Neutrosophic model to determine the degree of comprehension of higher education students in Ecuador

Jesús Estupiñan Ricardo[1], María Elena Llumiguano Poma[2], Alexandra Maribel Argüello Pazmiño[3], Andrea Daniela Albán Navarro[4], and Lissette Martín Estévez[5], Noel Batista Hernandez.

[1] Research Professor, Universidad Técnica de Babahoyo, Ecuador. E-mail: jestupinan2728@gmail.com
2 Research Professor, Universidad Estatal de Bolívar, Ecuador. E-mail: helenmary86@yahoo.es
3 Research Professor, Universidad Estatal de Bolívar, Ecuador. E-mail: alex_yta05@hotmail.com
4 Research Professor, Universidad Técnica de Babahoyo, Ecuador. E-mail: aalban@utb.edu.ec
5 Research Professor, Universidad Técnica de Babahoyo, Ecuador. E-mail: lmartin@utb.edu.ec
6 Research Professor, Universidad de Guayaquil, Ecuador. E-mail: noel.batistah@ug.edu.ec

Abstract. In the process of comprehension, the previous knowledge possessed by the individuals are used to infer the meaning of certain thing, this process is fundamental for the development of the abilities and skills of the students. Neutrosophy and in particular a model based on neutrosophic sets, using results obtained through linguistic terms, are used to determine the degree of comprehension that higher education students should have. Therefore, the objective pursued in this paper is to determine the degree of understanding that higher education students in Ecuador have, in order to favor the teaching-learning process, with the specific goal of finding, from a critical perspective, new teaching goals based on a better understanding of the processes involved in understanding, in order to incorporate them into the educational teaching process.

Keywords: Comprehension, teaching-learning, Neutrosophy, teaching - educational process, abilities, skill

1 Introduction

Understanding is considered a basic competence within existing educational models. It constitutes an approach to the teaching-learning process based on competencies and performances, associated with constructivist theories.

From Quispe Santos' point of view, the capacity to understand accompanies us throughout our existence and represents one of the most significant expressions of human knowledge. There are ideological antecedents that correspond to the process of teaching comprehension.

The process of understanding is not about innovative proposals, but rather it has solid foundations in experts on the learning of recent times. Essentially, comprehension constitutes a critical factor that affects learning, plays a fundamental role with the mental state, and in particular, with the intelligence and capacity that individuals have to learn and retain information, as well as the fact that it continues in constant education and training. This is achieved when we have quality educators, better curricular proposals, and new and efficient pedagogical. [1]

Understanding means being able to go beyond what has been learned, to operate with knowledge in new situations in order to solve problems. According to [2], the process of comprehension implies producing a certain number of activities in order to achieve higher levels of comprehension.

The aforementioned author states that comprehension is necessary to facilitate knowledge. This approach requires a group of activities that help to achieve a flexible performance, and go beyond the information provided.

Activities that teachers propose to students for greater understanding when using the content for learning are those referred by , highlighting the explanation, exemplification, application, justification, comparison and contrast, contextualization and generalization of content. The deficiencies in the retention, comprehension and active use of knowledge in the teaching-learning process are those that are defined by different studies, highlighting those of Gardner, where it exposes the students' comprehension as the center of the mentioned deficiencies, since a true Higher Education according to[3] includes the constant evaluation and reformulation of each process in order to guarantee an efficient comprehension.

Refers [4], that the main deficiencies associated with comprehension are those presented through fragile knowledge in students, denoting that they do not remember, do not understand or do not actively use part of what they have supposedly learned. Also, poor knowledge constitutes a deficiency associated with comprehension, it is shown at the moment when students do not know how to think using what they know. To contribute to improve

these deficiencies, Gardner [5], in his theory of multiple intelligences, proposes guidelines to represent multiple forms of a given knowledge.

The comprehension approach is a characteristic that is translated into human behavior, which has led many researchers of the subject to delve into analyzing the factors that intervene in behavior. With respect to this approach, models have been developed that approximate a classification of the different characteristics implicit in the understanding of higher education students in Ecuador.

In order to measure the students' comprehension, it is required to have information related to the phenomenon of study. The information that is available, on occasions, for such measurement is imprecise, reason why it is necessary the construction of models based on the human reasoning, because of these reasons is that the use of Neutrosophy is proposed in this work. Specifically, neutrosophic logic, which is useful to describe an imprecise logical system, based on neutrosophic subsets by means of linguistic variables.

2 Preliminaries

2.2 Neutrosophy Theory

Neutrosophy [6, 7] is theory developed for dealing with indeterminacy in real world. The truth value in neutrosophic set is as follows [8]:

Let N be a set defined as:
$$N = \{(T, I, F) : T, I, F \subseteq [0, 1]\} \tag{1}$$

Moreover a neutrosophic valuation n is a mapping from the set of propositional formulas that is for each sentence p we have
$$v(p) = (T, I, F) \tag{2}$$

To facilitate the real world applications of neutrosophic set and set-theoretic operators single valued neutrosophic set (SVNS) [9] was developed

A single valued neutrosophic set (SVNS) has been defined as follows [9]:

Definition 1. Let X be a universe of discourse. A single valued neutrosophic set A over X is an object having the form:
$$A = \{\langle x, (x), r(x), vA(x)\rangle : x \in X\} \tag{3}$$

where $u_A(x): X \to [0,1]$, $r_A(x), : X \to [0,1]$ and $v_A(x): X \to [0,1]$ with $0 \leq u_A(x) + r_A(x) + v_A(x) \leq 3$ for all $x \in X$. The intervals $u_A(x)$, $r_A(x)$ y $v_A(x)$ denote truth- membership degree, indeterminacy-membership degree and falsity membership degree of x to A, respectively.

Single valued neutrosophic numbers (SVN number) is denoted by $A = (a,b,c)$, where $a,b,c \in [0,1]$ and $a+b+c \leq 3$.

2.2 Neutrosophic Inference

Neutrosophic logic is based on linguistic rules dictated by experts [10], in order to treat the indeterminacy in a systematic way, but not entirely quantitative, because the key elements of human thought are not numbers, but concepts that can be represented by neutrosophic sets such as "high", "very high", "very high".[11]

Neutrosophic logic uses granulation, which is defined by Zadeh [12], as the use of words seen as a form of neutrosophic quantification. Neutrosophic logic makes use of the theory of neutrosophic con-joint, in order to give a degree of membership or belonging to its linguistic variables, which allows accepting a partial membership to certain sets, which are generalized with the theory of classical sets [8].

In order to model information, the neutrosophic inference [13]is used, which is the process of mapping input variables to an output space based on a mechanism of neutrosophic logic understood by the If-Then rules, the functions of belonging and the neutrosophic logical operators.

In an inference process a a typical deneutrosophicated value [14] denoted $den(T_B(y))$ by the centroid or center of gravity method which is given below [15]:
$$den(T_B(y)) = \frac{\int_a^b T_b(y)y\,dy}{\int_a^b T_b(y)\,dy} \tag{4}$$

Based on the above, the neutrosophic model is established to determine the degree of comprehension of higher education students in Ecuador. The model allows the use of different functions of belonging; in particular, the

trapezoidal function, given that its main advantage lies in the margin of tolerance around the value that is taken as most representative of the linguistic value associated with the neutrosophic set [16], as well as the center of gravity of the neutrosophic set[3] .

3 Proposed Model

The neutrosophic model proposed in this paper is presented in Figure 1. The model consists of four stages: data collection, Neutrosification, Neutrosophic inference rules and De - Neutrosification.
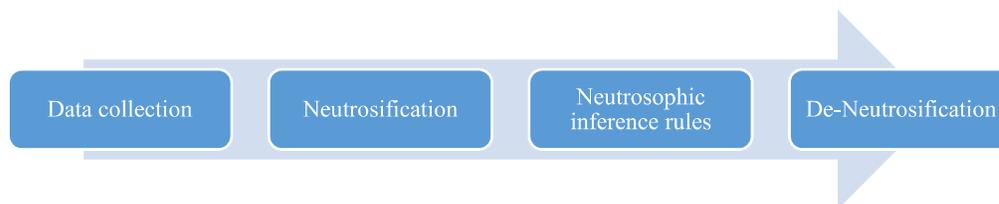
Figure 1: Proposed model. Source: Prepared by the authors.

The phases of the model are described below:

1. Data collection
A sample of 120 students of higher level was used, to them were applied the technique of observation of the activities that they carry out in their performance of pre-professional practices, to evaluate the understanding of the learning they have and their performance as future professionals. The process of classifying the learning was carried out according to the dimensions proposed by the psychologist Ausubel [17], which are:
- The way in which the informative material is presented to the student

- How the student incorporates information into his or her cognitive structure

The dimensions referred to have different types of learning are:
- Receptive learning
- Learning by discovery
- Repetitive or memoiristic learning
- Meaningful learning
According to the types of learning, the results are obtained by applying the technique of observation of the activities they carry out in their performance of pre-professional practices, in order to evaluate their understanding of the learning they have and their performance as a future professional [3].

2. Neutrosification
Neutrosification is performed once the data has been obtained, in order to define the linguistic variables and values, as well as the function of belonging to perform Neutrosification [18]. The linguistic variables identified are the types of learning related to the dimensions proposed by the psychologist Ausubel,[19].

3. Neutrosophic Inference Rules
Neutrosophic inference rules allow establishing a categorization, that is, the possibility of detecting a certain type of behavior pattern, which in this case represents the most significant or representative type of learning of students in accordance with the understanding of learning in higher education in Ecuador. This rule is based on the technique of observation of the activities they carry out in their performance of pre-professional practices.
The proposed neutrosophic model obeys a type of structure that is modeled based on the definition of a set of rules of the form:

$$\text{Si } X1 = A1 \text{ y } X2 = A2 \text{ y } \dots \dots \text{ y } Xn = An \text{ then } Z = B. \tag{5}$$

Where both the values of the linguistic variables of the antecedent (X_1, X_2,...Xn) and of the consequent (Z) are neutrosophic sets, in essence, linguistic results with associated semantics.
4. De - Neutrosification
The "De - Neutrosification" carries out the process of adapting the neutrosophic values generated in the inference, in this process the center of Gravity Method (COG) is used (Eq. 2).
With the De - Neutrosification the value y' is determined for the output variable, which has a maximum in its function of belonging B', if there is more than one maximum value in the function of belonging the average of them is taken.

3 Case Study

Based on the model proposed in Figure 1, the results shown in Table 1 are obtained from the data collection phase.

Receptive learning	Learning by discovery	Repetitive or memoiristic learning	Meaningful learning
5	5	0	0
6	7	1	4
8	10	4	5
9	8	5	7
10	7	2	12
11	10	10	12
9	11	16	18
9	15	12	13
9	16	14	12
12	19	12	15
9	2	10	9
7	6	14	10
5	1	13	2
6	2	5	1
5	1	2	0
120	120	120	120

Table 1: Results obtained when applying the technique of observation of the activities they carry out in their performance of pre-professional practices, to evaluate the understanding of learning. Source Own elaboration.

The following linguistic variables were identified in the Neutrosification process:

receptive: REAL

discovery: REAL

memoiristic: REAL

significant: REAL

NEUTROSIFICATION

TERM vh: = (0.85, 0) (0.9, 1) (1, 1)

TERM lo: = (0.4, 0) (0.45, 1) (0.55, 1) (0.55, 0)

TERM me: = (0.5, 0) (0.55, 1) (0.75, 1) (0.8, 0)

TERM hi: = (0.75, 0) (0.8, 1) (0.85, 1) (0.9, 0)

The inference of neutrosophic rules were considered the 4 types of learning and 4 linguistic values (very low, low, medium, high) being obtained:

Rules for very high style (vh)

IF (receptive IS vh AND discovery IS NOT vh AND memoiristic IS NOT vh AND significant IS NOT vh) THEN receptive-learning IS vh

Rules for high style (hi)

IF (receptive IS hi AND discovery IS NOT hi AND memoiristic IS NOT hi AND significant IS NOT hi AND discovery IS NOT vh AND memoiristic IS NOT vh AND significant IS NOT vh) THEN receptive-learning IS hi

Rules for the medium style (me)

IF (receptive IS NOT me AND discovery IS NOT me AND memoiristic IS NOT me AND significant IS NOT me AND discovery IS NOT vh AND memoiristic IS NOT vh AND significant IS NOT vh AND discovery IS NOT hi AND memoiristic IS NOT hi AND significant IS NOT hi) THEN receptive-learning IS me

Rules for low style (lo)

IF (receptive IS lo AND discovery IS NOT me AND memoiristic IS NOT me AND significant IS NOT me AND discovery IS NOT vh AND memoiristic IS NOT vh AND significant IS NOT vh AND discovery IS NOT NOT hi AND memoiristic IS NOT hi AND significant IS NOT hi AND discovery IS NOT lo AND memoiristic IS NOT lo AND significant IS NOT lo) THEN receptive-learning IS lo

Rules for very high styles (vh)
IF (receptive IS vh AND discovery IS vh AND memoiristic IS NOT vh AND significant IS NOT vh) THEN learning_e_Discovery IS vh;

Rules for very high styles (vh)
IF (receptive IS ma AND discovery IS ma AND memoiristic IS ma AND significant IS NOT ma) THEN receptive-discovery-memoristic-learning IS vh;

Rules for very high styles (vh)
IF (receptive IS vh AND discovery IS vh AND memoristic IS vh AND significant IS vh) THEN recepetive-discovery-memoristic-significant-learning IS vh;
The result of the De - Neutrosification are shown below:

Output Variables

receptive_learning: REAL;

discovery_learning: REAL;

memorial_learning: REAL;

cognitive_learning: REAL;

recptive_discovery_learning: REAL;

memorial_receptive_learning: REAL;

significant_receptive_learning: REAL;

Receptive_ memoristic_learning: REAL;

Significant _discovery_learning: REAL;

Significant_memoristic_learning: REAL;

receptive _memoristic_discovery_learning: REAL;

receptive_ significant_discovery: REAL;

Significant_memoristic_learning: REAL;

receptive_ significant_memoristic_discovery_learning: REAL;

receptive_ significant_memoristic_discovery_learning: REAL;

Based on the inference made and the definition of the output variables, the De - Neutrosification shown below corresponds to the case of receptive learning.
De-Neutrosification - receptive_learning

TERM vg := (0.3, 1) (0.4, 1) (0.45, 0);

TERM lo := (0.4, 0) (0.45, 1) (0.5, 1) (0.55, 0);

TERM me := (0.5, 0) (0.55, 1) (0.75, 1) (0.8, 0);

TERM hi := (0.75, 0) (0.8, 1) (0.85, 1) (0.9, 0);

TERM vh := (0.85, 0) (0.9, 1) (1, 1);

METHOD : COG;

DEFAULT := 0.3;

RANGE := (0.3 .. 1);

For "De - Neutrosification" the center of gravity is used, which implies that the value to be obtained for the type of receptive learning is located in the center of the range of belonging. Table 2 shows a summary of the types of learning predominantly after applying the neutrosophic model, obtained in the students, according to the technique of observation of the activities they carry out in their performance of pre-professional practices.

Number of Students	Type of apprenticeships with the observation technique	Types of learning with the proposed model	Degree of belonging to the type of learning
22	Discovery	Discovery	High
19	Significant	Significant	High
17	Discovery	Memoristic Discovery	Very High
10	Discovery	Memoristic Significant	Medium
9	Memoristic	Memoristic	High
7	Receptive	Significant Discovery	Medium
4	Significant	Memoristic Significant	Very High
4	Discovery	Memoristic Significant	High
3	Receptive	Receptive	Medium
3	Receptive	Receptive Discovery	Medium
2	Memoristic	Receptive	Medium
2	Memoristic Receptive	Memoristic	Very High
2	Significant Discovery	Memoristic Discovery	Very High
2	Memoristic Discovery	Memoristic Discovery	High
2	Memoristic	Memoristic Discovery	High
2	Memoristic Discovery	Memoristic Discovery	High
2	Significant	Significant	Medium
2	Memoristic	Receptive Discovery	Medium
3	Memoristic	Memoristic Significant	Medium
3	Memoristic Significant	Memoristic Significant	Medium

(63)

Table 2: Comparative summary of the types of learning. Source Prepared by the authors

Conclusion

In the present work, we made an identification of the understanding of learning as a psychological element that affects the teaching-learning process of higher level teachers. Neutrosophy was used and, in particular, a neutrosophic model was created to determine the degree of understanding of learning among higher education students in Ecuador.

With the neutrosophic model, a classification of the neutrosophic inference was carried out through the model, in addition to classifying the types of learning for the comprehension of learning in students at the higher level, it allows determining the degree of belonging of the types of learning or the predominant types of learning.

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