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Neutrosophic model to measure the impact of management projects on the process of pedagogical-research training

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Abstract This paper presents the influence of the research training process, which is based on the institutional dynamics, the management projects of the teaching and the educational process. The main issues present in the management of the pedagogical-research training process of the Faculty of Administrative Sciences of the University of Guayaquil are identified. In order to measure the impact of the management projects of the pedagogical-research training process on teachers of administrative careers, Neutrosophy techniques for multicriteria decision making are used. These techniques contribute to recommend the indicators of greatest incidence which affect the adequate development of the proposed projects. They are based on the interpretation of qualitative results, obtained from the analysis proposed in this paper. For this reason, this paper aims to design and apply a model to measure the impact of the management project of the process of pedagogical-research training on teachers of administrative careers. The model can be used beyond the scope of the Faculty of Administrative Sciences of the University of Guayaquil.

Keywords: educational management, pedagogical-research training process, Neutrosophy, multicriteria decision making

1 Introduction

The knowledge, particularly in Knowledge Societies, is characterized by the accumulation and the gradual loss of its value and by the diversity of the spaces where it is constructed and applied. This accelerated rhythm demands of institutions readies to assume the current general transformations. This purpose is achieved when the institutions count on qualified educators, adequate curricular proposals, novel and efficient pedagogical practices and schools provided by emotionally positive environments. Initiatives for educators' training are necessary in order to achieve the goals and to complete the innovation and the transformation of the education in favor of the human development, see [1].

Nowadays, university institutions have led knowledge production processes, which has having a positive impact on the management of the pedagogical-research training process. University research institutions have the constitutive mission of producing knowledge, transmitting knowledge and training new researchers, thus, providing a new way for looking at and conceiving the world, this is the so-called postmodernity, see [2].

Knowledge management in universities positively contributes to the knowledge-based economies of these institutions; nevertheless, it is an increasing challenge for them. Moreno et al. refer in [3], that this phenomenon is directly related to macro and micro structural variables, associated to policies of investment and economic financing in science and technology to countries and regions; but, at the same time, to internal situations inside the university institutions, specifically in curricular policies, training programs for researchers and pedagogical and didactic processes.

In the specialized literature, we can find diverse starting points and terms associated to the concept of pedagogical-research training, among those studies the approaches in [4, 5] can be consulted. These authors refer to starting points that lead to different concepts and scopes, like the work performance, the pedagogical professional performance, the performance from the workplace, the socially desired professional performance, among others, which constitute factors to be taken into account in the pedagogical-research training process.

In contrast, the systematization of the studies, see [6], makes possible to recognize the main characteristics present in the models of pedagogical-research training, they are:

- The presence of knowledge reproduction, which schematizes the characteristics of reality.
- The operativity and facility they offer for studying the target phenomena.
- By means of only one model, it is possible to represent an actual phenomena emitted by several models.
- The variables, relationships and constants in the model are interpreted by scientific theories.

Specifically in the University of Guayaquil (UG) we evidenced that the postgraduate's logic in the formation process, possesses a detached character in agreement to the research necessities of the pedagogical formation. Particularly, teachers' improvement and training are oriented to the study of Business Administration in The Faculty of Administrative Sciences of the University of Guayaquil. The process of pedagogical-research formation of the teachers occupies the foundations of the referred roles of the postgraduate's formation where it is advocated for:

- The response to society's expectations and necessities in terms of scientific and technological development.
- To promote the formative process in order to link the students to maintain in them the effective and efficient knowledge in the different fields of science and technology.
- To establish a knowledge management in harmony with the research processes and the students' linkage.

The elements above explained, justify the necessity to conceive a management project for the teachers' pedagogical-research formation process in the Faculty of Administrative Sciences of the University of Guayaquil, which includes the integration of high quality instructions and researches. Such project aims to achieve creative professionals' formation, which should be able to re-learning and re-inventing.

Thus, this paper aims to design a neutrosophic model, which is developed to measure the impact of certain indicators in the projects management during the pedagogical-research training process on the teachers of the Faculty of Administrative Sciences of the University of Guayaquil. These indicators are provided in a qualitative way, where we make use of linguistic terms. Moreover, techniques of neutrosophy designed to solve multicriteria decision making problems are applied. The advantage to use neutrosophy over fuzzy theory or over the intuitionistic fuzzy theory is that indeterminacy is included in the calculus. Indeterminacy is part of real life to make decisions, nevertheless, despite that persons are able to make decisions efficiently.

Some previous approaches to neutrosophic Multicriteria Decision Making can be read in [7, 8, 9, 10, 11, 12, 13, 14, 15, 16]. Several are dedicated to the design of decision making models and others to the application to real life problems.

This paper is divided as follows; Section 2 is dedicated to expose the previous concepts which serve as the theoretical basis on the rest of the paper. In Section 3 calculus and their interpretations are discussed. In Section 4 conclusions are drawn.

2 Preliminaries

This section is devoted to recall basic concepts of neutrosophic theory and to introduce the proposed model.

Definition 1 Let *X* be a universe of discourse, a space of points (objects) and *x* denotes a generic element of *X*. A *neutrosophic set A* in *X* is characterized by a truth-membership function $T_A(x)$, an indeterminacy-membership function $I_A(x)$, and a falsity-membership function $F_A(x)$. Where, $T_A(x)$, $I_A(x)$, $F_A(x) \subseteq]^-0, 1^+[$, i.e., they are real standard or nonstandard subsets of the interval $]^-0, 1^+[$. These functions do not satisfy any restriction, that is to say, the following inequalities hold:

$^-0 \leq \inf T_A(x) + \inf I_A(x) + \inf F_A(x) \leq \sup T_A(x) + \sup I_A(x) + \sup F_A(x) \leq 3^+$.

Definition 2 Let *X* be a universe of discourse, a space of points (objects) and *x* denotes a generic element of *X*. A *Single Valued Neutrosophic Set* (SVNS) *A* in *X* is characterized by a truth-membership function $T_A(x)$, an indeterminacy-membership function $I_A(x)$, and a falsity-membership function $F_A(x)$. Where, $T_A(x)$, $I_A(x)$, $F_A(x)$: $X \rightarrow [0, 1]$ such that: $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$. A *single valued neutrosophic number* (SVNN) is symbolized by <T,I,F> for convenience, where T, I, F$\in$ [0, 1] and 0≤ T+ I+ F≤3.

Therefore, $A = \{\langle x, T_A(x), I_A(x), F_A(x)\rangle : x \in X\}$ or more simply $A = \langle T_A(x), I_A(x), F_A(x)\rangle$, for every $x \in X$.

Given *A* and *B* two SVNSs, they satisfy the following relationships:

1. $A \subseteq B$ if and only if $T_A(x) \leq T_B(x)$, $I_A(x) \geq I_B(x)$ and $F_A(x) \geq F_B(x)$. Particularly, $A = B$ if and only if $A \subseteq B$ and $B \subseteq A$.
2. $A \cup B = \langle \max(T_A(x), T_B(x)), \min(I_A(x), I_B(x)), \min(F_A(x), F_B(x))\rangle$, for every $x \in X$.
3. $A \cap B = \langle \min(T_A(x), T_B(x)), \max(I_A(x), I_B(x)), \max(F_A(x), F_B(x))\rangle$, for every $x \in X$.

Decision making is an unavoidable process, which is essential in many real life situations. Such a process contains stages like the following:

1. To define the decision making problem

2. To analyze the problem and identify alternatives for the solution
3. To establish the criteria of assessment
4. To select experts
5. To assess the alternatives
6. To rank the choices and select the best of them

Many mathematical theories are dedicated to solve decision making problems, including neutrosophy theory.

The aggregation operator is a well-known concept in fuzzy theory, which has been naturally extended to neutrosophic theory and they are used to fusion information. It is utilized for the aggregation or fusion of some input values to obtain an only one output value. It is useful in decision making information, see [17].

Multicriteria decision making is a decision making process where the number of criteria is more than one, i.e., the criteria $C_1, C_2, \dots, C_n$ satisfy n>1. We have a Group Decision, when the number of Decision Makers is more than one.

The concept of Aggregation operator is formally defined in Definition 3.

Definition 3 Let *X* be a universe of discourse, a space of points (objects) and *x* denotes a generic element of *X*. ***A*** is a *Single Valued Neutrosophic Aggregation Operator* (SVNAO) if it is a mapping $\boldsymbol{A}: \cup_{n\in\mathbb{N}} ([0,1]^3)^n \to [0,1]^3$.

An example of SVNAO is the *Single Valued Neutrosophic Weighted Average operator* (SVNWA), which is formally defined in Definition 4, see [14].

Definition 4 Let $a_j = \langle T_j, I_j, F_j\rangle$, j = 1, 2, … n, be a collection of single valued neutrosophic numbers, then, the *Single Valued Neutrosophic Weighted Average operator* (SVNWA), is defined by the formula in Equation 1.

$$SVNWA_W(a_1, a_2, \dots, a_n) = \langle 1-\prod_{j=1}^n (1-T_j)^{w_j}, \prod_{j=1}^n I_j^{w_j}, \prod_{j=1}^n F_j^{w_j}\rangle \quad (1)$$

Where, W = ($w_1, w_2, \dots, w_n$) is the vector of weights, according to the importance assigned to every one of the attributes, such that, $w_i \in [0, 1]$ for i = 1, 2, …, n and $\sum_{i=1}^n w_i = 1$.

Another example of neutrosophic aggregation operator is the *Single Valued Neutrosophic Weighted Geometric Average operator* (SVNWG) defined by the formula in Equation 2, see Definition 5 and [14].

Definition 5 Let $a_j = \langle T_j, I_j, F_j\rangle$, j = 1, 2, … n, be a collection of single valued neutrosophic numbers, then, the *Single Valued Neutrosophic Weighted Geometric Average operator* (SVNWG), is defined by the formula in Equation 2.

$$SVNWG_W(a_1, a_2, \dots, a_n) = \langle \prod_{j=1}^n T_j^{w_j}, 1-\prod_{j=1}^n (1-I_j)^{w_j}, 1-\prod_{j=1}^n (1-F_j)^{w_j}\rangle$$

(2)

Proposition 1 Given $a_1, a_2, \dots, a_n$ and W = ($w_1, w_2, \dots, w_n$), then some properties of SVNWA and SVNWG are the following:

1. They are symmetric. $SVNWA_W(a_1, a_2, \dots, a_n) = SVNWA_W(a_{p(1)}, a_{p(2)}, \dots, a_{p(n)})$ and $SVNWG_W(a_1, a_2, \dots, a_n) = SVNWG_W(a_{p(1)}, a_{p(2)}, \dots, a_{p(n)})$, where P = (P(1), P(2), …, P(n)) is a permutation function.
2. They are associative. $SVNWA_W(SVNWA_W(a_1, a_2), a_3) = SVNWA_W(a_1, SVNWA_W(a_2, a_3))$ and $SVNWG_W(SVNWG_W(a_1, a_2), a_3) = SVNWG_W(a_1, SVNWG_W(a_2, a_3))$.
3. $SVNWG_W(a_1, a_2, \dots, a_n) \leq_N SVNWA_W(a_1, a_2, \dots, a_n)$, where $\leq_N$ is a partial order, defined as: $\langle T_1, I_1, F_1\rangle \leq_N \langle T_2, I_2, F_2\rangle$ if and only if $T_1 \leq T_2$, $I_2 \leq I_1$ and $F_2 \leq F_1$.

Proof.

1. It is easy to prove.
2. See that $\prod_{j=1}^n T_j^{w_j}$, $\prod_{j=1}^n I_j^{w_j}$ and $\prod_{j=1}^n F_j^{w_j}$ are evidently associative. Also, it is easy to prove that $1-\prod_{j=1}^2 (1-T_j)^{w_j}$, $1-\prod_{j=1}^2 (1-I_j)^{w_j}$ and $1-\prod_{j=1}^2 (1-F_j)^{w_j}$ are associative. Moreover, this property can be extended to $1-\prod_{j=1}^n (1-T_j)^{w_j}$, $1-\prod_{j=1}^n (1-I_j)^{w_j}$ and $1-\prod_{j=1}^n (1-F_j)^{w_j}$. Thus, both, SVNWA and SVNWG are associative.
3. See that $1-\prod_{j=1}^n (1-T_j)^{w_j} \geq \max_j T_j^{w_j}$, $1-\prod_{j=1}^n (1-I_j)^{w_j} \geq \max_j I_j^{w_j}$, $1-\prod_{j=1}^n (1-F_j)^{w_j} \geq \max_j F_j^{w_j}$, $\prod_{j=1}^n T_j^{w_j} \leq \min_j T_j^{w_j}$, $\prod_{j=1}^n I_j^{w_j} \leq \min_j I_j^{w_j}$ and $\prod_{j=1}^n F_j^{w_j} \leq \min_j F_j^{w_j}$, hence, according to Definitions 4 and 5 and the neutrosophic order, the inequality holds.□

Remark 1 Let us note that the previous properties are important for the aggregation calculus. Especially the last one indicates that the aggregation based on SVNWG is more “pessimistic” than that based on SVNWA.

The alternatives are ranked by using the scoring function defined in [18], see Equation 3.

$s(a_j) = 2 + T_j - F_j - I_j$ (3)

The definition of precision function is given in Equation 4.

$\alpha(a_j) = T_j - F_j$ (4)

See that s: $[0,1]^3 \rightarrow [0,\ 3]$ and α: $[0,1]^3 \rightarrow [-1,\ 1]$.

Thus, we use the following preference order criteria:

1. If $s(a_j) < s(a_i)$, then we say that a_i is preferred over a_j, and it is denoted by $a_j \prec a_i$ or equivalently by $a_i \succ a_j$.
2. If $s(a_j) = s(a_i)$ then,
   2.1. If $(a_j) < \alpha(a_i)$, then we say that a_i is preferred over a_j or $a_j \prec a_i$.

If $s(a_j) = s(a_i)$ and $(a_j) = \alpha(a_i)$, then we say that a_i and a_j are equally preferred and it is denoted by $a_i \sim a_j$. The scoring function is used to rank and evaluate the alternatives.

Other property of the fuzziness, including neutrosophy is the possibility it offer to deal with the vagueness of the natural language. Decision making includes the criteria given by experts on the subject, whom are not necessarily experts in mathematics; therefore, it is important to express these criteria in natural language. Thus, Tables 3 and 4 are given, which associate a linguistic term with a SVNN, they was defined in [19].

Linguistic term	SVNN
Very important (VI)	<0.90, 0.10, 0.10>
Important (I)	<0.75, 0.25, 0.20>
Medium (M)	<0.50, 0.50, 0.50>
Unimportant (UI)	<0.35, 0.75, 0.80>
Very Unimportant (VUI)	<0.10, 0.90, 0.90>

Table 1: Importance weight as linguistic terms

Linguistic Term	SVNN
Extremely good (EG)	<1.00, 0.00, 0.00>
Very very good (VVG)	<0.900, 0.10, 0.10>
Very good (VG)	<0.80, 0.15, 0.20>
Good (G)	<0.70, 0.25, 0.30>
Medium good (MG)	<0.60, 0.35, 0.40>
Medium (M)	<0.50, 0.50, 0.50>
Medium bad (MB)	<0.40, 0.65, 0.60>
Bad (B)	<0.30, 0.75, 0.70>
Very Bad (VB)	<0.20, 0.85, 0.80>
Very very bad (VVB)	<0.10, 0.90, 0.90>
Extremely bad (EB)	<0.00, 1.00, 1.00>

Table 2: Linguistic terms to rate the importance of alternatives

From the documentary analysis and the researchers' experience in the Faculty of Administrative Sciences of the University of Guayaquil, we can infer that diverse factors affect the pedagogical-research training, among them we can mention:

- Curricular processes, which integrate the role of the curriculum and training strategies for research.
- The articles referring to the actors in the pedagogical-research training process allude to the variables that influence both, teachers and students (roles, attitudes, meanings, among others).
- The institutional conditions of the universities respect to the topic of interest.

Then, a model is developed based on the aggregation of information to measure the impact of management projects in the process of pedagogical and research training on teachers of administrative careers at the University of Guayaquil, Ecuador. The workflow proposed in this paper is shown in Figure 1.

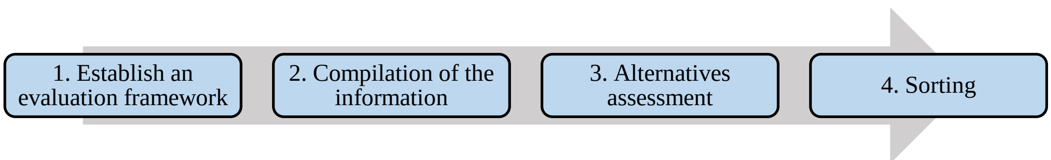

Figure 1: Scheme of the model based on the information aggregation to measure the impact of management projects on the

process of pedagogical-research training.

The proposed algorithm consists in the following steps:

Algorithm of the best alternative selection

1. To select the criteria: $C_1, C_2, \ldots, C_n$.
2. To select the alternatives: $X_1, X_2, \ldots, X_m$
3. The Expert or Experts select the linguistic term to assess the importance of every one of the criterion, from Table 1, let us denote it by: $t_1, t_2, \ldots, t_n$. Every one of them is associated to one SVNN: $<T_1, I_1, F_1>$, $<T_2, I_2, F_2>$, …, $<T_n, I_n, F_n>$, which can be found in the right column of Table 1.
   Then, calculate $w_j = \frac{T_j}{\sum_{k=1}^{n} T_k}$, which are the weights of every criterion.
4. The Expert or Experts select from Table 2 the linguistic term to assess every alternative according to every criterion. An n×m table is formed, where the element in the i^{th} row, j^{th} column is the evaluation of X_j according to C_i.
5. To aggregate each column of alternatives for every row of criteria, applying the SVNWA. Where, the weights were calculated in the step 3, and the alternatives correspond to the SVNN associated to the linguistic evaluations given by experts, according to Table 2.
6. To calculate the scoring and ranking functions, according to Equations 3 and 4.
7. Select the best alternative, according to the preference order criteria.

Remark 2 When the number of experts is more than one, the experts' evaluations median is provided. The median is calculated by using the indexes representing the order of the linguistic terms. Once the median index is calculated, the term with the closest index is selected and this represents the expert group evaluation. In case the median index is (2i+1)/2, i is chosen.
See the Example 1 to illustrate this calculation. Hence, these values are used in the Algorithm of the best alternative selection.

Example 1 Suppose that four experts, E_1, E_2, E_3, and E_4 are evaluating the importance of the criterion 1, according to Table 1. E_1 and E_3 say it is Important (I), E_2 considers it is Medium (M) and E_4 says it is Very Important (VI). Alternatively, we have an order of the terms {VUI, UI, M, I, VI}, it is indifferent that either the order is ascending or descending.
Therefore, according to the previous order we have the indexes of the experts' evaluations, {4, 3, 4, 5} corresponding to {I, M, I, VI}, the median of the indexes is 4, then, the group evaluation corresponds to I. This procedure can be extended to the rest of the assessments.

3 Results

For the evaluation the linguistic terms defined in [11] are used, see Tables 1 and 2. Subsequently, the information is collected, related to the indicators and factors of major incidence in the process of pedagogical-research training, to measure the impact of management projects in the Faculty of Administrative Sciences of the University of Guayaquil. The results obtained are shown in Table 3, see the criteria (C_1, C_2 and C_3) and the alternatives (X_1, X_2 and X_3) selected by experts.

Experts assess the importance of C_1 as "Very Important" and both, C_2 and C_3, as "Medium". Then, according to Table 1, we have:

$$w_1 = \frac{0.9}{0.9+0.5+0.5} = 0.47368,\ w_2 = w_3 = \frac{0.5}{0.9+0.5+0.5} = 0.26316.$$

Therefore, The vector used to measure the impact of management projects of the process of pedagogical-research training on teachers of the Faculty of Administrative Sciences in the University of Guayaquil, Ecuador is W = (0.47368, 0.26316, 0.26316).

Table 3 contains the matrix of the experts' assessments for each alternative by criterion.

Criterion\Alternatives	X_1 (curricular processes indicator)	X_2 (indicator of actors in the process of pedagogical-research training)	X_3 (indicator of institutional conditions of universities)
C_1 (research training to the curriculum)	MG	EG	VG
C_2 (instrumental character assigned to pedagogy)	G	MG	B
C_3 (micro conditions of the institutions to carry out the processes of research training)	MG	MG	G

Table 3: Results of information collection.

Subsequently, the decision-makers' opinions are aggregated using the SVNWA aggregation operator; the results are summarized in Table 4.

Alternative	Aggregation	Scoring	Ranking
X_1	<0.62916, 0.32034, 0.37084>	1.9338	3
X_2	<1.00000, 0.00000, 0.00000>	3.0000	1
X_3	<0.69058, 0.26207, 0.30942>	2.1191	2

Table 4: Results of assessing

According to the scoring function, the proposed indicators are ordered as follows: $X_2 \succ X_3 \succ X_1$, which shows that the most important indicator correspond to the instrumental character assigned to pedagogy, denoting the need to delimit variables such as culture and the relations between teacher, student and teaching that require contextual and local research in order to understand deeply the potentialities and limitations of research training.

Next, attention should be paid to the micro conditions of institutions to carry out the processes of research training in order to address the issues of science and technology, with respect to the aspects of organizational culture of universities and economic investment.

This leads to paying attention to research training in the curriculum, which aims to form skills and habits proper to technical and scientific research work in students to solve problems and propose solutions to disciplinary and professional objects from the research methodology.

4 Conclusions

In the present paper, a documentary analysis is carried out to obtain elements related to the management of the process of pedagogical-research training, in order to measure the impact in the University of Guayaquil. The indicators to be taken into account are obtained and they are evaluated through a model based on the aggregation of useful information to quantify the indicators and to recommend those that are necessary to attend for the adequate achievement of the pedagogical research training in the students of the careers of Administration of the University of Guayaquil, Ecuador. The proposed model can be applied to other university institutions, interested to study their conditions on the pedagogical-research training.

References

[1] Estupiñan Ricardo, J., Chero Cano, I. M., Intriago Alcivar, G. C., and Torres Vargas, R. J. (2016). *Cognitive neuroscience and emotional intelligence. Pedagogical management in the context of professional training (Neurociencia cognitiva e inteligencia emocional. La gestión pedagógica en el contexto de la formación profesional)* (In Spanish). Didasc@ lia: Didáctica y Educación, 4, 207-214.

[2] Estupiñán Ricardo, J., and Batista Hernandez, N. (2018). *Business management and postmodernity (Gestion empresarial y posmodernidad)* (In Spanish). Pons Publishing House, Bruxelles, Belgium.

[3] Moreno, G., Sánchez, R., Arredondo, V., Pérez, G., and Klingler, C. (2003). Training for research. In Ducoing, P. (ed.), *Collection: educational research in Mexico* 1992-2002, pp. 41-114. Mexico City, Mexico: Mexican Council for Educational Research.

[4] Pérez, M.F. (2010). *Educational program for improving the pedagogical professional performance of teachers in youth and adult education centers*. Thesis in option to the Scientific Degree of Doctor in Pedagogical Sciences. Havana, Cuba: ISPEJV.

[5] Valcárcel, N. (1998). *Interdisciplinary Overcoming Strategy for teachers of basic secondary sciences*. Thesis in option to the Scientific Degree of Doctor in Pedagogical Sciences. Havana, Cuba: ISPEJV

[6] Añorga, J. (2012). *Intellectual production: Organizational and pedagogical process*. Havana, Cuba: Editorial University, 50-60.

[7] Bhutani K. and Aggarwal S. (2017). *Neutrosophic Rough Soft Set – A Decision Making Approach to Appendicitis Problem*. Neutrosophic Sets and Systems, 16, 70-75.

[8] Biswas, P., Pramanik, S., and Giri, B.C., (2016). *Value and ambiguity index based ranking method of single-valued trapezoidal neutrosophic numbers and its application to multi-attribute decision making*. Neutrosophic Sets and Systems, 12, 127-138.

[9] Broumi, S., Ye, J., Smarandache, F. (2015) *An Extended TOPSIS Method for Multiple Attribute Decision Making based on Interval Neutrosophic Uncertain Linguistic Variables*. Neutrosophic Sets and Systems, 8, 22-31.

[10] Chen, J. Q., and Ye, J. (2016). *A projection model of neutrosophic numbers for multiple attribute decision making of clay-brick selection*. Neutrosophic Sets and Systems, 12, 139-142.

[11] Liu, P., and Li, H. (2017). *Multiple attribute decision-making method based on some normal neutrosophic Bonferroni mean operators*. Neural Computing and Applications, 28 (1), 179-194.

[12] Mondal, K., and Pramanik, S. (2014). *Multi-criteria group decision making approach for teacher recruitment in higher education under simplified neutrosophic environment*. Neutrosophic Sets and Systems, 6, 28-34.

[13] Mondal, K., and Pramanik, S. (2015). *Neutrosophic decision making model of school choice*. Neutrosophic Sets and Systems, 7, 62-68.

[14] Sahin, R., and Liu, P. (2016*). Maximizing deviation method for neutrosophic multiple attribute decision making with incomplete weight information*. Neural Computing and Applications, 27(7), 2017-2029.

[15] Ye, J. (2014). *Single-valued neutrosophic minimum spanning tree and its clustering method*. Journal of intelligent Systems, 23 (3), 311-324.

[16] Zaied, A. N. H., and Naguib, H. M. (2016). *Applications of Fuzzy and Neutrosophic Logic in Solving Multi-criteria Decision Making Problems*. Neutrosophic Sets and Systems, 13, 38-46.

[17] Torra, V. and Narukawa, Y. (2007), *Modeling decisions: information fusion and aggregation operators*: Springer, New York

[18] Liu, P., Chu, Y., Li, Y., and Chen, Y. (2014). *Some Generalized Neutrosophic Number Hamacher Aggregation Operators and Their Application to Group Decision Making*. International Journal of Fuzzy Systems, 16(2), 242-255.

[19] Sahin, R., and Yigider, M. (2016). *A Multi-Criteria Neutrosophic Group Decision Making Method Based TOPSIS for Supplier Selection*. Applied Mathematics and Information Sciences, 10 (5), 1-10.

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