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Model Based on Neutrosophic Ontologies for the Study of Entrepreneurship Competence

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Abstract. The entrepreneurship competence is of vital importance in the teacher training of students. It is inconceivable that citizens who are trained in schools do not have the ability to be autonomous, creative and daring, to make decisions that transform the social life in which we are immersed for the better. However, we do not always find institutions with the right education to develop this competence. That is why the aim of this article is to propose a model for the representation and obtaining of knowledge about the entrepreneurship competence in any educational system. For this end, there are neutrosophic ontologies, which is a tool to easily reflect the relationships between concepts. The use of neutrosophy allows us taking into account the truthfulness, falseness and indeterminacy of the belonging of an object to a specific set, for its evaluation and classification. To the knowledge of the authors, this is the first time that neutrosophic ontology has been used to model entrepreneurship competence.

Keywords: Entrepreneurship competence, ontology, neutrosophic ontology, education.

1 Introduction

An intention of change in education demands integrating training actions from the continuity that implies the verification, distribution and use of knowledge. It is transcendent that the learner manages diverse concepts and faces dissimilar interpretations that favor their critical thinking in the field of their reality.

Training by competencies confers the approach of the educational process from the complex and organic appreciation, which compose, knowledge, abilities, skills, attitudes and values, in synergistic interaction that makes viable the autonomous performance of the individual, by equipping him (her) with tools to create, manage, interpret, understand and transform the social environment with a proactive, holistic and innovative vision. This relevant appropriation specifies the need to develop the entrepreneurship competence in education as a contribution to the integral formation of the student, from its essence of systemic realization, which nurtures and agrees with other generic, basic and specific competences.

In this sense, the programs to develop the entrepreneurship competence in educational institutions, in general, do not educate for entrepreneurship, but rather guide about it and do not focus on skills, attributes and competencies of an entrepreneur, on the contrary, it focuses teaching on the creation of new companies and business administration, aspects that are insufficient to guarantee the training of entrepreneurial students, so the advancement of attributes should be strengthened as a priority, thinking, attitude and values [1].

The theoretical validation of any strategy expresses the establishment that the purposes for which it is established meet the requirements for the intended applications. It is the process by which it is demonstrated that the procedures and actions to be developed are pertinent to consummate the indicated objectives, the suitability of the strategy to achieve the expected performance is certified by experts or other methodologies. When we study the entrepreneurship competence, we must define which projects we consider most valuable for society, because they will be the ones that we will try to get students to undertake. We are not interested in educating the competence to undertake if we do not establish personal and social objectives, specified in a set of shared values.

One way to measure this process is by representing knowledge through what is known as Knowledge Engineering, which is the theoretical basis for dealing with the knowledge acquired by experts and reflected in publications, whether monographs, books, scientific articles, among other supports.

A tool that allows us the representation of knowledge is ontology [2-4]. The term ontology in computer sci-

ence refers to the formulation of an exhaustive and rigorous conceptual scheme within one or several given domains; in order to facilitate communication and the exchange of information between different systems and entities. Although it takes its name by analogy, this is the difference with the philosophical point of view of the word ontology.

A current technological common use of the concept of ontology, in this semantic sense, is found in artificial intelligence and knowledge representation. In some applications, several schemas are combined into a *de facto* complete data structure, containing all the relevant entities and their relationships within the domain.

Computer programs can thus use this view of ontology for a variety of purposes, including inductive, and a variety of problem-solving techniques.

Typically, ontologies in computers are closely related to fixed vocabularies (a foundational ontology) with whose terms everything else must be described. Because this can lead to poor representations for certain problem domains, more specialized schemas must be created to make the data useful for real-world decision-making.

Classical ontologies based on bivalent logic allow us the representation of knowledge only in a strict way, where the measurement of the belonging of an entity or object to a certain concept can be assumed without nuances, where either it is white or it is black. This does not correspond to reality, where there is uncertainty. That is why fuzzy ontologies allow us a more exact modeling of reality, where the object belongs to a fuzzy set with a certain degree of veracity, which is given by the lack of certainty that exists in the world around us, especially the world of social relationships, [3,4].

Although fuzzy ontologies better reflect reality, because they include shades of gray in the evaluations, even more precision is needed at the cost of greater indeterminacy; this can be solved with the help of neutrosophic logic. Neutrosophic logic allows the inclusion of degrees of truthfulness, falsity and indeterminacy explicitly. That is why in this paper we use neutrosophic ontologies as a way of representing the knowledge of the entrepreneurship competence. Other papers that can be found on the application of neutrosophy in pedagogy can be consulted on [5-11].

In other words, this paper aims to offer a model for representing and obtaining knowledge about the entrepreneurship competence with the help of neutrosophic ontologies. To do this, in the following section the fundamental concepts are developed, such as some details about the entrepreneurial competence and the basic notions about neutrosophic ontologies. Section 3 contains the fundamentals of the proposed model, while the last section is dedicated to giving the conclusions.

2 Preliminaries

2.1 Entrepreneurship competence

Learning development strategies are complex constructs that are oriented towards decision-making resulting from a training need, containing actions that activate knowledge in close correspondence with the search for the achievement of pre-established goals, effectively ([1,5,9,12-14]).

The definition of competence as the relevant appropriation of cross-cutting skills, knowledge, attitudes and values, which, when persistently updated, allow the individual to effectively and responsibly guide their interaction and development in dissimilar social settings.

The entrepreneurship competence has the duality of integrating terminal objectives and procedural elements, which combine substantive and adjective functions at the same time, all that it allows us from its decomposition into relevant cognitive nuclei and to group its dimensions into four cardinal groups:

Instrumental Dimension*:* (relates the procedural-adjective components) planning, organization, execution, control, management, evaluation, communication, project design, negotiation, manifest skills and abilities.

Cognitive dimension*:* (brings together the resources of appropriation and use of knowledge) learning to learn, interpreting in social reality, understanding the environment, understanding, solving problems, establishing judgments and reasoning, information management and its management for the development of comprehensive general culture.

Attitudinal dimension: (summarizes the motivational-volitional compositions of the competence) creativity, initiative, critical thinking, holistic vision, leadership, decision-making, teamwork, proactivity, risk management, motivation and audacity to achieve one's own goals or that of the group, perseverance, autonomy in action and the ability to delay the need for immediate satisfaction, development of the will to innovate.

Axiological dimension*:* (provides resources related to values and the conditioning of acting) resilience, optimism, responsibility, sustainability, altruism, preponderance of social interest, equity, respect for differences and equality, care for the environment.

Each one of these dimensions reaches its own magnitudes that distinguish them, but they cannot be isolated, since they form a unit. Its operating system is systemic, which increases its synergistic behavior to the extent that they are enhanced.

The dimensions function as a complex and coherent organization, in which each element fulfills a function, establishes an order, involves a logic of relationships, which give fullness to the whole and distinguish it, by di-

recting and complementing the development that gives rise to competition.

Approaching the entrepreneurship competence from the pedagogical performance of teachers in any level of education means the development of constructs that promote participation, inclusion and social responsibility. It is to develop a quality dedicated to individual and group protagonism.

It is to train the student by reinforcing the attitudinal, cognitive and axiological elements that lead to the mutation of the role of passive executors to men and women with critical thinking, actors of change, producers of innovative ideas, of viable projects, with the aptitudes and attitudes to materialize it. This is graphically summarized in Figure 1.

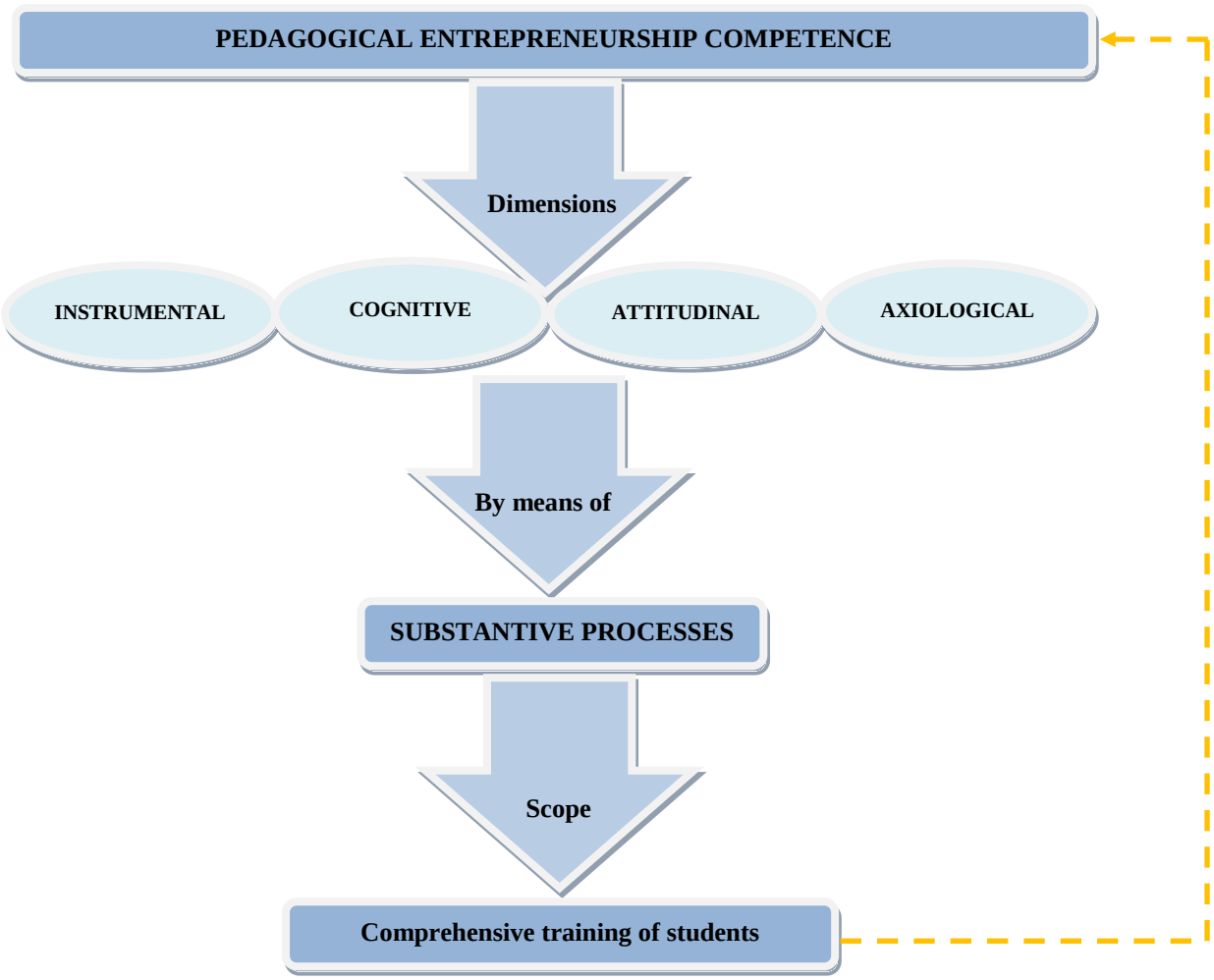

Figure 1: Graphical representation of the development of the entrepreneurship competence. Source ([1]).

2.2 Neutrosophic Ontologies

Classical ontologies are based on objects and their relationships and have the following components ([2]):

- Individuals: Instances or objects.
- Classes: Sets, collections, concepts, etc.
- Attributes: Aspects, properties, features, characteristics, etc.
- Relations: How classes and individuals relate to one another.
- Function terms: Complex structures designed from certain relations.
- Restrictions: Constrains which describe what is true to be accepted as input.
- Rules: Statements in the form of IF-THEN sentences.
- Axioms: Assertions which include rules, in a logical form that comprise the overall theory that the ontology describes in its domain of application.

Figure 2 represents an example of ontology:

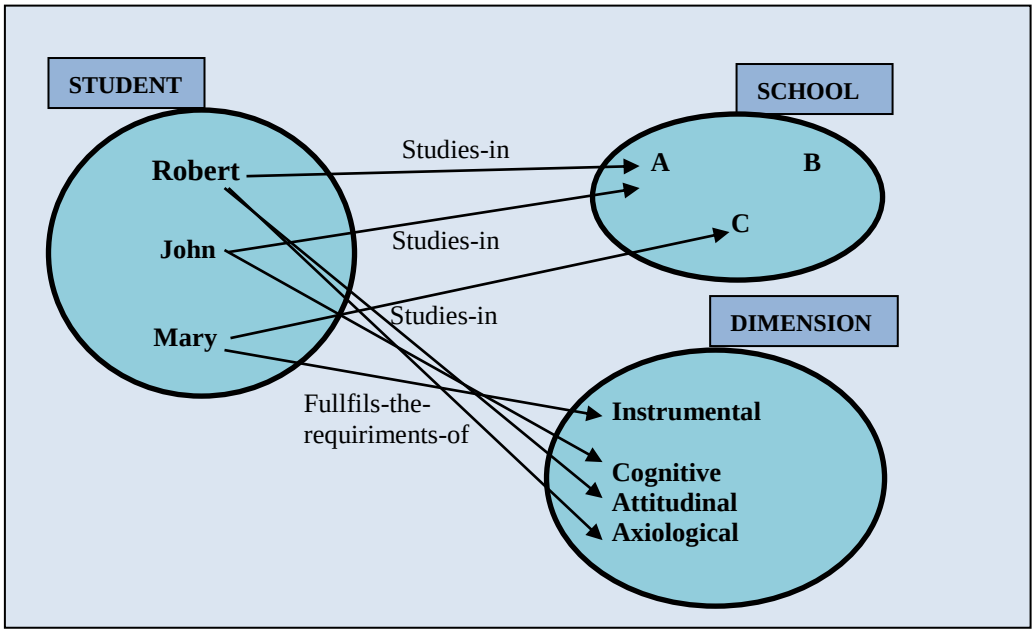

Figure 2: Graphical representation of a basic generic ontology. Source: The authors.

Neutrosophic logic is a logic in which every proposition is estimated to have the degree of truthfulness, indeterminacy, and falsity (T, I, F).

Definition 1: ([15,16]) The *Neutrosophic set* N is characterized by three membership functions, which are the truth-membership function T_A, indeterminacy-membership function I_A, and falsity-membership function F_A, where U is the Universe of Discourse and $\forall x \in U$, $T_A(x), I_A(x), F_A(x) \subseteq]^-0, 1^+[$, and $^-0 \leq \inf T_A(x) + \inf I_A(x) + \inf F_A(x) \leq \sup T_A(x) + \sup I_A(x) + \sup F_A(x) \leq 3^+$.

See that according to Definition 1, $T_A(x), I_A(x), F_A(x)$ are real standard or non-standard subsets of $]^-0, 1^+[$ and hence, $T_A(x), I_A(x), F_A(x)$ can be subintervals of $[0, 1]$.

Definition 2: ([15,16]) The *Single-Valued Neutrosophic Set* (SVNS) N over U is $A = \{< x; T_A(x), I_A(x), F_A(x) > : x \in U\}$, where $T_A: U \to [0, 1]$, $I_A: U \to [0, 1]$, and $F_A: U \to [0, 1]$, $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$.

The *Single-Valued Neutrosophic number* (SVNN) is symbolized by $N = (t, i, f)$, such that $0 \leq t, i, f \leq 1$ and $0 \leq t + i + f \leq 3$.

Definition 3: ([17]) A neutrosophic ontology is a sextuple $NO = < I, C, T, N, X, indeterminacy >$ where I is the set of instances, C is the set of classes. T denotes the taxonomy relations among the set of concepts C. N denotes the set of non-taxonomy neutrosophic associative relationships. X is the set of axioms expressed in a proper logical language. Indeterminacy is the degree of indeterminacy existing in the overlapping region.

A Neutrosophic Ontology in the example of Figure 2 contains triple truth values for truthfulness, indeterminacy, and falseness. For example, "Studies-in" can be associated with $< 1,0,0 >$ in all the three cases because a student usually studies in only one school. On the other hand, for the relationship "Fulfils-the-requirements-of" there are different degrees of satisfaction, for example Robert could satisfy the Instrumental dimension with $< 0.03,0.2,0.9 >$, the Cognitive with $< 0.1,0.1,0.8 >$, the Attitudinal with $< 0.9,0.1,0.2 >$, and the Axiological with $< 0.85,0.15,0.2 >$.

3 The Model

In the proposed model, the neutrosophic ontology is used to represent knowledge and to evaluate each student in terms of its ability to undertake.

The set I in this case is the set of students that are going to be evaluated on their entrepreneurship competence. Set C is that of the classes involved, in this case "Has the entrepreneurship competence", which are measured by the attributes of having the "Instrumental", "Cognitive", "Attitudinal" and "Axiological" dimensions. N contains the opposite of the concepts within the classes, that is, "does not have the entrepreneurship competence".

The rules defined in this model are very simple and obvious:

1. If student S satisfies the "Instrumental" dimension, then he or she has a greater capacity for "Entrepreneurship Competence".

2. If student S satisfies the "Cognitive" dimension, then he or she has a greater capacity for “Entrepreneurship Competence”.
3. If student S satisfies the “Attitudinal” dimension, then he or she has a greater capacity for “Entrepreneurship Competence”.
4. If student S satisfies the “Axiological dimension”, then he or she has a greater capacity for “Entrepreneurship Competence”.
5. If student S satisfies a greater number of dimensions, then he or she will have a greater capacity for “Entrepreneurship Competence”.

The teachers of the students to evaluate are invited to give an evaluation out of 100 points that reflects the behavior of the students on each of the previous dimensions. This must be stored in a database. The evaluators are explained that for each evaluation they must give 3 values out of 100 points, the first value corresponds to how certainty they have that the student satisfies the indicated attribute, which is one of the 4 dimensions, the second value corresponds within the same scale to the indeterminacy that the evaluator has about the satisfaction or not of the dimension, while the third value corresponds to the certainty that the student does not satisfy the attribute. Although evaluators are asked for a greater number of elements to evaluate, this will result in greater accuracy, taking into account that teachers are not always satisfied with giving a grade in a single number that often leaves them dissatisfied.

The proposed ontology is visualized in Figure 3.

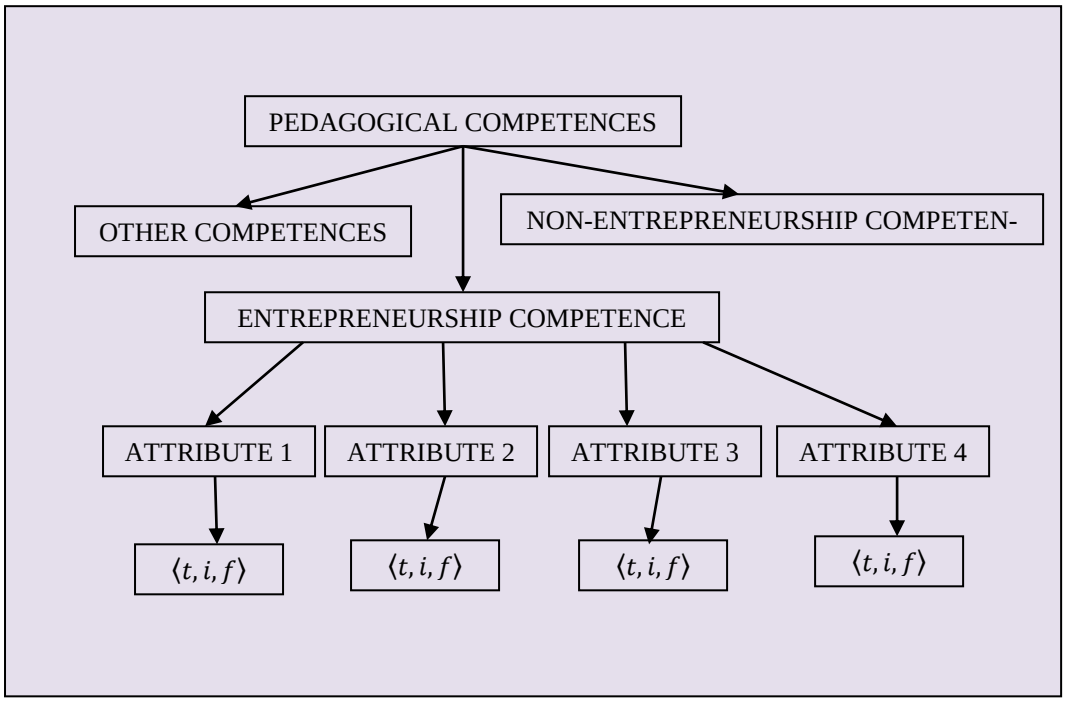

Figure 3: Neutrosophic Ontology of entrepreneurship competence. Source: The authors.

Note that the triple ⟨t, i, f⟩ corresponds to the neutrosophic evaluation of each student, as explained above.

Following the 5 rules, they can be summarized in that the entrepreneurship competence is measured according to the satisfaction of the 4 attributes (or dimensions). In addition to the fact that the greater the number of satisfied attributes, the greater the entrepreneurship competence, this is reflected in the following logical predicate:

$$EC \leftrightarrow Inst\ AND\ Cogn\ AND\ Attit\ AND\ Axiol \quad (1)$$

Where *EC* denotes the entrepreneurship competence, *Int*, *Cogn*, *Attit* and *Axiol*, represents each one of the dimensions and AND is the logical conjunction operator.

To perform the calculations, the grades given to the student are de-neutrosified using the following formula ([18]):

$$S(\langle t, i, f\rangle) = \frac{1}{3}\left(2 + \frac{t-i-f}{100}\right) \quad (2)$$

Then the AND is applied using the classical t-norm min(·) formula.

Let us illustrate the use of the proposed model with a generic example:

Example 1. Let us revisit the example in Figure 2 where the evaluations of the 3 students are summarized in Table 1.

Student (Instance)	Attrib1(Int)	Attrib2 (Cogn)	Attrib3 (Attit)	Attrib4 (Axiol)	CE
Robert	< 3,20,90 >	< 10,10,80 >	< 90,10,20 >	< 85,15,20 >	0.31
John	< 60,10,30 >	< 70,5,15 >	< 63,7,24 >	< 80,15,20 >	0.73333
Mary	< 90,1,5 >	< 95,2,1 >	< 80,0,20 >	< 81,1,21 >	0.86333

Table 1: Neutrosophic Ontology of the example.

We can see, according to Table 1 that Mary has a better development of the entrepreneurship competence, followed by John. On the other hand, the assessment of Robert is low.

Conclusion

The Entrepreneurship Competence is essential for the useful development of the student within the school. This competence will provide us with citizens who have initiatives that promote the progress of the society in which we live, while being critical and who have their own innovative thinking. One of the challenges that modern pedagogy has is to give it the importance that this competence deserves within the curriculum. That is why in this article we propose a model where this competence is measured in students of any level of education. The model is based on the use of neutrosophic ontologies, where ontology is combined as a technology to represent knowledge and neutrosophy that allows us the evaluation of relationships among concepts using neutrosophic numbers. To the knowledge of the authors, neutrosophic ontologies are used for the first time in the modeling of the Entrepreneurship Competence.

References

[1] Batista-Hernández, N. and Valcárcel-Izquierdo, N. (2018) Theoretical validation of the strategy for the development of competence engage as a contribution to the integral training of the student of pre-university education (In Spanish). Revista Magazine de las Ciencias, 3, 103-116.

[2] Zhong, B., Wu, H., Li, H., Sepasgozar, S., Luo, H. and He, L. (2019) A scientometric analysis and critical review of construction related ontology research. Automation in Construction, 101, 17-31.

[3] Adel, E., El-Sappagh, S., Barakat, S. and Elmogy, M. (2018) Distributed electronic health record based on semantic interoperability using fuzzy ontology: a survey. International Journal of Computers and Applications, 40, 223-241.

[4] Qasim, I., Alam, M., Khan, S., Khan, A.W., Malik, K.M., Saleem, M. and Bukhari, S.A. (2020) A comprehensive review of type-2 fuzzy ontology. Artificial Intelligence Review, 53, 1187-1206.

[5] Batista-Hernandez, N., Valcarcel-Izquierdo, N., Leyva-Vazquez, M. and Smarandache, F. (2018) Validation of the pedagogical strategy for the formation of the competence entrepreneurship in high education through the use of neutrosophic logic and Iadov technique. Neutrosophic Sets and Systems, 23, 45-51.

[6] Jadán-Solís, P.Y., Auria-Burgos, B.A., Triana-Palma, M.L., Mackencie-Álvarez, C.Y. and Carriel-Paredes, F.-D.-R. (2019) Compensatory fuzzy logic model for impact assessment when implementing ICT in pedagogical scenarios. Neutrosophic Sets and Systems, 26, 41-48.

[7] Fernández-Rodríguez, K.L., Abad-Peña, G., Ortiz-Luzuriaga, M.T., Ramos-López, Y., Cevallos-Uve, G.E., Obaco-Soto, E.E. and Rey-Suquilanda, C.F. (2019) Neutrosophic model to measure the impact of management projects on the process of pedagogical-research training. Neutrosophic Sets and Systems, 26, 12-18.

[8] Álvarez-Gómez, G., Viteri-Moya, J., Estupiñán-Ricardo, J. and Viteri-Sanchez, C.B. (2020) Evaluating Strategies of Continuing Education for Academics Supported in the Pedagogical Model and Based on Plithogenic Sets. Neutrosophic Sets and Systems, 37, 16-23.

[9] Batista-Hernández, N., Leyva-Vázquez, M.Y., González-Caballero, E., Valencia-Cruzaty, L.E., W., O.-C. and Smarandache, F. (2021) A new method to assess entrepreneurship competence in university students using based on plithogenic numbers and SWOT analysis. International Journal of Fuzzy Logic and Intelligent Systems, 21, 280–292.

[10] Mondal, K. and Pramanik, S. (2015) Neutrosophic Decision Making Model of School Choice. Neutrosophic Sets and Systems, 7, 62-68.

[11] Ricardo, J.E., Poma, M.E.L., Argüello, A.M., Pazmiño, A.D.A.N., Estévez, L.M. and Batista, N. (2019) Neutrosophic model to determine the degree of comprehension of higher education students in Ecuador. Neutrosophic Sets and Systems, 26, 54-61.

[12] Marina, J.A. (2010) The entrepreneurship competence. Revista de Educación, 351, 49-71.

[13] Halberstadt, J., Timm, J.M., Kraus, S. and Gundolf, K. (2019) Skills and knowledge management in higher education: how service learning can contribute to social entrepreneurial competence development. Journal of Knowledge Management, 23, 1925-1948.
[14] Tittel, A. and Terzidis, O. (2020) Entrepreneurial competences revised: developing a consolidated and categorized list of entrepreneurial competences Entrepreneurship Education 3, 1-35.
[15] Şahin, R. and Küçük, A. (2015) Subsethood measure for single valued neutrosophic sets. Journal of Intelligent & Fuzzy Systems, 29, 525-530.
[16] Wang, H., Smarandache, F., Zhang, Y. and Sunderraman, R. (2010) Single valued neutrosophic sets, Infinite study.
[17] Bhutani, K. and Aggarwal, S. (2015) Experimenting with neutrosophic ontologies for medical data classification. In: 2015 IEEE Workshop on Computational Intelligence: Theories,Applications and Future Directions (WCI) pp. 1-6, IEEE.
[18] Abdel-Basset, M., El-hoseny, M., Gamal, A. and Smarandache, F. (2019) A novel model for evaluation Hospital medical care systems based on plithogenic sets. Artificial Intelligence In Medicine, 100, 101710.

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