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Analysis of the Critical Success Factors of Projects for Engineering Thinking Development

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Abstract. This research constitutes a formative work that enhances the research line of automation and control to implement a program for the development of engineering thinking of students of the Systems and Software Engineering at UNIANDES, Quevedo. The research contributed to form a source of knowledge for Systems students of all levels from a productive approach, following basic principles of didactic engineering and multiple intelligences. It brings the student closer to learning by discovery while applying knowledge of their own competencies specific to their student profile; it also increased their analytical capacity developing automation products from UNIANDES. The procedure fostered interdisciplinary work, and other values in the axiological context that underpin the integral training of future professionals, on the definition of key success factors. We decided to use the neutrosophic TOPSIS technique since the uncertainty and imprecision of the multicriteria decision are incorporated, in the form of three membership functions: truthfulness, indeterminacy and falsehood.

Keywords: Professional training, didactic engineering, Neutrosophic TOPSIS, multi-criteria decision, statistical inference.

1 Introduction

In Quevedo, at Universidad Regional Autónoma de los Andes, UNIANDES, among its academic offers for professional training is the Systems career, which has professionals who have stood out over the years at a local, national and international level. One of the strengths of the career is the current company's demand for automation and control of various areas of production, security, communication among others, and the enhancement of the Systems teaching in the area of automated control, generating research projects whose results are production with an educational-practical-productive approach [1].

Through this project, we managed to get the Systems students to participate in a research work that allows them to apply all the theoretical and practical knowledge acquired in the university while focusing them on a practical technical solution.

One of the fundamental pillars of the UNIANDES pedagogical model is research and through it the students are linked to the scientific field and the technological development of the environment in which they live, thus developing the competencies that support our model. In addition, the present project is related to The Good Living Plan in its Objective 11, Policy 11.3, Guideline 11.3.b[2].

Every project undertaken by UNIANDES has the support of the teachers and the participation of the students; in addition, the respective evaluation will be carried out to verify the achievement of the proposed objectives.

The project has aspects that reflect the professional empowerment of the students and the confidence in their own capacity of the applicability of their knowledge.

It has a course of action or project dimension, with indicators that have to do with the achievement of the proposed purposes to some degree:

1. The interconnection of the university with the educational community measured by the interactions carried out.
2. The generation of knowledge by the educational community measured in the production of new proposals and studies generated.

3. Carrying out a research process and tools for solutions to modern problems through automation, measured in a complex competence acquired by the participants.
4. The creation of opportunities for change derived from the implementation of the project, related to new courses of action and the ability of this project to connect with others.

The training of students [3] and teachers in the effective fulfillment of the teaching-learning process is significant. It is also possible through the development of the project to expand and discover knowledge about computer science and electronics in the trend of the development of engineering thinking of students and teachers, with control systems automated solutions, since it allows them personal control and confidence for their professionalization in future projects related to production.

Automation [4] is a system where production tasks, usually performed by human operators, are transferred to a set of technological elements that try to apply mechanical, electronic and computer-based systems to operate and control production.

In many educational institutions there is no disciplinary learning with automation and control, since the advantages and benefits that it brings in educational institutions have not been investigated as a facilitating element of the teaching-learning process [5].

Currently, every company requires professionals who bring new ideas to solve the problems that technological development requires. Moreover, at a higher educational level, to strengthen the research process in university students, as well as the enhancement of the logical thinking of the professional. The academic board of UNIANDES and the Research and Development Center (RDC), designs research projects on software production and very few projects on automation and control. Thus, out of the final products in Systems Engineering and Informatics Thesis, approximately 99% are developed in software, despite the existence of a line of professorships where Electronics, Artificial Intelligence and Robotics have an impact on the engineering thinking of students. It would allow them to take advantage of the human resources and available infrastructure to generate the management of adaptation of specialized areas for the development of the project[6, 7].

To achieve the objectives of this project, the following research tasks were carried out: bibliographic research, to obtain the scientific and technical foundations of the impact of the creation of software and electronic artifacts as a means for the professional empowerment of UNIANDES Quevedo students. Direct and indirect observation, to obtain data from the available resources for the objective development of this project. The application of interviews and surveys to informants classified by strata that allow identifying the main variables on which technological production should be elaborated.

An applied research was carried out because it is aimed at promoting and encouraging the teaching-learning process at all levels of formal and informal education, it is an investigation that meets the ordinary requirements of feasibility and has the resources and knowledge necessary for its development.

The type of research chosen to formalize this project was experimental and it was used because we are looking for the production of computer and feasible solutions, with an engineering thinking for solving everyday problems from an automation approach.

Through the collection of information, we can describe the structure of the actors, population, who take part in this research. And the universe is considered for the sample because it is a finite population. With the use of research techniques of the students and teachers, the most appropriate one will be selected to determine the existence of an educational process since its beginning in the field of electronics, digital electronics, simulation, artificial intelligence, robotics, special packages in an automation concept for the improvement of the teaching-learning process[8].

Select the panel of experts and get their commitment to collaboration. The people who are chosen must not only be highly knowledgeable about the subject on which the study is carried out, but must also present a plurality in their approaches. This plurality should avoid the appearance of biases in the information available on the panel. Explain to the experts what the method consists of. This is intended to obtain reliable forecasts, since the experts will know at all times what is the objective of each of the processes required by the methodology.

The study of the situation of the most relevant and innovative lines of research and the application of knowledge of different subjects was carried out through a survey of students and professors of the Engineering in Systems and Software program at UNIANDES - Quevedo, from seven questions. Which yielded favorable data.

To select the best strategies to improve the research lines, we used the technique called TOPSIS (Technique for Order Preference by Similarity to Ideal Solution). This method is characterized by its effectiveness and the simplicity of its principle in solving multi-criteria decision problems[9-11].

A multi-criteria decision problem starts from the evaluation given by a group of experts on the subject, around a set of alternatives on certain criteria. The problem is to find the best evaluated alternative. In the case of TOPSIS, the selection is based on finding the alternative that is closest to the ideal solution and further away from the worst solution.

To enrich this technique, de decided to use the neutrosophic TOPSIS. Neutrosophy is the branch of philosophy that studies the origin, nature and scope of neutralities. Logic and neutrosophic sets constitute generalizations of Zadeh's logic and fuzzy sets, of Atanassov's intuitionist logic, among others. The incorporation of neutrosophic sets in TOPSIS guarantees that we into account the uncertainty of decision-making, including indeterminacies. In this case, the Neutrosophic TOPSIS will be used to determine the alternatives that are the strongest and the weakest quantitatively measured, regarding the most relevant and innovative lines of research in the Systems and Software Engineering courses at UNIANDES - Quevedo.

In addition, the key success factors of the lines of research were defined for a correct relationship of the teaching-learning process. All that with the application of the knowledge acquired in the subjects of mathematics, basic electronics, digital electronics, simulation, artificial intelligence, robotics in the projects such as parking lot automation, automated irrigation systems, earthquake alarm systems, tele-manipulated robotic monkeys, inmotic environment control systems, among others.[3-5, 12-19]

2 Materials and Methods

This section details the main concepts and techniques that will be used in this study.

Definition 1([20]): Let X be a universe of discourse. A *Neutrosophic Set* (NS) is characterized by three membership functions, $u_A(x), r_A(x), v_A(x) : X \rightarrow]^{-}0, 1^{+}[$, which satisfy the condition $^{-}0 \leq \inf u_A(x) + \inf r_A(x) + \inf v_A(x) \leq \sup u_A(x) + \sup r_A(x) + \sup v_A(x) \leq 3^{+}$ for all x∈X. $u_A(x), r_A(x)$ and $v_A(x)$ are the membership functions of truthfulness, indeterminacy and falseness of x in A, respectively, and their images are standard or non-standard subsets of $]^{-}0, 1^{+}[$.

Definition 2: ([21]) Let X be a universe of discourse. A *Single-Valued Neutrosophic Set* (SVNS) A on X is a set of the form:

$$A = \{\langle x, u_A(x), r_A(x), v_A(x)\rangle : x \in X\} \tag{1}$$

Where $u_A, r_A, v_A : X \rightarrow [0,1]$, satisfy the condition $0 \leq u_A(x) + r_A(x) + v_A(x) \leq 3$ for all x∈X. $u_A(x), r_A(x)$ and $v_A(x)$ denotes the membership functions of truthfulness, indeterminacy and falseness of x in A, respectively. For convenience a *Single-Valued Neutrosophic Number* (SVNN) will be expressed as $A = (a, b, c)$, where $a, b, c \in [0,1]$ and satisfy $0 \leq a + b + c \leq 3$.

SVNNs came up with the idea of applying neutrosophic sets for practical purposes.

Some operations between SVNN are expressed below:

1. Given A1 = (a1, b1, c1) and A2 = (a2, b2, c2) two SVNNs, the sum between A1 and A2 is defined as:
A1+A2 = (a1 + a2 - a1a2, b1b2, c1c2) (2)
2. Given A1 = (a1, b1, c1) and A2 = (a2, b2, c2) two SVNN we have that the multiplication between A1 and A2 is defined as:
A1xA2 = (a1a2, b1 + b2 - b1b2, c1 + c2 - c1c2) (3)
The multiplication by a positive scalar $\lambda \in \Re$ with SVNS, A = (a, b, c) is defined by:
$$\lambda A = \left(1 - (1 - a)^{\lambda}, b^{\lambda}, c^{\lambda}\right) \tag{4}$$
3. Let {A1, A2,…, An} be a set of n SVNN, where Aj = (aj, bj, cj) (j = 1, 2,…, n), then the *Single Value Neutrosophic Weighted Average Operator* (SVNWA) over the set is calculated by the following Equation[22]:

$$P_w(A_1, A_2, \dots, A_n) = \langle 1 - \prod_{j=1}^{n}\left(1 - T_{A_j}(x)\right)^{w_j}, \prod_{j=1}^{n}\left(I_{A_j}(x)\right)^{w_j}, \prod_{j=1}^{n}\left(F_{A_j}(x)\right)^{w_j}\rangle \tag{5}$$

(5)

Where $w = (w_1, w_2, \dots, w_n)$ is vector of $A_j (j = 1,2, \dots, n)$ such that $w_n \in [0,1]$ y $\sum w_j = 1$.

Definition 3 ([20, 23, 24]). Let $A^* = (A_1^*, A_2^*, \dots, A_n^*)$ a vector SVNS such that $A_j^* = (a_1^*, b_2^*, c_2^*)$ $(j = 1,2, \dots, n)$ and $B_i = (B_{i1}, B_{i2}, \dots, B_{im})$ $(i = 1,2, \dots, m)$ are m vectors such that $B_{ij} = (a_{ij}, b_{ij}, \dots, c_{ij})$ $(i = 1,2, \dots, m)(j = 1,2, \dots, n)$, then the distance measure between B_i and A^* is as follows:

$$s_i = \left(\frac{1}{3}\sum_{j=1}^{n}\left\{\left(a_{ij} - a_j^*\right)^2 + \left(b_{ij} - b_j^*\right)^2 + \left(c_{ij} - c_j^*\right)^2\right\}\right)^{\frac{1}{2}}$$
(7)

Definition 4([25, 26]). Let A = (a, b, c) be a SVNN, the scoring function S of an SVNN, based on the true membership degree, the indeterminate membership degree and the false membership degree is defined by the following Equation:

$$S(s) = \frac{1 + a - 2b - c}{2} \tag{8}$$

where S (A) ∈[-1,1].

In this article, linguistic terms will be associated with SVNN, so that experts can carry out their assessments in linguistic terms, because it is more natural. Therefore, we will use the scales shown in Tables 1 and 2.

Linguistic term	SVNN
Extremely Good (EG)	(1,0,0)
Very Very Good (VVG)	(0.9, 0.1, 0.1)
Very Good (VG)	(0.8,0,15,0.20)
Good (G)	(0.70,0.25,0.30)
Moderately good (MDG)	(0.60,0.35,0.40)

Average (A)	(0.50,0.50,0.50)
Moderately Bad (MDB)	(0.40,0.65,0.60)
Bad (B)	(0.30,0.75,0.70)
Very Bad (VB)	(0.20,0.85,0.80)
Very Very Bad (VVB)	(0.10,0.90,0.90)
Extremely Bad (EB)	(0,1,1)

Table 1. Linguistic terms used

Linguistic term	SVNN
Very Important (VI)	(0.9, 0.1, 0.1)
Important (I)	(0.75,0.25,0.20)
Average (A)	(0.50,0.50,0.50)
Not Important (NI)	(0.35,0.75,0.80)
Not Very Important (NVI)	(0.10,0.90,0.90)

Table 2. Linguistic terms that represent the weight of the importance of the alternatives.

the following steps will be carried out:

Step 1: Determine the experts' weight.

For this, the specialists evaluate according to the linguistic scale that appears in Table 1, and the calculations are made with its associated SVNN, let's call the SVNN At = (at, bt, ct) corresponding to the t-th decision-maker (t = 1, 2 , ..., k). The weight is calculated by the following formula[27]:

$$\lambda_t = \frac{a_t + b_t\left(\frac{a_t}{a_t+c_t}\right)}{\sum_{t=1}^{k} a_t + b_t\left(\frac{a_t}{a_t+c_t}\right)} \quad (8)$$

where: $\lambda_t \geq 0$ y $\sum_{t=1}^{k} \lambda_t = 1$

Step 2: Construction of the neutrosophic decision matrix of aggregated single values.

This matrix is defined by $D = \sum_{t=1}^{k} \lambda_t\, d_{ij}$, where $d_{ij} = \left(u_{ij}, r_{ij}, v_{ij}\right)$ is used to aggregate all individual assessments.

d_{ij} is calculated as the aggregation of the evaluations given by each expert $\left(u_{ij}{}^{t}, r_{ij}{}^{t}, v_{ij}{}^{t}\right)$, using the weights of each decision maker with the help of Equation 8.

In this way a matrix D = $\left(d_{ij}\right)_{ij}$, where each d_{ij} is a SVNS (i = 1,2,.., m; j = 1,2,…, n).

Step 3: Determination of the weight of the criteria.

Suppose that the weight of each criterion is given by W = (w_1, w_2,…, w_n), where w_j denotes the relative importance of the criterion β_j. If $w_j^t = a_j^t, b_j^t, c_j^t$ is the evaluation of the criterion j-th by the t-th expert.

Then Equation 5 is used to aggregate the w_j^t the weights λ_t.

Step 4: Construction of the single valued neutrosophic weighted averaging decision matrix with respect to the criteria.

$$D^* = D \otimes W, where\ d_{ij}^* = W_j \otimes d_{ij} = \left(a_{ij}, b_{ij}, c_{ij}\right) \quad (9)$$

Step 5: Calculation of the ideal positive and negative SVNN solutions.

The criteria can be classified as cost or benefit type. Let G1 be the set of benefits type criteria and G2 the cost type criteria. The ideal alternatives will be defined as follows:

$$\rho^+ = \left(a_{\rho^+w}(\beta_j), b_{\rho^+w}(\beta_j), c_{\rho^+w}(\beta_j)\right) \quad (10)$$

Denote the positive ideal solution, corresponding to G1.

$$\rho^- = \left(a_{\rho^-w}(\beta_j), b_{\rho^-w}(\beta_j), c_{\rho^-w}(\beta_j)\right) \quad (11)$$

Denote the ideal negative solution, corresponding to G2. Where:

$$a_{\rho^+w}(\beta_j) = \begin{cases} max_i a_{\rho_i w}(\beta_j), & if \quad j \in G_1 \\ min_i a_{\rho_i w}(\beta_j), & if \quad j \in G_2 \end{cases}$$

$$b_{\rho^+w}(\beta_j) = \begin{cases} min_i b_{\rho_i w}(\beta_j), & if \quad j \in G_1 \\ max_i b_{\rho_i w}(\beta_j), & if \quad j \in G_2 \end{cases}$$

$$c_{\rho^+w}(\beta_j) = \begin{cases} min_i c_{\rho_i w}(\beta_j), & if \quad j \in G_1 \\ max_i c_{\rho_i w}(\beta_j), & if \quad j \in G_2 \end{cases}$$

On the other hand,

$$a_{\rho^-w}(\beta_j) = \begin{cases} min_i a_{\rho_i w}(\beta_j), & if \quad j \in G_1 \\ max_i a_{\rho_i w}(\beta_j), & if \quad j \in G_2 \end{cases}$$

$$b_{\rho^- w}(\beta_j) = \begin{cases} max_i b_{\rho_i w}(\beta_j), & if \quad j \in G_1 \\ min_i b_{\rho_i w}(\beta_j), & if \quad j \in G_2 \end{cases}$$

$$c_{\rho^- w}(\beta_j) = \begin{cases} max_i c_{\rho_i w}(\beta_j), & if \quad j \in G_1 \\ min_i c_{\rho_i w}(\beta_j), & if \quad j \in G_2 \end{cases}$$

Step 6: Calculate the distances to the ideal positive and negative SVNN solutions. With the help of Equation 6, the following Equations are calculated:

$$s_i^+ = \left(\frac{1}{3}\sum_{j=1}^{n}\left\{\left(a_{ij} - a_j^+\right)^2 + \left(b_{ij} - b_j^+\right)^2 + \left(c_{ij} - c_j^+\right)^2\right\}\right)^{\frac{1}{2}} \quad (12)$$

$$s_i^- = \left(\frac{1}{3}\sum_{j=1}^{n}\left\{\left(a_{ij} - a_j^-\right)^2 + \left(b_{ij} - b_j^-\right)^2 + \left(c_{ij} - c_j^-\right)^2\right\}\right)^{\frac{1}{2}} \quad (13)$$

Step 7: Calculation of the Coefficient of Proximity (CP).
The CP of each alternative is calculated with respect to the positive and negative ideal solutions.

$$\tilde{\rho}_j = \frac{s^-}{s^+ + s^-}$$

Where
$0 \leq \tilde{\rho}_j \leq 1$

Step 8: Determine the ranking of the alternatives.
Additionally, for the statistical processing the following formula was used to calculate the sample size

$$n = \frac{Z\,Npq}{E^2(N-1) + Z^2pq} \quad (14)$$

Where:
n: Sample size,
Z: It is the value of the normal distribution with the assigned confidence level,
E: Desired sampling error, N: Population size, p, q: They are taken as 50% or 0.05.

3 Results

In order to collect the information, the survey was used as a way to explore reality. The selection of the sample was random. There is a population of N = 158 students of the Systems and Software Engineering degree at UNIANDES - Quevedo, and the total number of respondents was n = 49, with Z = 1.96 and E = 0.05, after applying the Equation 14.[12]

The surveys carried out examined the main components of the research lines: the teaching-learning environment, the role of the teacher and the student, the use of different subjects of the systems engineering curriculum, the importance for the sustainable development of the race.

The questions to the respondents were the following:

Survey applied on the research lines of the Systems and Software Engineering degree at UNIANDES - Quevedo.

Below, there will be eight questions about the research lines of the Systems and Software Engineering degree at UNIANDES - Quevedo. Please answer honestly by ticking only one of the possible answers. We guarantee the anonymity of your responses.

1. Do you know what a line of research is?
 Yes Not
2. Do you consider that the lines of research allow a better teaching-learning relationship?
 Yes Not
3. Do you consider the lines of research important for the professional practice of the systems and software engineer?
 Yes Not
4. How would you rate the contribution made by your career teachers in favor of your engineering training?
 It is a systematic contribution It is a sporadic contribution It is not a significant contribution
5. Do you consider necessary to develop and offer talks and other training activities that promote the integration of university students to lines of research?
 Yes Not
6. How do you evaluate yourself in terms of your level of professional training?
 High level Average level Low level Very low level
7. Do you consider the engineering training received during the years of studies in higher education sufficient?
 Yes Not

The results show that the components of the lines of research have a high incidence in the teaching-learning environment and directly affect the role of the teacher on the student in the systems engineering career:

- 85% of the students surveyed express having knowledge about what the lines of research are.
- Out of the total students surveyed, only 12% do not consider the lines of research necessary in their engineering training.
- Only 5% of the surveyed students do not consider the use of lines of research important for the professional practice of systems and software engineers.
- Regarding the contribution that teachers make to their engineering training, only 8% out of the total of surveyed students, do not consider that their teachers work in favor of improving their professional training.
- 93% of those surveyed think it is necessary to develop and offer talks and other training activities that promote research lines.
- The self-evaluation regarding the level of professional training, yields the following data:
    - High level (8.7%);
    - Average level (58%);
    - Low level (32%);
    - Very low level (1.3%)
- For 59% of those surveyed, the lines of research received during their years of studies in higher education are insufficient.

We consulted a group of four specialists who have studied in depth the contribution of the lines of research in the engineering training of the students, including the results of the previous survey. This study included a review of study programs, interviews with teachers, visits to classrooms, interviews with UNIANDES Academic Board, among other activities that allowed them to determine a set of strategies to continue promoting lines of research in the Systems Engineer degree.

They reached to the conclusion that engineering training is a complex process, which requires the integration of both students and teachers. Therefore, they proposed the following criteria to evaluate the lines of research:

β1: Little integration and importance in the teaching-learning approach, β2: Effective in the teaching-learning approach, β3: Insufficient in the teaching-learning approach.

The lines of research to be evaluated are the following:

ρ1: Research that has a direct impact on the country's economy and the number of subjects is high, but they are assigned to the university by the problem bank of the associated companies ("Seismic alarm for the prevention of natural disasters", "Prototype of an automated sprinkler irrigation system", "Functional robotic hand with manipulation capacity");

ρ2: Research that allows the creativity of students and the number of subjects used is high, but they are assigned by the problem bank of the companies associated with the university, and they do not have a direct impact on the economic development of the country ("Web-controlled robotic HAND", "Automation in the control of a multifunction robotic cart").

Results are shown in the following Tables:

Criterion	Expert 1	Expert 2	Expert 3	Expert 4
Little integration and importance in the teaching-learning approach	I	I	I	VI
Effective in the teaching-learning approach	I	I	M	I
Insufficient in the teaching-learning approach	M	VI	NI	I

Table 3. Importance given by each decision maker to each of the criteria

Little integration and importance in the teaching-learning approach				
Lines	**Expert 1**	**Expert 2**	**Expert 3**	**Expert 4**
ρ1	NI	NI	NI	NVI
ρ2	VI	I	I	VI

Table 4. Evaluation of each line regarding the "little integration and importance in the teaching-learning approach".

Effective in the teaching-learning approach				
Lines	**Expert 1**	**Expert 2**	**Expert 3**	**Expert 4**
ρ1	VI	VI	VI	I
ρ2	M	I	M	M

Table 5. Evaluation of the effectiveness of the lines.

Insufficient in the teaching-learning approach				
Lines	Expert 1	Expert 2	Expert 3	Expert 4
ρ1	NI	NVI	M	M
ρ2	VI	I	VI	VI

Table 6. Evaluation of each line with respect to "Insufficient in the teaching-learning approach".

Importance	Expert 1	Expert 2	Expert 3	Expert 4
Linguistics	M	M	M	M
Numerical	0.2	0.2	0.2	0.2

Table 7. Relative importance given to each of the Decision-makers.

Applying the Neutrosophic TOPSIS algorithm, the matrices given in the following tables (Tables 8-12) are calculated:

	β1	β2	β3
ρ1	(0.30629, 0.77785; 0.81907)	(0.87989, 0.12011, 0.11487)	(0.37540, 0.66140, 0.67869)
ρ2	(0.80095; 0.19905; 0.18206)	(0.56472, 0.43528, 0.41628)	(0.85573, 0.14427, 0.13195)

Table 8. Decision table added by experts.

Criterion	Weight
β1	(0.82671, 0.17329, 0.15157)
β2	(0.76091, 0.23909, 0.20913)
β3	(0.71056, 0.29784, 0.27595)

Table 9. Table of the weights assigned by the experts to each criterion.

	β1	β2	β3
ρ1	(0.25321, 0.81635, 0.84649)	(0.66952, 0.33048, 0.29998)	(0.26674, 0.76225, 0.76736)
ρ2	(0.66215, 0.33785, 0.30604)	(0.42970, 0.57030, 0.53835)	(0.60805, 0.39914, 0.37149)

Table 10. Aggregate decision table weighted by experts.

Criterion	Positive ideal value	Negative ideal value
β1	(0.66215, 0.33785, 0.30604)	(0.25321, 0.81635, 0.84649)
β2	(0.66952, 0.33048, 0.29998)	(0.42970, 0.57030, 0.53835)
β3	(0.60805, 0.39914, 0.37149)	(0.26674, 0.76225, 0.76736)

Table 11. Positive and negative ideal values by criterion.

Alternative	d-	d +	CP	Order
ρ1	0.23934	0.60369	0.71610	one
ρ2	0.60369	0.24014	0.28458	two

Table 12. Calculation of the CP for each of the alternatives and their ordering.

According to the results shown in Table 12, we obtained that ρ1 was preferred over ρ2, although both can be carried out. This preference may be because it has a greater impact on the economic development of the country. Once the preferred lines of research have been analyzed, we proceed to extract potential factors (variables) and their impact on the university:

Line of research	Key factors	Impact
Seismic alarm for the prevention of natural disasters	Integration and coordination with the department in charge of forecasting natural	1. Enables an early warning system for natural disasters 2. It incorporates a management way to mitigate the possible consequences of disasters

	disasters	3. Development of our own software for the prevention of natural disasters
Prototype of an automated sprinkler irrigation system	Direct impact on food, and contribution to the economy.	1. Less impact on soils and food. 2. Establishes a working trend for less possessed farmers. 3. Direct influence on the agricultural sustainability of the country.
Functional robotic hand with manipulative ability	Integration with the health of workers, and increased productivity.	1. Establish a safe way of working. 2. It directly influences the productivity of the entity.

Table 13. Key factors of the ρ1 lines of research and their impact on the university. Own elaboration.

Conclusions

- The results obtained through the survey applied to the student community of the Systems Engineering degree in the city of Quevedo, shows that steps are being taken to solve the existing problem, and that there is a need for a change in the way the thinking of new professionals, with their integration into the lines of research.
- The research process developed has allowed scientific production and participation of teachers and students in international scientific events.
- It is very clear that the evaluation of the lines of scientific research, within UNIANDES, is a perfectible task. Therefore, it is not surprising to perceive a wrong operation in criteria and methodologies for the evaluation and follow-up of research. It is also true that the current situation allows the improvement of the process through the initiatives gradually proposed for the development of research projects, knowing the key factors for their success.
- The Neutrosophic TOPSIS technique, where a group of specialists determined that the line of research more important is: Research that has a direct impact on the country's economy and the number of subjects it uses is high, but they are assigned by the Problem bank of the companies associated with the university.

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