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Mentoring and Entrepreneurship in Higher Education: A Study from the Plithogenic Statistics

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Abstract. Entrepreneurship management in university students is a key factor for economic and social development, especially in intercultural contexts such as the Peruvian Amazon. However, the absence of effective training strategies limits the strengthening of these competencies. This study aims to evaluate the impact of a mentoring program on strengthening entrepreneurship management in students at the National Intercultural University of the Amazon in Peru. The research concludes that the implementation of mentoring programs can represent a key strategy to promote student entrepreneurship in regions with development needs, providing relevant evidence for educational practice and future interventions in higher education. Plithogenic statistics is an extension of traditional statistics that allows the analysis of data sets with multiple levels of uncertainty, contradiction, and neutrality, integrating variables that do not necessarily belong entirely to a sample or population. Its importance lies in the fact that it provides mathematical tools to study complex real-world phenomena—such as social, medical, or organizational dynamics—where the data are not entirely clear or defined, thus improving the accuracy of analysis and decision-making. It is for all these advantages that we use the Plithogenic Statistics as a tool for the study to be conducted. Mentoring and entrepreneurship in higher education encompass several dimensions that interact dynamically with each other, and there are also components of uncertainty within this phenomenon.

Keywords: Mentoring, entrepreneurship, university students, educational intervention, Plithogeny, Plithogenic Statistics, t-test for independent samples, t-test for paired samples.

1 Introduction

This study is based on three key theoretical pillars: mentoring as an entrepreneurial empowerment strategy, entrepreneurship management in university contexts, and mixed methodological approaches in educational research.

Regarding mentoring as a strategy for entrepreneurial skills, recent research has shown that it promotes the development of entrepreneurial skills in university students through structured support processes. Furthermore, university entrepreneurship management is defined as the management of entrepreneurship within a set of strategic practices for developing projects, which includes planning, innovation, and leadership. Strengthening mentoring favors the transformation of ideas into sustainable initiatives.

The quasi-experimental design combined with qualitative analysis allows for the evaluation of changes in quantifiable indicators (e.g., competencies) and the understanding of the subjective dynamics inherent to mentoring. These foundations create a solid basis for the study's primary objective, which is to evaluate the impact of a mentoring program on strengthening entrepreneurial management among university students at the National Intercultural University of the Amazon.

Three recent studies have been identified that provide relevant evidence:

1. Entrepreneurial Curriculum Reform in Peru: This is a quasi-experimental study on curricular innovation and mentoring, which concludes that this strategy improves entrepreneurial skills, although it does not include qualitative analysis.
2. Mentoring and experiential learning: This is a mixed-design study that reveals how mentoring, combined with practical experiences, strengthens intrapersonal skills in undergraduate students.
3. Intrinsic motivation and entrepreneurship in Peru: This correlational study demonstrates the relationship between intrinsic motivation and entrepreneurial capacity in Peruvian universities, suggesting that incremental support strategies such as mentoring are effective.

These studies show progress in the use of mentoring to improve entrepreneurial skills, but they have limitations in their methodological scope, context, and variables analyzed. Based on the literature review, three relevant gaps are identified.

a. Absence of Amazonian intercultural contexts: The literature on mentoring and entrepreneurship lacks studies in Peruvian Amazonian universities, where cultural and ethnic factors may influence the effectiveness of the mentoring program.
b. Lack of mixed (quantitative-qualitative) evaluation. Although there are studies with quasi-experimental designs, few integrate a comprehensive qualitative analysis to explore participants' perceptions and experiences.
c. Entrepreneurship management as a dependent variable. Most studies address generic competencies (e.g., creativity, motivation) but do not directly focus on entrepreneurship management as a specific outcome of mentoring.

This project responds to these gaps, focusing on an Amazon intercultural context, using a plithogenic statistical-based design and measuring the impact on entrepreneurship management, filling important methodological and geographical gaps.

Therefore, the purpose of this article is to evaluate the impact of a mentoring program on strengthening entrepreneurship management among university students at the National Intercultural University of the Amazon. This objective seeks to close the identified gaps, strengthen academic knowledge in Amazonian intercultural contexts, and provide empirical evidence using a rigorous methodology.

Plithogenic statistics is an advanced extension of multivariate statistics that allows the analysis of complex phenomena with multiple levels of uncertainty, contradiction, and neutrality [1]. It was developed by Professor Florentin Smarandache as part of his plithogenic theory, which seeks to integrate diverse—even opposing—elements into a coherent analytical framework [2].

This theory stands out for the following aspects [3]:

1. Multidimensionality: It is not limited to classical variables, but incorporates variables with degrees of truthfulness, falsehood, and indeterminacy.
2. Substatistics: Each variable can have its form of probabilistic representation, such as fuzzy, neutrosophic, or hybrid sets.
3. Conceptual flexibility: Allows us to work with data that do not fully belong to a sample or population, such as students participating in part-time or intermittent courses.

For these characteristics, we selected the Plithogenic Statistics as a tool for the study we conducted. This is because we have several dimensions of the same phenomenon to study. We must also consider uncertainty and indeterminacy in the assessments of the aspects to be measured, which are primarily subjective.

This paper is divided into a Preliminaries section, where the basic notions of Plithogenic Statistics are explained. Later, there is a Results section with the details obtained from the study. The paper ends with the conclusions.

2 Preliminaries

This section is dedicated to recalling the main elements of the Plithogenic Statistics [1, 4-10].

Plithogenic probability refers to the calculation of the likelihood of an event occurring, taking into account multiple random variables or interrelated parameters. This approach, based on the plithogenic analysis of variables, is considered a multidimensional probability, where each subcomponent represents how a specific variable behaves under the hypothesis that the event is influenced by one or more of them. These variables are expressed as probability distribution functions (PDFs).

F. Smarandache identifies several forms of plithogenic probability, depending on the type of PDF used:

- Classical MultiVariate Probability: all PDFs adopt the conventional probabilistic approach.
- Plithogenic Neutrosophic Probability: each PDF is expressed as a triple (T, I, F), where:
  T indicates the possibility of the event occurring,
  I reflects the degree of uncertainty,
  F indicates the probability of non-occurrence,
  (with $T, I, F \in [0,1]$ and $T + I + F \leq 3$)
- Plithogenic Indeterminate Probability: PDFs contain ambiguous or undefined elements.
- Plithogenic Intuitionistic Fuzzy Probability: they are represented as (T, F), with $T + F \leq 1$.
- Plithogenic Picture Fuzzy Probability: it has the form (T, N, F), where N represents neutrality.
- Plithogenic Spherical Fuzzy Probability: it is expressed as (T, H, F), and satisfies that $T^2 + H^2 + F^2 \leq 1$.
- Plithogenic (fuzzy-extension) Probability: all PDFs follow this structural pattern.
- Plithogenic Hybrid Probability: PDFs combine several styles from the list above.

Because of plithogenic statistics, which expands traditional analytical tools to study events related to output variables that may be neutrosophic or indeterminate, it is a statistic that addresses multiple levels of uncertainty.

Subcategories in this field include:

- Multivariate Statistics,
- Plithogenic Neutrosophic Statistics,
- Plithogenic Indeterminate Statistics,
- Plithogenic Intuitionistic Fuzzy Statistics,
- Plithogenic Picture Fuzzy Statistics,
- Plithogenic Spherical Fuzzy Statistics,
- and in general: Plithogenic (fuzzy-extension) Statistics,
- and Plithogenic Hybrid Statistics.

Furthermore, a more advanced form of plithogenic statistics can be contemplated, which is based on the study of events using refined plithogenic probability.

On the other hand, in traditional statistical inference, population values are estimated based on data obtained from a sample, assuming that all individuals in that sample are part of the population. This approach, however, does not adapt to changing contexts such as the academic one, where students may participate in courses at different levels of dedication (full-time, part-time, intensive), and their degree of membership varies.

Within a neutrosophic population, each element is described with a triple value (T_j, I_j, F_j) fulfilling the condition:

$$0 \leq T_j + I_j + F_j \leq 3$$

Given a set of n elements, the average membership is calculated by:

$$\frac{1}{n}\sum_{j=1}^{n}(T_j, I_j, F_j) = \left(\frac{\sum_{j=1}^{n} T_j}{n}, \frac{\sum_{j=1}^{n} I_j}{n}, \frac{\sum_{j=1}^{n} F_j}{n}\right) \qquad (1)$$

3 Results

This research adopted a quasi-experimental design with a mixed approach, aimed at evaluating the impact of a mentoring program on strengthening entrepreneurial management among university students. The mixed approach allowed for the integration of quantitative and qualitative methods to gain a broader and more contextualized understanding of the phenomenon studied. The quantitative dimension focused on comparing pretest and post-test results between groups, while the qualitative component provided contextual information on perceptions of the program.

The sample consisted of 200 university students from the National Intercultural University of the Amazon (NIUA), selected using non-probability convenience sampling. Participants were divided into two groups: an experimental group ($n_1 = 100$) and a control group ($n_2 = 100$).

Inclusion criteria are students enrolled in undergraduate academic programs. Signed informed consent is required to participate in the study, and participants are required to be willing to participate during the pretest, intervention, and post-test phases. Students who had previously participated in similar mentoring programs or who had dropped out of the process before completing the post-test phase were excluded.

The research was conducted in three phases. For the pretest, a validated questionnaire was administered to measure the level of entrepreneurial management in both groups (control and experimental). The scale categorized the levels as High, Medium, and Low.

During the intervention (Mentoring Program), the experimental group participated in a structured mentoring program over an academic period. The program included coaching sessions, entrepreneurial skills development, and personalized advice. The control group received no intervention.

During the post-test, the same questionnaire was administered to both groups to measure changes in entrepreneurship management and evaluate the program's impact. The instrument used was a standardized questionnaire that measures entrepreneurship management in university settings. The instrument was validated by expert judgment and achieved a reliability index (Cronbach's alpha) of 0.89, indicating acceptable internal consistency.

For data analysis, the quantitative data had to be processed using descriptive statistics, although based on inferential statistics, such as the Student t test for both independent and paired data.

For the qualitative approach, thematic analysis was used based on semi-structured interviews conducted only with the experimental group. To minimize bias, the two groups were ensured to be equivalent in demographic variables (age, gender, and faculty). The instrument was administered anonymously and supervised by personnel external to the mentor teachers. Incomplete or inconsistent questionnaires were excluded from the analysis. Limitations include the use of non-probability sampling, which restricts the generalization of the results. The duration of the intervention is limited to one academic year.

The steps taken were as follows:

1. The survey was conducted on 200 students, 100 from the experimental group and 100 from the control group.
2. The survey results were evaluated according to the scale shown in Table 1, where nominal values such as Low, Medium, and High are associated with Single-Valued Neutrosophic Numbers.

Table 1. The linguistic scale and the SVNNs were used in the survey of the study, [11].

Linguistic Value	Single-Valued Neutrosophic Number (SVNN)
Low	(0.1,0.1,0.8)
Medium	(0.55,0.1,0.35)
High	(0.8,0.1,0.1)

3. Each student is assessed on the dimensions of entrepreneurship, which are as follows:

D_1. Creativity: Educating university students to be creative means stimulating their ability to generate novel and useful ideas to address real-life problems. This skill is cultivated through educational environments that encourage divergent thinking, the free exploration of solutions, and interdisciplinary connections. Promoting creativity prepares future entrepreneurs to face uncertainty with imagination, finding opportunities in the challenges of the world of work and business.

D_2. Innovation: Developing students with an innovative mindset involves teaching them to transform ideas into solutions that generate economic and social value. Through practical learning experiences, the use of technology, and the analysis of real-life cases, their initiative to improve products, services, or processes can be cultivated. Innovation, in this sense, is not just a technical skill but a proactive attitude toward change and continuous improvement in any work context.

D_3. Leadership and decision-making: Fostering leadership in students is not limited to teaching them how to lead groups, but also how to influence others ethically, assume responsibility, and make informed decisions. An educational environment that encourages active participation, self-management, and critical reflection develops young people capable of leading projects, managing conflicts, and responding autonomously to the challenges they will face as entrepreneurs outside of the university setting.

D_4. Technological tools: Nowadays, it is impossible to think about being an entrepreneur without having a minimum command of technological tools. Technology offers added value to the products and services that can be created, which is why the knowledge and use of technological tools offer a decisive advantage to those who possess them.

D_5. Social Responsibility: Teaching social responsibility during university education prepares students to be entrepreneurs with ethical awareness and community commitment. Through service practices, projects with social impact, and sustainability training, they are taught that entrepreneurship should not be motivated solely by economic gain, but also by the desire to positively transform their environment. This dimension strengthens empathy, a sense of purpose, and active citizenship.

D_6. Resilience: Resilience is taught when students learn to see mistakes as opportunities and failure as a natural part of growth. Through methodologies that promote reflection, adaptation, and experiential learning, they are prepared to face the ups and downs of the entrepreneurial world. Resilience gives them the emotional and mental strength to persevere, reinvent themselves, and continue building their goals even in difficult times.

In this way, we have the set $D = \{D_1, D_2, D_3, D_4, D_5, D_6\}$ of dimensions.

In general, we have the evaluation results:

a_{ij}, which is the evaluation on the scale shown in Table 1 of the ith student (i=1, 2,…, 200) in terms of the jth dimension (j=1, 2,.., 6) for the pretest. The results b_{ij} are similar for the post-tests. Note that the evaluation for each dimension is a comprehensive student grade based on their results for the questions appearing in each corresponding test.

Each a_{ij} is a linguistic value, which has an associated SVNN, so to perform the calculations, we have triples of values: one for truthfulness, another for indeterminacy, and a third one for falseness. The same occurs with b_{ij}.

Students numbered 1 to 100 belong to the control group, and those numbered 101 to 200 belong to the experimental group.

4. For the comparison of results, the following methods are available:
   4.1. Student t test for paired samples to compare pre vs. post in each group [12].

4.2. Student t-test for independent samples to compare post-control vs. post-experimental [13]. Both methods are adapted to the conditions of SVNNs. We will explain the details further. Note that these methods are parametric, and it is necessary to demonstrate normality in the data distribution. In our study, since this is a non-probability sample, we use the statistics from the methods as comparison measures. These comparisons are made for each dimension.

Below, we explain the adaptations we made to the Student t method for paired and independent samples.

The Student t-test for independent samples is a parametric test that compares the means of two independent groups to determine whether there is a statistically significant difference between them. It is used to determine whether two populations differ concerning a quantitative variable. A classic example is comparing the average blood pressure between people who receive a treatment versus those who do not.

To use it,

1. The groups that must be independent (not related to each other) are defined.
2. The following assumptions are verified:
   - The dependent variable is continuous.
   - The variable follows a normal distribution in both groups,
   - The variances are equal,

   The t-test is calculated.

   The p-value is interpreted: If $p < 0.05$, there is significant evidence to affirm that the means are different.

   Equation 2 shows the formula for the statistic used [14, 15]:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{s_p^2\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}} \quad (2)$$

Where:

$\bar{X}_1$ and $\bar{X}_2$ are the averages of the two groups,

n_1 and n_2 are the sample sizes of each group.

s_p^2 is the pooled variance, which is calculated as:

$$s_p^2 = \frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}$$

s_1^2 and s_2^2 are the individual variances of each group.

$df = n_1 + n_2 - 2$ is the degree of freedom.

When the variances of both samples are different, the formula that appears in Equation 3 is used.

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}} \quad (3)$$

The formula for approximate degree of freedom is as follows:

$$\text{df} = \frac{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)^2}{\frac{\left(\frac{s_1^2}{n_1}\right)^2}{n_1 - 1} + \frac{\left(\frac{s_2^2}{n_2}\right)^2}{n_2 - 1}}$$

Student t-test (also called the related-samples t-test) is used when two measurements are taken from the same group—for example, before and after a treatment—and we want to determine whether there is a significant difference between them. It is used when each subject has two observations (e.g., weight before and after a diet). The differences between pairs should follow a normal distribution. It is a parametric test, so the data must be quantitative and have an interval scale.

The main formula is Equation 4 [16]:

$$t = \frac{\bar{D}}{s_D/\sqrt{n}} \quad (4)$$

Where:

$\bar{D}$ is the average of the differences between pairs.

s_D is the standard deviation of the differences.

n is the number of pairs.

In both methods, we convert the equations of the means, standard deviations, and variances to a single value. For that, we use the formula of the score function, which is the one shown below [17]:

$$\mathcal{S}\big((T,I,F)\big) = \frac{2+T-F-I}{3} \quad (5)$$

This formula is applied for each element in the form of SVNN of the data, and then we apply Equations 3 and 4, to then apply the operations in the form of crisp values, e.g., $t = \frac{\bar{X}_1-\bar{X}_2}{\sqrt{\left(\frac{s_1^2}{n_1}+\frac{s_2^2}{n_2}\right)}}$ becomes the equivalent equation where the data is converted into crisp values, and then this Equation is applied.

From now on, we present the results obtained.

Table 2 contains a summary of the means obtained in the form of SVNNs for the creativity dimension and also their crisp values after applying the score function.

Table 2. SVNN means for the "Creativity" dimension and its score function values.

Group and Stage	**SVNN Mean**	**Crisp value from the score function**
Control Pretest	[0.3295, 0.1, 0.5705]	0.553
Experimental Pretest	[0.1, 0.1, 0.8]	0.4
Control Post-test	[0.3745, 0.1, 0.5255]	0.583
Experimental Post-test	[0.4565, 0.083, 0.2905]	0.694

Tables 3-7 contain similar results for the dimensions, viz., innovation, leadership and decision making, technological tools, social responsibility, and resilience, respectively.

Table 3. SVNN means for the "Innovation" dimension and its score function values.

Group and Stage	**SVNN Mean**	**Crisp value from the score function**
Control Pretest	[0.529, 0.1, 0.371]	0.686
Experimental Pretest	[0.3705, 0.1, 0.5295]	0.580
Control Post-test	[0.253, 0.1, 0.647]	0.502
Experimental Post-test	[0.655, 0.1, 0.245]	0.77

Table 4. SVNN means for the dimension "Leadership and decision-making" and its score function values.

Group and Stage	**SVNN Mean**	**Crisp value from the score function**
Control Pretest	[0.301, 0.1, 0.599]	0.534
Experimental Pretest	[0.3365, 0.1, 0.5635]	0.558
Control Post-test	[0.3535, 0.1, 0.5465]	0.569
Experimental Post-test	[0.5775, 0.1, 0.3225]	0.718

Table 5. SVNN means for the "Technological tools" dimension and its score function values.

Table 5. SVNN means for the "Technological tools" dimension and its score function values.

Group and Stage	SVNN Mean	Crisp value from the score function
Control Pretest	[0.382, 0.1, 0.518]	0.588
Experimental Pretest	[0.5935, 0.1, 0.3065]	0.729
Control Post-test	[0.4465, 0.1, 0.4535]	0.631
Experimental Post-test	[0.5935, 0.1, 0.3065]	0.729

Table 6. SVNN means for the "Social Responsibility" dimension and its score function values.

Group and Stage	SVNN Mean	Crisp value from the score function
Control Pretest	[0.3295, 0.1, 0.5705]	0.553
Experimental Pretest	[0.361, 0.1, 0.539]	0.574
Control Post-test	[0.2905, 0.1, 0.6095]	0.527
Experimental Post-test	[0.615, 0.1, 0.285]	0.743

Table 7. SVNN means for the "Resilience" dimension and its score function values.

Group and Stage	SVNN Mean	Crisp value from the score function
Control Pretest	[0.3925, 0.1, 0.5075]	0.595
Experimental Pretest	[0.605, 0.1, 0.295]	0.737
Control Post-test	[0.352, 0.1, 0.548]	0.568
Experimental Post-test	[0.605, 0.1, 0.295]	0.737

Table 8 contains the results of comparing the control group with the experimental group at the post-test stage. Equation 3 is used, where X_1 represents the results of the control group and X_2 represents the variable for the experimental group. A negative value means improvement, a positive value indicates worsening, and a value of 0 indicates no change. The higher the absolute value of the results, the more significant they are for both improvement and worsening.

Table 8. Results of comparing the post-tests of each dimension between the control group and the experimental group.

Dimension	t-Student statistic value for the post-test
Creativity	-2.194
Innovation	-5.139
Leadership and decision-making	-2.7281
Technological Tools	-1.4746
Social responsibility	-3,800
Resilience	-3.2410

Table 8 shows that the intervention within the experimental group was effective, as improvements were achieved in all aspects. The most notable improvement was in the innovation dimension, with t = -5.139.

Table 9 contains the results of the comparisons for the paired samples, between the control group before and after, and the experimental group before and after.

Table 9. Results of comparing each group with respect to before and after the intervention using the statistic for paired cases.

Dimension	Group to compare	Value of the statistic
Creativity	Control	-2.429
	Experimental	-52.1819
Innovation	Control	12.9421
	Experimental	-17.2004

Leadership and decision-making	Control	-3.7534
	Experimental	-11.258
Technological Tools	Control	-2.997
	Experimental	0.000
Social responsibility	Control	3.2193
	Experimental	-13.177
Resilience	Control	3.66567
	Experimental	0.000

Table 9 shows that there was no decline within the experimental group; in fact, there was a significant improvement in creativity compared to the other results (-52.1819), although there were no changes in "Technological Tools" and "Resilience". On the other hand, in the control group, deteriorations were observed in "Innovation", "Social Responsibility", and "Resilience".

4. Conclusion

The results achieved in this investigation show clearly that the mentoring program implemented had a positive and significant impact on strengthening entrepreneurial management skills among participating university students. In the experimental group, entrepreneurial management skills improved considerably after the intervention. In contrast, the control group, which did not receive the intervention, did not show significant improvements in some aspects. These findings confirm the effectiveness of mentoring as a training strategy for the development of key competencies in the entrepreneurial field.

Regarding the research objective—to evaluate the impact of a mentoring program on strengthening entrepreneurship management among university students at the National Intercultural University of the Amazon— the results allow us to affirm that this objective was satisfactorily achieved. The comparative analysis between the control and experimental groups, before and after the intervention, shows that the mentoring program generated substantial improvements in entrepreneurship management skills, suggesting that its implementation can be an effective pedagogical tool for entrepreneurial development in the context of university students.

Another positive aspect to highlight is the effectiveness of the use of Plithogenic Statistics in the comparison of the results of implementing pedagogical programs at the higher education level. This was demonstrated with the combination of plithogenic statistics with traditional statistical methods such as the Student t test for both independent and paired samples. In this study, tests for different dimensions were used, which allows capturing the multidimensionality and multivariate nature of the problem. The use of single-valued neutrosophic numbers supports incorporating uncertainty and indeterminacy into decision-making.

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