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Plithogenic Iadov model to study university teaching practices in the complexity of the educational process of comprehensive training by competencies

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Abstract. Teaching practices constitute a dynamic performance with the capacity for transformation, the evolution of human consciousness, autonomy, leadership and conscious commitment to strategic intervention with a holistic vision in the process of teaching and educating that generates emotionally healthy spaces to "learn to learn", to do, to coexist, to be and to undertake the student. In this context, the article reports research that had the purpose of measuring and modeling the meanings of university teaching practices in the complexity of the educational process of comprehensive competency training. To do this, 25 professors from Latin American universities were surveyed regarding the impact of today's university graduates in the region on social life, technology, and entrepreneurship. The plithogenic Iadov technique was introduced to process the data, where the Iadov logic chart becomes mainly Plithogenic Inconsistent Picture Fuzzy Numbers. We consider that the theory of plithogeny makes a formal approach to complex phenomena because it generalizes dynamic systems.

Keywords: University teaching, educational process, training by competencies, Iadov technique, plithogenic Iadov technique, plithogenic inconsistent picture fuzzy set.

1 Introduction

University teaching practices as a conscious dynamic performance are fundamental in the comprehensive training of students. In this sense, the complexity of the educational process in achieving the professional and human profile of students in university training requires demanding preparation with a holistic vision of education, under a multilevel-multidimensional perspective.

Holistic education in vocational training is a challenge that must consider humanistic, scientific, and technological aspects, while also adapting to the context, future challenges, trends, and new educational perspectives. This approach combines integrity and quality in education; harmonizing their work on the principles of knowing how to learn, knowing how to do, knowing how to live together, knowing how to be, and knowing how to undertake with the permanent implementation of pedagogy by example.

Despite the diversity and complexity of the context in which the educational process moves, universities continue to be transmitters, consumers, and reproducers of knowledge on a large scale, but today they need to change their own academic and administrative structures to respond to the demands and requirements of a society in permanent evolution.

The educational process on the competency-based training curricular approach is encouraged to educate in diversity and complexity, learn in contexts of knowledge application, and tend towards human and professional training that allows combining other branches of knowledge, in such a way that it ensures the development of a consistent platform for understanding the problems that the future professional will have to solve. In this context, the epistemology of complexity as a reform for thought implies supporting an integrative vision that avoids the reduction, disjunction, and separation of knowledge.

From this perspective, the competency-based approach represents important challenges, since it implies a break with practices, ways of being, thinking, and feeling from rationality in which it is conceived that the function of the university is to teach, reproduce forms of life, culture, and ideology of content-laden studies and the teaching of theory without practice. Education must promote the training of people whose interaction with social reality leads them to build knowledge for a healthy lifestyle.

University teaching practices are a great responsibility that will allow students to have skills and abilities for research, development, innovation, and entrepreneurship (R+D+i+e). In this context, the meaning of university teaching practices is summarized as professionalism, which carries a particularly relevant meaning, on the one hand, effectiveness, and on the other hand, efficiency in the exercise of good teaching. That is why teaching requires a combination of skills, challenges, and knowledge; mainly, it requires curiosity and motivation, to be more competitive every day.

This paper aims to offer a logical-mathematical model to measure and model the complexity involved in university teaching practice by competencies in the Latin American context. To this end, we turn to Plithogeny, which is a theory that emerged from Neutrosophy, and which generalizes it. What is more, it is the theory that generalizes the dynamics of a phenomenon <A> against <AntiA> and includes in the dynamics <NeutA> of what is neither <A> nor <AntiA>. In addition to its interaction with other elements <B>, <NeutB>, and <AntiB>, among others that are necessary ([1]). That is, this is a new formal approach to modeling complex phenomena.

In this sense, 25 university professors were chosen, taking as criteria the experience in the practice of university teaching with two or more years in Latin American public universities. For the first time, it is used the Iadov logic table technique hybridized with the Plithogeny, although the neutrosophic Iadov technique already exists ([2]).

Iadov's technique constitutes an indirect way to study satisfaction when performing certain activities ([3]). It is based on the analysis of a questionnaire that has a specific internal structure that is unknown to the interviewee. The internal structure of the questionnaire follows a relationship between three closed questions and the subsequent analysis of other open questions. The relationship between closed questions is established through the so-called "Iadov Logical Chart". This technique and its generalizations have been used in studies carried out in the field of pedagogy [3-7].

The Neutrosophic Iadov converts the scalar numerical elements of the Iadov Logic Chart into neutrosophic numbers ([8-12]). Therefore, with the plithogenic Iadov technique we convert these elements into plithogenic neutrosophic numbers, especially the Plithogenic Inconsistent Picture Fuzzy Numbers (PIPFN) ([13]). PIPFN are types of Refined Neutrosphic Numbers where the indeterminacy I is split into I_1 as indeterminacy in general and I_2, as indeterminacy due to refusal [14-15]. We specifically use these numbers because they have applications in voting where there is abstention. The closed questions consist of determining the opinion of the respondents regarding how they perceive the impact of teaching by competencies through the imprint of graduates from Latin American universities today, in social life, in their levels of entrepreneurship, and technology.

The advantage offered by a plithogenic Iadov logic chart is that it can be studied with a tool designed to generalize the dynamics, about the behavior of the impact of Latin American pedagogy on important aspects of the societies of the region. In addition, it allows us to measure the current situation.

The article has a Materials and Methods section where the Iadov technique and basic notions of the Plithogeny theory are presented. The Results section contains the details of the plithogenic Iadov model and the results of the survey. The last section is dedicated to conclusions.

2 Materials and Methods

We begin this section by explaining the basic notions of plithogeny, to end it with the details of the Iadov technique.

Let U be a universe of discourse, and P a non-empty set of elements $P \subseteq U$ ([16-20]). Let A be a non-empty set of *one- dimensional attributes* $A = \{\alpha_1, \alpha_2, \dots, \alpha_m\}$, $m \geq 1$; and $\alpha \in A$ let be a given attribute whose spectrum of all possible values (or states) is the non-empty set S, where S can be a discrete finite set, $S = \{s_1, s_2, \dots, s_l\}$ $1 \leq l < \infty$, or infinitely countable set $S = \{s_1, s_2, \dots, s_\infty\}$, or infinitely uncountable (continuous) set $S =]a, b[$, $a < b$ where] ... [is an open, semi-open, or closed interval of the set of real numbers or another general set.

Let V be a non-empty subset of S, where V is the range of all attribute values needed by experts for their application. Each element $x \in P$ is characterized by the values of all attributes in $V = \{v_1, v_2, \dots, v_n\}$, for $n \geq 1$.

In the set of attribute values V, in general, there is a dominant attribute value, which is determined by experts in its application. The dominant attribute value means the most important attribute value that experts are interested in.

Each attribute value $v \in V$ has a corresponding *degree of appurtenance* $d(x, v)$ of element x, to the set P, concerning some given criteria.

The degree of membership can be a *fuzzy degree of appurtenance*, an *intuitionistic degree of appurtenance*, or a *neutrosophic degree of appurtenance* to the plithogenic set:

Therefore, the *degree of appurtenance function* is*:*

$$\forall x \in P, d: P \times V \rightarrow P([0,1]^z) \quad (1)$$

So $d(x, v)$ is a subset of $[0, 1]^z$, where $\mathcal{P}([0, 1]^z)$ is the power set of $[0, 1]^z$, where z = 1 (fuzzy degree of appurtenance), z = 2 (for the intuitionistic degree of appurtenance), or z = 3 (for the neutrosophic degree of appurtenance).

Be the cardinal $|V| \geq 1$. Let be $c: V \times V \rightarrow [0,1]$ the *fuzzy attribute value contradiction degree function* between any two attribute values v_1 and v_2, denoted by $c(v_1, v_2)$, and satisfying the following axioms:

1. $c(v_1, v_1) = 0$, the degree of contradiction between the same attribute values is zero;
2. $c(v_1, v_2) = c(v_2, v_1)$, commutativity.

One can define a fuzzy attribute value contradiction degree function (c as before, which we can denote by c_F to distinguish it from the next two), an intuitionistic attribute value contradiction degree function ($c_{IF}: V \times V \rightarrow [0,1]^2$), or more generally, a function of neutrosophic attribute value contradiction degree function ($c_N: V \times V \rightarrow [0,1]^3$) can be used increasing the complexity of the calculation, but also increasing the precision.

We mainly calculate the degree of contradiction between the values of uni-dimensional attributes. For multi-dimensional attribute values, we divide them into corresponding one-dimensional attribute values.

The degree of attribute value contradiction degree function helps the plithogenic aggregation operators and the plithogenic inclusion relation (partial order) to obtain a more accurate result.

The attribute value contradiction degree function is designed in each field where a plithogenic set is used according to the application to be solved. If ignored, aggregations still work, but the result may lose precision.

Then (P, a, V, d, c) is called a *plithogenic set*, [16]:

1. Where "P" is a set, "a" is an attribute (multidimensional in general), "V" is the range of the attribute values, "d" is the degree of appurtenance of the attribute value of each element x to the set P for some given criteria ($x \in P$), and "d" means "d_F" or "d_{IF}" or "d_N", when it is a fuzzy degree of appurtenance, an intuitionistic degree of appurtenance, or a neutrosophic degree of appurtenance, respectively of an element x to the plithogenic set P;
2. "c" means " c_F" or " c_{IF}" or " c_N", when it comes to fuzzy degree of contradiction, intuitionistic degree of contradiction, or neutrosophic degree of contradiction between the attribute values, respectively.

The functions $d(\cdot,\cdot)$ and $c(\cdot,\cdot)$ are defined according to the applications that the experts need to solve.

The following notation is used:

$x(d(x, V))$, $d(x, V) = \{d(x, v), \text{for all } v \in V\}, \forall x \in P$ where:

The attribute value contradiction degree function is calculated between each attribute value concerning the dominant attribute value (denoted by v_D) in particular, and concerning other attribute values as well.

The degree of contradiction function of the attribute value c between the attribute values is used in the definition of plithogenic aggregation operators (intersection (AND), union (OR), implication ($\Rightarrow$), equivalence ($\Leftrightarrow$), inclusion relation (order partial), and other plithogenic aggregation operators that combine two or more degrees of attribute values acting on the t-norm and the t-conorm).

Most plithogenic aggregation operators are linear combinations of the fuzzy t-norm (denoted by $\wedge_F$), and the fuzzy t-conorm (denoted by $\vee_F$), but nonlinear combinations can also be constructed.

If the t-norm is applied on the dominant attribute value denoted by v_D, and the contradiction between v_D and v_2 is $c(v_D, v_2)$, then on the attribute value v_2 it is applied:

$$[1 - c(v_D, v_2)] \cdot t_{norm}(v_D, v_2) + c(v_D, v_2) \cdot t_{conorm}(v_D, v_2) \quad (2)$$

Or, by using symbols:

$$[1 - c(v_D, v_2)] \cdot (v_D \wedge_D v_2) + c(v_D, v_2) \cdot (v_D \vee_D v_2) \quad (3)$$

Similarly, if the t- conorm is applied on the dominant attribute value denoted by v_D, and the contradiction between v_D and v_2 is $c(v_D, v_2)$, then on the attribute value v_2 it is applied:

$$[1 - c(v_D, v_2)] \cdot t_{conorm}(v_D, v_2) + c(v_D, v_2) \cdot t_{norm}(v_D, v_2) \quad (4)$$

Or, by using symbols:

$$[1 - c(v_D, v_2)] \cdot (v_D \vee_D v_2) + c(v_D, v_2) \cdot (v_D \wedge_D v_2) \quad (5)$$

The *Plithogenic Neutrosophic Intersection* is defined as:

$$(a_1, a_2, a_3) \wedge_P (b_1, b_2, b_3) = \left(a_1 \wedge_D b_1, \frac{1}{2}[(a_2 \wedge_D b_2) + (a_2 \vee_D b_2)], a_3 \vee_D b_3\right) \quad (6)$$

The *Plithogenic Neutrosophic Union* is defined as:

$$(a_1, a_2, a_3) \vee_P (b_1, b_2, b_3) = \left(a_1 \vee_D b_1, \frac{1}{2}[(a_2 \wedge_D b_2) + (a_2 \vee_D b_2)], a_3 \wedge_D b_3\right) \quad (7)$$

In other words, concerning what applies to appurtenance, the opposite applies to non-appurtenance, while in indeterminacy the average between them applies.

Next, we follow this section with the details of Iadov's modeling.

Let us begin with Iadov's logical chart as can be seen in Table 1.

Table 1: Generic Iadov logic chart with three closed questions. Source: [4].

	1. Closed question								
	No			I don't know			Yes		
2. Closed question	3.Closed question								
	Yes	I don't know	No	Yes	I don't know	No	Yes	I don't know	No
Very satisfied.	1	2	6	2	2	6	6	6	6
Partially satisfied.	2	2	3	2	3	3	6	3	6
I don't care.	3	3	3	3	3	3	3	3	3
More unsatisfied than satisfied.	6	3	6	3	4	4	3	4	4
Not at all satisfied.	6	6	6	6	4	4	6	4	5
I don't know what to say.	2	3	6	3	3	3	6	3	4

The personal and individual satisfaction scale for these activities responds to the following structure based on the score obtained:

1. Clear satisfaction with the activities,
2. More satisfied than dissatisfied,
3. Satisfaction not defined,
4. More dissatisfied than satisfied,
5. Clear dissatisfaction,
6. Contradictory.

The results are then coded according to the numbering using Table 2.

Table 2: Individual satisfaction scale. Source: [4].

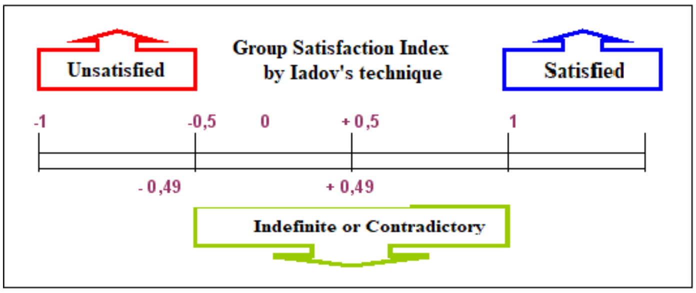
Expression	**Score**
Clear Satisfaction	1
More satisfied than dissatisfied	0.5
Not defined or Contradictory	0
More dissatisfied than satisfied	-0.5
Clear dissatisfaction	-1

To calculate the ISG (*Group Satisfaction Index*), a numerical scale is established with Equation 8 ([4]).

$$GSI = \frac{A(+1)+B(+0.5)+C(0)+D(-0.5)+E(-1)}{N} \quad (8)$$

In this formula, A, B, C, D, and E, represent the number of respondents with individual indexes 1, 2, 3 or 6, 4, 5, and where N represents the total number of respondents that the group has. The group satisfaction index fluctuates between -1 and +1. Values between -1 and -0.5 indicate dissatisfaction; those between -0.49 and +0.49 show contradiction and those that fall between 0.5 and 1 indicate that there is satisfaction. See Figure 1.

Figure 1: Linguistic interpretation of the Group Satisfaction Index. Source: [4].



3 Results

To process the data collected, the Iadov's logical chart is used, which appears in Table 1, with three closed questions:

1. Do you consider that as a result of the pedagogical models, university graduates in your country are entrepreneurs?
2. How do you perceive the influence of university graduates in your country on their social environment, as a result of pedagogical models?
3. Do you consider that as a result of the pedagogical models, university graduates in your country positively influence the technological development of your country?

Additionally, they were asked to respond to open questions that substantiated each of their answers in the closed questions in as much detail as possible.

Table 2 is replaced by Neutrosophic Numbers, most of which are Plithogenic Inconsistent Picture Fuzzy Numbers (PIPFNs) as shown in Table 3.

Table 3: Individual satisfaction scale mainly based on Plithogenic Inconsistent Picture Fuzzy Numbers.

Expression	Neutrosophic Numbers
Clear Satisfaction	(0.9, 0, 0, 0.1)
More satisfied than dissatisfied	(0.6, 0.1, 0.1,0.2)
Not Defined	(0,0,1,0)
Contradictory	(1,0,0,1)
More dissatisfied than satisfied	(0.2, 0.1,0.1, 0.6)
Clear dissatisfaction	(0.9,0,0,0.1)

PIPFNs generalize Picture Fuzzy Numbers as a special case of Refined Neutrosophic Numbers because the indeterminate component of the Neutrosophic numbers (T, I, F) is split into two elements I_1, which is indetermination as itself and I_2 which is indeterminacy due to refusal, therefore the PIPFN are of the form (T, I_1, I_2, F) that F. Smarandache defines so that they comply with the condition $T + I_1 + I_2 + F = 1$, however, we consider the condition $T + I_2 + F = 1$ such that of the Picture Fuzzy Numbers, and in addition $I_1 \in [0, 1]$ ([13, 21-23-24-25-26]). The idea of using these numbers is in their application in voting situations where abstention is included. The model we are proposing is a kind of vote of the 25 specialists surveyed on the effectiveness of the pedagogy according to its impact on the country.

Of the numbers that appear in Table 2, see that all of them satisfy the condition $T + I_1 + I_2 + F = 1$, excluding (1,0,0,1) which is not a PIPFN, we use this exception to represent the contradiction in the best possible way, which is allowed in the field of Neutrosophic Numbers.

We are based on the Refined Neutrosophic Norm (Equation 8) and Conorm (Equation 9) which are defined as below:

Given, $x = (T_A, I_{1_A}, I_{2_A}, F_A)$ and $y = (T_B, I_{1_B}, I_{2_B}, F_B)$, then:

$$x \wedge_{RN} y = \left(min(T_A, T_B), max\left(I_{1_A}, I_{1_B}\right), max\left(I_{2_A}, I_{2_B}\right), max(F_A, F_B)\right) \quad (8)$$

$$x \vee_{RN} y = \left(max(T_A, T_B), min\left(I_{1_A}, I_{1_B}\right), min\left(I_{2_A}, I_{2_B}\right), min(F_A, F_B)\right) \quad (9)$$

We use these operators conveniently combined as explained below:

1. All results with the same value on the scale in Table 2 are aggregated using the operator $\wedge_{RN}$ of Equation 8.
2. These five results are aggregated. Let us call w_1 the weight corresponding to “Clear satisfaction”, w_2 those corresponding to “More satisfied than dissatisfied”, w_3 those corresponding to “Not defined” along with the “Contradictory”, w_4 those corresponding to “More dissatisfied than satisfied”, and w_5 corresponds to “Clear dissatisfaction”.
   These weights are obtained from the survey, as the proportion among those who gave their opinion for one of those values that appears in Table 2 divided by 25. That is $w_1 = \frac{A}{N}$, $w_2 = \frac{B}{N}$, $w_4 = \frac{D}{N}$, and $w_5 = \frac{E}{N}$, in addition to $w_3 = 0$, according to the classical Iadov's technique for N = 25.
   We start by aggregating with Equation 10:

$$Agg_1 = [w_1(0.9, 0, 0, 0.1) \wedge_{RN} w_2(0.6, 0.1, 0.1,0.2)] + [w_1(0.9, 0, 0, 0.1) \vee_{RN} w_2(0.6, 0.1, 0.1,0.2)] \quad (10)$$

Then with Equation 11.

$$Agg_2 = [w_4(0.1, 0, 0, 0.9) \wedge_{RN} w_5(0.2, 0.1, 0.1, 0.6)] + [w_4(0.1, 0, 0, 0.9) \vee_{RN} w_5(0.2, 0.1, 0.1, 0.6)] \quad (11)$$

The last aggregation is obtained as:

$$Agg = (Agg_1 \wedge_{RN} Agg_2) + (Agg_1 \vee_{RN} Agg_2) \quad (12)$$

Let us remark what we consider $\alpha(T, I_1, I_2, F) = (\alpha T, \alpha I_1, \alpha I_2, \alpha F)$ for $\alpha \in [0, 1]$.

In practice the details of the survey are as follows: The information collection process was carried out through in-depth interviews with the subjects through guiding questions sent in a Google form using instant messaging resources such as WhatsApp; while others were sent through phone calls, audio recording, then these interviews were taken to Excel form and in the case of audio it was converted to mp3 with the online-audio-with-pour tool.

The results are shown in Table 4:

Table 4: Plithogenic Iadov logic chart with the results of the survey. The number of professionals who voted according to each cell appears in parentheses.

	1. Do you consider that as a result of the pedagogical models, university graduates in your country are entrepreneurs?								
	No			I don't know			Yes		
2. How do you perceive the influence of graduates from universities in your country on their social environment, as a result of pedagogical models?	3. Do you consider that as a result of the pedagogical models, university graduates in your country positively influence the technological development of your country?								
	Yes	I don't know	No	Yes	I don't know	No	Yes	I don't know	No
Very satisfied.	1**(2)**	2	6	2	2	6	6	6	6
Partially satisfied.	2**(2)**	2**(10)**	3	2	3	3	6	3	6
I don't care.	3	3	3	3	3	3	3	3	3
More unsatisfied than satisfied.	6	3	6	3	4	4	3	4	4**(4)**
Not at all satisfied.	6	6	6	6	4	4	6	4	5**(7)**
I don't know what to say.	2	3	6	3	3	3	6	3	4

From Table 4 we have $w_1 = \frac{2}{25}$, $w_2 = \frac{12}{25}$, $w_4 = \frac{4}{25}$, $w_5 = \frac{7}{25}$ in addition to $w_3 = 0$.

From Equations 10-12 we have:

$Agg_1 = (0.36, 0.048, 0.048, 0.104)$,

$Agg_2 = (0.072, 0.028, 0.028, 0.312)$,

$Agg = (0.432, 0.076, 0.076, 0.416)$.

This means that there is a 43.2% certainty that the pedagogical methods are adequate and therefore the graduates are useful to society, contributing with technology, and are entrepreneurs. There is a total indetermination of 15.2%, with 7.6% indetermination in general and the same percentage of refusal. Finally, there is a 41.6% certainty that this is not true.

Conclusion

Being a university teacher in the 21st century and the complexity of the educational process of comprehensive training by competencies, in Latin American university spaces, means understanding the great responsibility, commitment, and human and professional competence of dynamic action in the transformation, evolution of consciousness of human, autonomy, leadership and strategic intervention with a holistic vision in the comprehensive training process to “learn to learn”, learn to do, learn to live together, learn to be and learn to undertake.

This article proposes a logical-mathematical model to determine the degree of satisfaction with the objectives of university education in terms of entrepreneurship of graduates, the influence of graduates in society, and technology. To this end, we introduced the Plithogenic Iadov technique, where the logical chart of the classical Iadov technique is interpreted according to plithogenic neutrosophic numbers, most of them on a Plithogenic Inconsistent Picture Fuzzy Numbers scale, which allows the results to be interpreted as a vote.

We applied the model to a real-life case, where 25 Latin American professors were surveyed and the conclusion was reached that 43.2% think that graduates are influential in the aforementioned aspects, against 41.6% who do not, plus 15.2% of indeterminacy. That is why we recommend delving deeper into the teaching methods in force in the region to improve them and make them more effective.

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