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# Enhancing the Teaching-Learning Process through Neutrosophic Statistical Analysis of Professional Competencies and Metacognitive Strategies

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**Abstract**. In the educational field, teaching effectiveness depends on the interaction between professional competencies and teachers' metacognitive strategies. Therefore, the present study has proposed to evaluate the relationship between professional competencies and metacognitive strategies, by using the management of indeterminacies to improve the teaching-learning process. To this end, the neutrosophic statistics method was applied to analyze data on meta-cognitive competencies and strategies in a group of teachers. Among the results, a general positive relationship was revealed between professional competencies and metacognitive strategies, with significant variations in specific areas. Finally, it has been concluded that there is a significant connection, where the variability suggests the need to strengthen training in specific competencies and metacognitive strategies to optimize the educational process.

**Keywords:** Neutrosophic statistics, Teaching-learning, Educational methodology, Teaching process.

## 1 Introduction

The educational field plays a central role in the development of society, by promoting learning and the physical and psychological growth of students [1]. Education not only focuses on the acquisition of knowledge, but also on the comprehensive development of the human being, including cognitive, social and moral aspects [2]. In this sense, teaching work at the university is not limited to teaching a profession, but also seeks to train individuals who contribute to the progress of society.

Therefore, the competency approach has emerged as a key methodology in education, particularly in the training of education professionals [3]. This approach encompasses a series of knowledge, attitudes and skills that allow individuals not only to understand their environment, but also to transform it effectively. Competencies, understood as the integration of theoretical and practical knowledge, are essential for successful professional performance, and the university has the responsibility to foster their continuous development [4].

The concept of competence is complex and multidimensional, involving not only technical knowledge, but also the ability to apply such knowledge in specific contexts [5]. Professional competences include the ability to solve problems autonomously, work in a team and adapt to the changing demands of the environment. Within this framework, university education must provide the necessary tools for students to develop these competences and apply them effectively in professional life [6].

Therefore, metacognitive strategies must be proposed that play a crucial role in the development of competencies, by allowing students to reflect on their own learning process and regulate it effectively [7]. Metacognition , which involves the knowledge and control of one's own cognitive processes, focuses on achieving meaningful learning and the development of autonomy in students. Therefore, university teachers must master these strategies to implement them in pedagogical practices and thus enhance the comprehensive development of students [8].

Finally, it has been observed that the Universidad Nacional Mayor de San Marcos, by participating in projects such as Tuning , recognizes the competencies in the formation of human capital. These competencies not only prepare students for the labor market, but also promote personal and social growth. Although the indeterminate elements that affect the integration of the variables, professional competencies and metacognitive strategies must be identified and analyzed. In this context, the present research seeks to evaluate the relationship between professional competencies and metacognitive strategies of teachers, by using neutrosophic statistics to manage indeterminacies and improve the teaching-learning process.

## 2 Materials and methods

### 2.1 Neutrosophic statistics.

Neutrosophic probability and statistics are a generalization of classical, imprecise probability and statistics [6]. The neutrosophic probability of an event E is the probability that event E occurs, the probability that event E does not occur, and the probability of indeterminacy (not knowing whether event E occurs or not) [9]. In classical probability nsup≤1, while in neutrosophic probability nsup≤3+. The function that models the neutrosophic probability of a random variable X is called the neutrosophic distribution:

Where $\vartheta_A(x), \eta_A(x), \delta_A(x)$the following condition is met$0 \leq \vartheta_A(x), \eta_A(x), \delta_A(x) \leq 3$ for all $x \in X$. So to define each neutrosophic number it is expressed in the following way $h, i, j$for the modeling of the neutrosophic methodology to be used. Therefore, the following functions are defined:

$h = \vartheta_A(x)$for membership functions to true, where ∈ {0,1}.

$i = \eta_A(x)$for membership functions to indeterminate, where ∈ {0,1}.

$j = \delta_A(x)$for membership functions to false, where ∈ {0,1}.

Therefore, the neutrosophic number defined for the study is determined as $L = (h, i, j)$, where h, i, j ∈ {0,1}and satisfies the following condition $0 \leq h + i + j \leq 3$. Thus, let B be defined as the scoring function of a neutrosophic number according to the proposal of Smarandache or Basset for deneutrosification.

Where h represents the probability that the value x occurs, j(x) represents the probability that the value x does not occur, and I(x) represents the indeterminate or unknown probability of the value x. Neutrosophic statistics is the analysis of neutrosophic events and deals with neutrosophic numbers, neutrosophic probability distribution, neutrosophic estimation, and neutrosophic regression among others. For this, one must operate with neutrosophic numbers belonging to the single valued neutrosophic set (SVNS), in order to be used for practical purposes [10]. Some operations between SVNS are expressed below:

Given $L_1 = \ and \ L_2 = (h_2, i_2, j_2)$ , the sum between them $L_1 y\ L_2$is defined as:

$$L_1 + L_2 = (h_1 + h_2 - h_1 h_2, i_1 i_2, j_1 j_2) \quad (1)$$

Given $L_1 = (h_1, i_1, j_1)$and $L_2 = (h_2, i_2, j_2)$ the multiplication between $L_1 y\ L_2$is defined as:

$$L_1 \cdot L_2 = (h_1 h_2, i_1 + i_2 - i_1 i_2, j_1 + j_2 - j_1 j_2) \quad (2)$$

The product of a positive scalar with a SVNS, $L = (h, i, j)$c) is defined by:

$$L = (1 - (1 - h), i, j) \quad (3)$$

Finally, neutrosophic logic [11], neutrosophic sets and neutrosophic probabilities and statistics have a wide application in various research fields and constitute a novel reference for study in full development. Neutrosophic statistics includes all the techniques to summarize and describe the characteristics of neutrosophic numerical data [12].

For the development of the study, probabilities and neutrosophic statistics are used, when integrated into the analysis of the relationship between professional teaching skills and the use of metacognitive strategies, by incorporating an indeterminacy component. This allows us to address the evaluation of educational events with information that may be imprecise, incomplete or unknown. For the modeling of neutrosophic statistics, the neutrosophic random variable is identified, where L represents the lower and upper level that the variable studied can reach, in an indeterminate interval. Thus, the neutrosophic mean of the variable follows ($\bar{L}$)when formulating [14]:

$$\bar{L} = \frac{1}{n_N} \sum_{i=1}^{n_N} L_i \quad (4)$$

Where $n_N$is a neutrosophic random sample of the population studied. In this study the sample consisted of (20-40) teachers, to whom validated questionnaires were applied. A neutrosophic response scale was used to collect data on the variables studied (see table 1).

**Table 1:** Neutrosophic linguistic terms. Source: Own elaboration.

| Criterion | SVNS |
|---|---|
| Extremely high (EA) | (1,0,0) |
| Very very high (MMA) | (0.91,0.06,0.14) |
| Very high (MA) | (0.81,0.16,0.24) |
| High (A) | (0.71,0.26,0.34) |
| Moderately high (MDA) | (0.61,0.36,0.44) |
| Medium (M) | (0.51,0.46,0.54) |
| Medium Low (MDB) | (0.41,0.56,0.64) |
| Bass (B) | (0.31,0.65,0.74) |
| Very low (MB) | (0.21,0.76,0.84) |
| Very very low (MMB) | (0.11,0.86,0.94) |
| Extremely Low (EB) | (0,0.96,1) |

Once the neutrosophic mean has been defined, the variance of the neutrosophic sample is calculated. To do this, the following equation is defined [15]:

$$S_N^2 = \frac{\sum_{i=1}^{n_N} (L_i - \bar{L}_i)^2}{n_N} \quad (5)$$

The neutrosophic coefficient (NCV) is then calculated, which measures the consistency of the variable. The lower the NCV value, the more consistent the performance of the factor is than that of the other factors. To do this, the following equation is proposed [16]:

$$CV_N = \sqrt{S_N^2} \times 100 \quad (6)$$

A null hypothesis was formulated in neutrosophic terms, which proposed the nonexistence of a significant relationship between the variables, using a significance level $\alpha = 0.05$, evaluated under neutrosophic criteria . While to determine the Pearson correlation between both variables, the following equation is applied [17].

$$r = \frac{Cov\ (L^X, L^Y)}{\sqrt{\sigma_{L^X}^2 \cdot \sigma_{L^Y}^2}} \qquad (7)$$

Where to calculate the Covariance, the following formula is applied [18].

$$Cov\ (X,Y) = \frac{\sum_{i=0}^{n}(L_i^X - \bar{L}^X)(L_i^Y - \overline{L^Y})}{n-1} \qquad (8)$$

While it $\sigma$is obtained from the results obtained from neutrosophic statistics or can be replaced by for $S_N^2$sample analysis.

## 3 Results

### 3.1 Data collection. Description of variables.

Metacognitive strategies were applied to the teachers, both appointed and contracted, of the PAE of Physical Education of the Faculty of Education of the UNMSM. Below, the variables and dimensions are visualized, where the elements that allow the neutrosophic analysis are highlighted (see table 2).

**Table 2:** Variables that affect the comprehensive development of university students. Source: Prepared by the authors.

| Variable | Code | Dimensions | Code | Items | |
|---|---|---|---|---|---|
| Professional skills | CP | Subject competencies | CP-A | ▪ | Knowledge of the subject |
| | | | | ▪ | Curriculum management |
| | | Teaching management skills | CP-B | ▪ | Teaching didactics |
| | | | | ▪ | Teaching planning |
| | | | | ▪ | Teaching activities |
| | | Participatory skills | CP-C | ▪ | Link with the institution |
| | | | | ▪ | Link to address |
| | | | | ▪ | Link to context |
| Metacognitive strategies | EM | Expectations towards students | EM-A | ▪ | Learning to understand |
| | | | | ▪ | Identification with students |
| | | | | ▪ | Tutorial performance |
| | | Teaching strategies | EM-B | ▪ | Didactic adaptation |
| | | | | ▪ | Pedagogical communication |
| | | | | ▪ | Motivator |
| | | Affectivity in the classroom | EM-C | ▪ | Promoter of ecological climate |
| | | | | ▪ | Social behavior |
| | | | | ▪ | Mediator of peer interactions |

### 3.2 Neutrosophic statistics.

#### 3.2.1 Professional skills.

The study carried out evaluated the *professional competences* of 40 teachers, using an approach based on neutrosophic logic. To do so, three key dimensions were defined: subject competences, teaching management competences, and participatory competences, incorporating indeterminacy in the final assessment of each element (see table 3).

**Table 3:** Neutrosophic evaluation of each dimension belonging to the professional competencies variable. Source: Own elaboration.

| Teaching | CP-A | CP-B | CP-C |
|---|---|---|---|
| 1 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.71,0.26,0.34) |
| 2 | (0.71,0.26,0.34) | (0.91,0.06,0.14) | (0.81,0.16,0.24) |
| 3 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.61,0.36,0.44) |
| 4 | (0.71,0.26,0.34) | (0.81,0.16,0.24) | (0.71,0.26,0.34) |
| 5 | (0.61,0.36,0.44) | (0.91,0.06,0.14) | (0.71,0.26,0.34) |
| 6 | (0.81,0.16,0.24) | (0.91,0.06,0.14) | (0.81,0.16,0.24) |
| 7 | (0.71,0.26,0.34) | (0.81,0.16,0.24) | (0.61,0.36,0.44) |
| 8 | (0.71,0.26,0.34) | (0.81,0.16,0.24) | (0.71,0.26,0.34) |
| 9 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.61,0.36,0.44) |
| 10 | (0.71,0.26,0.34) | (0.91,0.06,0.14) | (0.71,0.26,0.34) |
| 11 | (0.71,0.26,0.34) | (0.81,0.16,0.24) | (0.81,0.16,0.24) |
| 12 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.71,0.26,0.34) |
| 13 | (0.61,0.36,0.44) | (0.91,0.06,0.14) | (0.71,0.26,0.34) |
| 14 | (0.71,0.26,0.34) | (0.81,0.16,0.24) | (0.61,0.36,0.44) |
| 15 | (0.71,0.26,0.34) | (0.81,0.16,0.24) | (0.71,0.26,0.34) |
| 16 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.71,0.26,0.34) |
| 17 | (0.81,0.16,0.24) | (0.91,0.06,0.14) | (0.81,0.16,0.24) |
| 18 | (0.71,0.26,0.34) | (0.81,0.16,0.24) | (0.71,0.26,0.34) |
| 19 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.71,0.26,0.34) |
| 20 | (0.71,0.26,0.34) | (0.81,0.16,0.24) | (0.71,0.26,0.34) |
| 21 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.61,0.36,0.44) |
| 22 | (0.81,0.16,0.24) | (0.91,0.06,0.14) | (0.81,0.16,0.24) |
| 23 | (0.71,0.26,0.34) | (0.81,0.16,0.24) | (0.71,0.26,0.34) |
| 24 | (0.81,0.16,0.24) | (0.91,0.06,0.14) | (0.71,0.26,0.34) |
| 25 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.71,0.26,0.34) |
| 26 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.61,0.36,0.44) |
| 27 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.61,0.36,0.44) |
| 28 | (0.71,0.26,0.34) | (0.81,0.16,0.24) | (0.71,0.26,0.34) |
| 29 | (0.81,0.16,0.24) | (0.91,0.06,0.14) | (0.81,0.16,0.24) |
| 30 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.61,0.36,0.44) |
| 31 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.71,0.26,0.34) |
| 32 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.61,0.36,0.44) |
| 33 | (0.71,0.26,0.34) | (0.81,0.16,0.24) | (0.71,0.26,0.34) |
| 34 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.61,0.36,0.44) |
| 35 | (0.81,0.16,0.24) | (0.91,0.06,0.14) | (0.81,0.16,0.24) |
| 36 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.61,0.36,0.44) |
| 37 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.61,0.36,0.44) |
| 38 | (0.71,0.26,0.34) | (0.81,0.16,0.24) | (0.71,0.26,0.34) |
| 39 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.61,0.36,0.44) |
| 40 | (0.71,0.26,0.34) | (0.81,0.16,0.24) | (0.71,0.26,0.34) |

Interpretation and analysis:

Knowledge of the subject (CP-A): Most teachers fall into the neutrosophic categories ranging from "Average High" to "Very High". This indicates that most teachers have a solid and varied understanding of the subjects they teach, although there is a range in the depth of their knowledge.

Use of content (CP-B): The results show a predominance in neutrosophic categories such as "Very High" and "Extremely High". This reflects that teachers organize and apply the content in a highly effective manner. This suggests that the use of content in teaching practice is adapted to the needs of

students.

Curriculum Management and Assessment (CP-C): In this dimension, most teachers are classified in neutrosophic levels ranging from "Medium High" to "Very High". This shows that, although most teachers manage curriculum planning and assessment well, there is some variability and indeterminacy in the effectiveness of their curriculum management.

Taken together, these results provide a clear view of teachers' performance in terms of knowledge, content application and curriculum management. Most of them are at high levels, reflecting a generalized competence, although with some indeterminations in the depth and effectiveness in each dimension. Therefore, it is necessary to resort to the analysis of $CV_{ND}$ these dimensions and determine which one has the greatest impact on the variable to determine the planned solutions (see table 4).

**Table 4:** Determination of $\bar{L}$, $S_N$ and $CV_N$ of each dimension in the professional competencies variable. Source: Own elaboration.

| Professional skills | L | | S N | CV N |
|---|---|---|---|---|
| CP-A | 0.76 | [(0.61,0.36,0.44);(0.71,0.26,0.34)] | 0.005 | 0.072 |
| CP-B | 0.92 | [(0.81,0.16,0.24);(0.91,0.06,0.14)] | 0.002 | 0.043 |
| CP-C | 0.78 | [(0.61,0.36,0.44);(0.71,0.26,0.34)] | 0.005 | 0.069 |

From the results obtained, it can be seen that the *teaching management competencies dimension* has the most consistent performance among the other dimensions with a value of 0.043. While, on the contrary, the *subject competencies dimension* contains a greater indeterminacy in the professional development process with a value of 0.072. Therefore, the results obtained from the variable should be enhanced by including the indeterminate elements that exist for the development of professionals.

**Metacognitive strategies.**

Finally, the variable of metacognitive strategies was evaluated in 40 teachers, by applying a neutrosophic measurement. For the comprehensive assessment, three fundamental dimensions were defined: expectations towards students, pedagogical strategies, and affectivity in the learning environment. Thus, it allowed the incorporation of indeterminacy in the final evaluation, by offering a more complete and precise vision of the educational dynamics (see table 5).

**Table 5:** Neutrosophic evaluation of each dimension belonging to the metacognitive strategies variable. Source: Own elaboration.

| Teaching | EM-A | EM-B | EM-C |
|---|---|---|---|
| 1 | (0.71,0.26,0.34) | (0.81,0.16,0.24) | (0.71,0.26,0.34) |
| 2 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.51,0.46,0.54) |
| 3 | (0.81,0.16,0.24) | (0.75,0.25,0.1) | (0.71,0.26,0.34) |
| 4 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.61,0.36,0.44) |
| 5 | (0.71,0.26,0.34) | (0.71,0.26,0.34) | (0.71,0.26,0.34) |
| 6 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.51,0.46,0.54) |
| 7 | (0.81,0.16,0.24) | (0.71,0.26,0.34) | (0.71,0.26,0.34) |
| 8 | (0.71,0.26,0.34) | (0.81,0.16,0.24) | (0.51,0.46,0.54) |
| 9 | (0.61,0.36,0.44) | (0.71,0.26,0.34) | (0.71,0.26,0.34) |
| 10 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.61,0.36,0.44) |
| 11 | (0.71,0.26,0.34) | (0.71,0.26,0.34) | (0.71,0.26,0.34) |
| 12 | (0.81,0.16,0.24) | (0.81,0.16,0.24) | (0.51,0.46,0.54) |
| 13 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.71,0.26,0.34) |
| 14 | (0.71,0.26,0.34) | (0.71,0.26,0.34) | (0.61,0.36,0.44) |

| Teaching | EM-A | EM-B | EM-C |
|---|---|---|---|
| 15 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.71,0.26,0.34) |
| 16 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.51,0.46,0.54) |
| 17 | (0.81,0.16,0.24) | (0.71,0.26,0.34) | (0.71,0.26,0.34) |
| 18 | (0.71,0.26,0.34) | (0.81,0.16,0.24) | (0.61,0.36,0.44) |
| 19 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.51,0.46,0.54) |
| 20 | (0.61,0.36,0.44) | (0.71,0.26,0.34) | (0.71,0.26,0.34) |
| 21 | (0.71,0.26,0.34) | (0.81,0.16,0.24) | (0.51,0.46,0.54) |
| 22 | (0.81,0.16,0.24) | (0.71,0.26,0.34) | (0.71,0.26,0.34) |
| 23 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.61,0.36,0.44) |
| 24 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.51,0.46,0.54) |
| 25 | (0.71,0.26,0.34) | (0.71,0.26,0.34) | (0.71,0.26,0.34) |
| 26 | (0.81,0.16,0.24) | (0.71,0.26,0.34) | (0.71,0.26,0.34) |
| 27 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.61,0.36,0.44) |
| 28 | (0.71,0.26,0.34) | (0.81,0.16,0.24) | (0.71,0.26,0.34) |
| 29 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.51,0.46,0.54) |
| 30 | (0.81,0.16,0.24) | (0.71,0.26,0.34) | (0.71,0.26,0.34) |
| 31 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.61,0.36,0.44) |
| 32 | (0.71,0.26,0.34) | (0.71,0.26,0.34) | (0.71,0.26,0.34) |
| 33 | (0.81,0.16,0.24) | (0.81,0.16,0.24) | (0.51,0.46,0.54) |
| 34 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.71,0.26,0.34) |
| 35 | (0.71,0.26,0.34) | (0.71,0.26,0.34) | (0.61,0.36,0.44) |
| 36 | (0.81,0.16,0.24) | (0.81,0.16,0.24) | (0.71,0.26,0.34) |
| 37 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.51,0.46,0.54) |
| 38 | (0.71,0.26,0.34) | (0.71,0.26,0.34) | (0.71,0.26,0.34) |
| 39 | (0.81,0.16,0.24) | (0.81,0.16,0.24) | (0.51,0.46,0.54) |
| 40 | (0.61,0.36,0.44) | (0.81,0.16,0.24) | (0.71,0.26,0.34) |

Interpretation and analysis:

Expectations of Students (EM-A): Most teachers fall into the neutrosophic categories of "Average High" to "High." This suggests that, overall, teachers show a strong commitment to student expectations, albeit with some variability.

Teaching strategies (EM-B): The results indicate predominance in the neutrosophic categories "Medium High" and "High", which reflects the effective application of teaching strategies by teachers.

Classroom Affectivity (EM-C): Teachers are at neutrosophic levels of "Medium High" to "High", which shows effective management of the classroom environment and interactions with students, although with some variations in effectiveness.

Therefore, it is necessary to determine and analyze the dimensions of the $CV_{ND}$ metacognitive strategies variables. This seeks to evaluate the levels of uncertainty and include them in the planned solutions (see table 6)

**Table 6:** Determination of $\bar{L}$, $S_N$ and $CV_N$ of each dimension in the metacognitive strategies variable. Source: Own elaboration.

| Metacognitive strategies | L | | S N | CV N |
|---|---|---|---|---|
| EM-A | 0.77 | [(0.61,0.36,0.44);(0.71,0.26,0.34)] | 0.007 | 0.081 |
| EM-B | 0.85 | [(0.71,0.26,0.34);(0.81,0.16,0.24)] | 0.004 | 0.062 |
| EM-C | 0.71 | [(0.61,0.36,0.44);(0.71,0.26,0.34)] | 0.008 | 0.087 |

From the results obtained, it is observed that the *teaching strategies dimension (EM-B)* presents the most consistent performance among the dimensions evaluated, with a value of 0.062. In contrast, the

*affectivity dimension in the classroom (EM-C) shows greater indeterminacy in the process of applying* metacognitive strategies, with a value of 0.087. Therefore, the results obtained in the variable must be strengthened by integrating the indeterminate elements present to optimize the development and effectiveness of metacognitive strategies.

### 3.2.3 Correlation between professional competences and metacognitive strategies.

To carry out the correlation analysis, the neutrosophic values of the evaluations carried out by the teachers for the variable professional competences and metacognitive strategies must be converted (see table 7). To do this, these values are deneutrosified according to the Basset equation. In this way, the correlation between both variables can be analyzed (see table 8).

**Table 7:** Teachers' evaluation of the variables professional competencies and metacognitive strategies . Source: Own elaboration.

| Teaching | Professional skills | Metacognitive strategies |
|---|---|---|
| 1 | (0.94,0.15,0) | (0.94,0.15,0) |
| 2 | (0.94,0.15,0) | (0.74,0.35,0.25) |
| 3 | (0.74,0.35,0.25) | (0.74,0.35,0.25) |
| 4 | (0.94,0.15,0) | (0.74,0.35,0.25) |
| 5 | (0.94,0.15,0) | (0.94,0.15,0) |
| 6 | (0.94,0.15,0) | (0.74,0.35,0.25) |
| 7 | (0.94,0.15,0) | (0.94,0.15,0) |
| 8 | (0.94,0.15,0) | (0.74,0.35,0.25) |
| 9 | (0.74,0.35,0.25) | (0.74,0.35,0.25) |
| 10 | (0.94,0.15,0) | (0.74,0.35,0.25) |
| 11 | (0.94,0.15,0) | (0.94,0.15,0) |
| 12 | (0.94,0.15,0) | (0.94,0.15,0) |
| 13 | (0.94,0.15,0) | (0.94,0.15,0) |
| 14 | (0.94,0.15,0) | (0.74,0.35,0.25) |
| 15 | (0.94,0.15,0) | (0.94,0.15,0) |
| 16 | (0.94,0.15,0) | (0.74,0.35,0.25) |
| 17 | (0.94,0.15,0) | (0.94,0.15,0) |
| 18 | (0.94,0.15,0) | (0.94,0.15,0) |
| 19 | (0.94,0.15,0) | (0.74,0.35,0.25) |
| 20 | (0.94,0.15,0) | (0.74,0.35,0.25) |
| 21 | (0.74,0.35,0.25) | (0.74,0.35,0.25) |
| 22 | (0.94,0.15,0) | (0.94,0.15,0) |
| 23 | (0.94,0.15,0) | (0.74,0.35,0.25) |
| 24 | (0.94,0.15,0) | (0.74,0.35,0.25) |
| 25 | (0.94,0.15,0) | (0.94,0.15,0) |
| 26 | (0.74,0.35,0.25) | (0.94,0.15,0) |
| 27 | (0.74,0.35,0.25) | (0.74,0.35,0.25) |
| 28 | (0.94,0.15,0) | (0.94,0.15,0) |
| 29 | (0.94,0.15,0) | (0.74,0.35,0.25) |
| 30 | (0.74,0.35,0.25) | (0.94,0.15,0) |
| 31 | (0.94,0.15,0) | (0.74,0.35,0.25) |
| 32 | (0.74,0.35,0.25) | (0.94,0.15,0) |
| 33 | (0.94,0.15,0) | (0.94,0.15,0) |
| 34 | (0.74,0.35,0.25) | (0.94,0.15,0) |
| 35 | (0.94,0.15,0) | (0.74,0.35,0.25) |
| 36 | (0.74,0.35,0.25) | (0.94,0.15,0) |

| Teaching | Professional skills | Metacognitive strategies |
|---|---|---|
| 37 | (0.74,0.35,0.25) | (0.74,0.35,0.25) |
| 38 | (0.94,0.15,0) | (0.94,0.15,0) |
| 39 | (0.74,0.35,0.25) | (0.94,0.15,0) |
| 40 | (0.94,0.15,0) | (0.94,0.15,0) |

**Table 8:** Pearson correlation of the variables $L^X$ y $L^Y$. Source: Own elaboration.

| | $S^2$ | $Cov(L^X, L^Y)$ | r |
|---|---|---|---|
| $L^X$ | 0.0012564 | - | |
| $L^Y$ | 0.0007477 | - | 0.913 |
| - | - | 0.001 | |

Metacognitive strategies reveals a positive and significant relationship with a correlation coefficient of 0.913. This result validates the research hypothesis and rejects the null hypothesis, indicating that as professional competences are strengthened, teachers' metacognitive strategies improve. However, the neutrosophic relationship between variables and dimensions with indeterminate elements must be included:

1. Subject knowledge (CP-A) and teaching strategies (EM-B):
   - Variability in depth of knowledge: The knowledge dimension of the topic shows that most teachers have a solid understanding, although with variations in depth. This variability can directly influence the teaching strategy. Teachers with deeper knowledge implement more effective and tailored strategies, while those with less depth would face difficulties in applying the strategies optimally.
2. Use of content (CP-B) and expectations towards students (EM-A):
   - Adaptability and engagement: A predominance of neutrosophic categories of content use indicates that teachers implement and organize content effectively. This ability to adapt to student needs is linked to expectations for students. A high level of expectations generally translates into better adaptation and use of content, as teachers adjust their approach according to student expectations and needs.
3. Curriculum management and evaluation (CP-C) and affectivity in the classroom (EM-C):
   - Efficiency of classroom management and environment management: The curriculum management and assessment dimension shows good planning and assessment with some variability in its effectiveness. This indeterminacy is related to affectivity in the classroom. Therefore, effective management of the environment and interactions with students improves the effectiveness of planning and assessment. It even facilitates a more coherent and adapted implementation of the curriculum plans.
4. Knowledge of the subject (CP-A) and expectations towards students (EM-A):
   - Depth of knowledge and engagement: Strength of subject knowledge influences expectations for students. Deeper knowledge enables teachers to set higher, more realistic expectations for students based on a thorough understanding of the topics and content. This, in turn, leads to greater clarity and consistency in the expectations set.
5. Use of content (CP-B) and affectivity in the classroom (EM-C):
   - Effective implementation and classroom environment: Effective use of content contributes to better management of the classroom environment, since teachers who implement content appropriately tend to better manage interactions and classroom climate, facilitating a positive and productive learning environment.

The dimensions analyzed show interdependent relationships with each other. Indeterminacy in the depth of knowledge, the ability to use and adapt content, curricular management, and affectivity in the classroom are all interrelated. These relationships highlight how different aspects of teaching practice mutually influence and affect student development and performance. Consequently, it reinforces the need for professional competences in optimizing teacher training, improving pedagogical intervention, and fostering socio-cognitive skills, critical reflection, and creativity.

## 4. Conclusion

Once the investigation was concluded, the following conclusions could be reached:

Analysis based on the neutrosophic statistical method has revealed that UNMSM teachers mostly exhibit a high level of professional competence, particularly in terms of pedagogical management. However, significant variations have been identified in the areas of subject knowledge and curricular management. These observations suggest the need for targeted interventions to strengthen training in these specific areas and thus improve the homogeneity of teaching performance.

Metacognitive strategies by teachers have shown a positive trend, especially in the adaptation of teaching strategies. However, the neutrosophic analysis also reveals a high variability in the affective dimension in the classroom. Thus, it indicates the need to improve training in the management of emotional and social aspects of the educational environment to optimize teaching effectiveness.

The correlation between professional competences and metacognitive strategies, assessed using the neutrosophic method, has shown a positive overall relationship. However, the observed variability suggests that, although there is a significant connection between the domain of the variables, efforts should be intensified to achieve a more consistent integration and optimize the impact on the educational process.

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