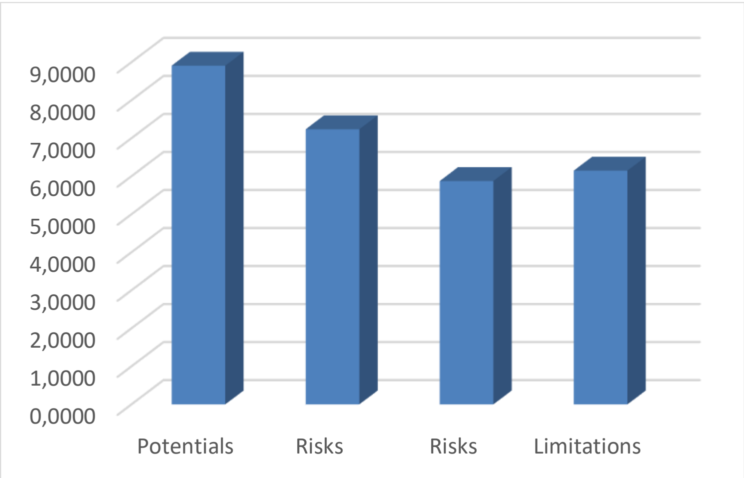

Figure 1. Calculation results for the WO quadrant.

To design an effective strategy that ensures a positive impact on the Academic Training of Systems Engineering Students, it is crucial to address in detail the critical factors identified through the PEST analysis and neutrosophic calculations. This exhaustive analysis reveals a series of threats, opportunities, weaknesses and strengths that shape the educational landscape in the context of Information and Communication Technologies (ICT). In the political sphere, threats arising from regulatory changes in data protection and technological legislation suggest the constant need for adaptation and regulatory compliance by educational institutions. This not only involves operational adjustments, but also strategic investments to ensure the security and privacy of student information in a digitally changing environment. Likewise, political instability can affect the long-term planning of ICT-based educational projects, complicating investment in infrastructure and the effective implementation of education-al innovations. From an economic perspective, fluctuations in app development and digital marketing costs stand out as significant challenges. Educational institutions face pressure to keep their educational platforms up to date while managing limited financial resources. Additionally, rising promotion costs may restrict the reach and adoption of advanced educational technologies, exacerbating disparities in access to digital education. Socially, resistance to adopting new educational technologies and the need to integrate digital platforms into traditional educational cultures are key obstacles. The reluctance of some students and teachers to adopt digital tools may hinder the effectiveness of ICT integration in the educational process, requiring cultural change and adaptation strategies to foster broader and more effective acceptance.

In the technological field, limitations in interoperability between educational systems and the short-age of experts in the development of educational applications are critical challenges. The lack of seamless integration between technological platforms can affect user experience and learning efficiency, while the lack of specialized talent limits the capacity for innovation and continuous improvement in digital educational environments.

However, political, economic, social and technological opportunities offer fertile ground for educational transformation. Government support for educational digitalization, for example, can provide additional resources and crucial financial support for the expansion of innovative educational technologies. Economically, the creation of new learning models through digital platforms and the increase in educational competitiveness are significant advantages that can drive the development of personalized and adaptive educational content. Socially, educational technologies have the potential to generate local employment and improve educational accessibility, benefiting both urban and rural communities. Furthermore, the ability of online educational platforms to improve access to higher education and promote cultural and linguistic diversity underlines their importance in global educational inclusion.

From a technological perspective, advances in personalization and adaptation of learning, together with the research and development of new educational tools, promise to continually improve the academic experience and prepare Systems Engineering students to meet the technological challenges of the future. Identified weaknesses, such as a shortage of UX/UI specialists and complexity in integration with existing management systems, represent critical barriers that must be addressed. The lack of specialized user experience designers can limit the usability and acceptance of educational platforms, while the difficulty in integrating these platforms with preexisting academic systems can generate incompatibilities and redundancies. On the other hand, current strengths, such as the growing use of online education and the improvement in operational efficiency through tracking and personalization tools, highlight the ability of ICT to optimize educational management and improve the student experience. These tools not only facilitate academic administration and coordination between departments, but also promote student retention and academic satisfaction through innovative teaching and learning methods. In conclusion, designing a comprehensive strategy to enhance the Academic Training of Systems Engineering Students involves navigating a complex terrain of threats, opportunities, weaknesses and strengths. Overcoming the identified challenges will demand a multidisciplinary approach that promotes collaboration between various educational and technological actors, thus ensuring an effective and sustainable implementation of educational technologies. This process not only requires investment in infrastructure and resources, but also a continuous commitment to educational innovation and cultural adaptation in educational institutions.

4 Conclusion

Designing an effective strategy that guarantees a positive impact on the Academic Training of Systems Engineering Students involves thoroughly addressing the critical factors revealed by the PEST analysis and neutrosophic calculations. This exhaustive analysis has highlighted a series of challenges and opportunities that outline the educational landscape in the context of Information and Communication Technologies (ICT). In the political sphere, threats arising from regulatory changes in data protection and technology legislation highlight the constant need for regulatory and strategic adjustments to safeguard student information in a constantly evolving digital environment. Furthermore, political instability can complicate long-term planning of ICT-based educational initiatives, impacting investment in infrastructure and the effective execution of innovative educational projects. From an economic perspective, fluctuations in digital marketing and app development costs represent significant challenges. Educational institutions face pressure to keep their educational platforms up to date while managing limited financial resources. Additionally, increased promotion costs may restrict the reach and adoption of advanced educational technologies, exacerbating disparities in access to digital education. Socially, resistance to adopting new educational technologies and the need to integrate digital platforms into traditional educational cultures are key obstacles. The reluctance of some students and teachers to adopt digital tools may hinder the effective integration of ICT into the educational process, requiring strategies to encourage broader and more effective acceptance. In the technological field, limitations in interoperability between educational systems and the shortage of experts in the development of educational applications are critical challenges. The lack of seamless integration between technological platforms can affect user experience and learning efficiency, while the lack of specialized talent limits the capacity for innovation and continuous improvement in digital educational environments. However, political, economic, social and technological opportunities offer fertile ground for educational transformation.

For example, government support for educational digitalization can provide additional resources and crucial financial support for the expansion of innovative educational technologies. Economically, the creation of new learning models through digital platforms and the increase in educational competitiveness are significant advantages that can drive the development of personalized and adaptive educational content. Socially, educational technologies have the potential to generate local employment and improve educational accessibility, benefiting both urban and rural communities. From a technological perspective, advances in personalization and adaptation of learning, together with the re-search and development of new educational tools, promise to continually improve the academic experience and prepare Systems Engineering students to meet the technological challenges of the future. Identified weaknesses, such as a shortage of UX/UI specialists and complexity in integration with existing management systems, represent critical barriers that must be addressed. The lack of specialized user experience designers can limit the usability and acceptance of educational platforms, while the difficulty in integrating these platforms with pre-existing academic systems can generate incompatibilities and redundancies. On the other hand, current strengths, such as the growing use of online education and the improvement in operational efficiency through tracking and personalization tools, highlight the ability of ICT to optimize educational management and improve the student experience. These tools not only facilitate academic administration and coordination between departments, but also promote student retention and academic satisfaction through innovative teaching and learning methods. In conclusion, designing a comprehensive strategy to enhance the Academic Training of Systems Engineering Students involves navigating a complex terrain of threats, opportunities, weaknesses and strengths. Overcoming the identified challenges will demand a multidisciplinary approach that promotes collaboration between various educational and technological actors, thus ensuring an effective and sustainable implementation of educational technologies. This process not only requires investment in infrastructure and resources, but also a continuous commitment to educational innovation and cultural adaptation in educational institutions.

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