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USING DECISION MAKING METHODS TO ASSESS STUDENT ACHIEVEMENT

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Abstract. In order to determine student success, considering other factors that affect success along with exam success is a very important step in terms of education. In this study, the decision-making method that evaluates student achievements with guidance counselors was used. Student achievements were estimated by using a combination of intuitionistic fuzzy sets and decision-making methods.

1. INTRODUCTION

The fuzzy logic was defined by Zadeh in 1965 [1]. In this process, while researches and applications on fuzzy logic continue, the intuitionistic fuzzy set theory, which is the generalization of fuzzy logic in which sensitivity is also activated in cases of uncertainty, was put forward by Atanassov in 1983 [3]. Multi-criteria decision making is interested in structuring and solving decision and planning problems involving multiple criteria. The goal is to support decision makers who face such problems. Typically, there is no unique optimal solution for such problems, and it is necessary to use the decision maker's preferences to distinguish between solutions. PROMETHEE was firstly developed by Brans in 1982 and continued to be developed thereafter [4, 5, 6]. The PROMETHEE method is in the outranking method class, one of the multi-criteria decision-making methods. Many researchers have developed applications using PROMETHEE methods and intuitionistic fuzzy sets [7, 8, 9, 10, 16, 17, 39, 26, 25]. The PROMETHEE method provides very effective benefits by combining intuitionistic fuzzy sets and decision-making methods. This system, which allows decision makers to make both objective and most accurate decisions, was used for educational application in our article. Student success and guidance can be made more accurately, thanks to a system that examines both students' course success and psychological characteristics and puts them all into action at the same time. In addition, thanks to this system, teachers who guide students can make more accurate determinations and be more successful in guiding. There are many studies in which decision-making methods are used together with

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intuitionistic fuzzy sets, and the authors have achieved effective results in their studies [12, 14, 15, 21, 22, 23, 24, 27, 28, 29, 30, 31, 32, 33, 37].

2. PRELIMINARIES

Definition 1. *([3, 2])Let $X \neq \emptyset$. An intuitionistic fuzzy set A in X;*

$$A = \{\langle x, \mu_A(x), \nu_A(x)\rangle |\ x \in X\},$$

$$\mu_A(x), \nu_A(x), \pi_A(x) : X \to [0,1]$$

defined membership, nonmembership and hesitation degree of the element $x \in X$ respectively.

$$\mu_A(x) + \nu_A(x) + \pi_A(x) = 1.$$

Intuitionistic fuzzy value (IFV) defined by Xu ([36]). Intuitionistic fuzzy value (IFV) is shown as follows: $\tilde{a} = (\mu_{\tilde{a}}, \nu_{\tilde{a}}, \pi_{\tilde{a}})$, where $\mu_{\tilde{a}}, \nu_{\tilde{a}}, \pi_{\tilde{a}} \in [0,1]$
For each IFS $\tilde{A}$;

$$\pi_{\tilde{A}} = 1 - \mu_{\tilde{A}} - \nu_{\tilde{A}} \tag{2.1}$$

For IFVs $\tilde{a} = (\mu_{\tilde{a}}, \nu_{\tilde{a}})$ and $\tilde{b} = (\mu_{\tilde{b}}, \nu_{\tilde{b}})$ the following operations have been carried out([36, 35]):

$$(1) \quad \tilde{a} \oplus \tilde{b} = (\mu_{\tilde{a}} + \mu_{\tilde{b}} - \mu_{\tilde{a}}\mu_{\tilde{b}}, \nu_{\tilde{a}}\nu_{\tilde{b}}) \tag{2.2}$$

$$(2) \quad \tilde{a} \otimes \tilde{b} = (\mu_{\tilde{a}}\mu_{\tilde{b}}, \nu_{\tilde{a}} + \nu_{\tilde{b}} - \nu_{\tilde{a}}\nu_{\tilde{b}}) \tag{2.3}$$

$$(3) \quad \oplus_{j=1}^{m} \tilde{a}_j = (1 - \prod_{j=1}^{m}(1-\mu_j), \prod_{j=1}^{m}\nu_j) \tag{2.4}$$

$$(4) \quad \otimes_{j=1}^{m} \tilde{a}_j = (\prod_{j=1}^{m}\mu_j, \prod_{j=1}^{m}(1-\nu_j)) \tag{2.5}$$

This function is used to rank IFVs:

$$\rho(\alpha) = 0.5(1+\pi_\alpha)(1-\mu_\alpha)) \tag{2.6}$$

As the $\rho(\alpha)$ value decreases, the preferred value α increases.

3. The Intuitionistic Fuzzy PROMETHEE Method

The criteria's weights could be depicted as IFVs: $\tilde{w}_j$ where $\mu_{\tilde{w}_j} \in [0,1], \nu_{\tilde{w}_j} \in [0,1], \mu_{\tilde{w}_j} + \nu_{\tilde{w}_j} \leq 1, j = 1,2,...,m$. According to the weights, $\mu_{\tilde{\omega_j}}$ and $\nu_{\tilde{\omega_j}}$ demonstrate the membership and non-membership degrees of the alternative x_i respectively. Some methods can help decision makers in determining intuitionistic fuzzy weights ([18, 19, 34, 38, 11, 13]). In this study, linguistic terms were used to make the evaluation more accurate. Also, V shape criterion type has been used:

$$P(d) = \begin{cases} 0, & d \leq q \\ \frac{d-q}{p-q}, & q < d \leq p \\ 1, & d > p \end{cases} \tag{3.1}$$

Parameter thresholds q and p are indicated as indifference and strict preference, respectively. Evaluate the alternatives $x_i (i = 1,2,...,n)$ with respect to the criteria $c_j (j = 1,2,...,m)$ and determine the deviations based on pairwise comparisons:

$$d_j(x,y) = c_j(x) - c_j(y) \tag{3.2}$$

where $d_j(x, y)$ shows the distinction between the alternatives' the assessments x and y on the criterion c_j.

Definition 2. *([37]) An intuitionistic fuzzy preference relation R on the set $X = x_1, x_2, ..., x_n$ is represented by a matrix $R = (r_{ik})_{n\times n}$, where $r_{ik} = \langle (x_i, x_k), \mu(x_i, x_k), \nu(x_i, x_k)\rangle$ for all $i, k = 1, 2, ..., n$. For convenience, we let $r_{ik} = (\mu_{ik}, \nu_{ik})$ where μ_{ik} denotes the degree to which the object x_i is preferred to the object x_k, ν_{ik} indicates the degree to which the object x_i is not preferred to the object x_k, and $\pi(x_i, x_k) = 1 - \mu(x_i, x_k) - \nu(x_i, x_k)$ is interpreted as an indeterminacy degree or a hesitancy degree, with the condition:*

$$\mu_{ik},\ \nu_{ik} \in [0, 1],\ \mu_{ik} + \nu_{ik} \le 1,\ \mu_{ik} = \nu_{ki},\ \mu_{ki} = \nu_{ik},$$

$$\mu_{ii} = \nu_{ii} = 0.5,\ \pi_{ik} = 1 - \mu_{ik} - \nu_{ik},$$

$$for\ all\ i, k = 1, 2, ..., n \tag{3.3}$$

The preferences μ_{ik} between the alternatives x_i and x_k according to the criterion c_j could be calculated by Equations (3.2) and (3.1), and then the preference matrix according to the criterion c_j is obtained as follows ([20]):

$$U^{(j)} = (\mu_{ik}^{(j)})_{n\times n} = \begin{bmatrix} - & \mu_{12}^{(j)} & \dots & \mu_{1n}^{(j)} \\ \mu_{21}^{(j)} & - & \dots & \mu_{2n}^{(j)} \\ \vdots & \vdots & - & \vdots \\ \mu_{n1}^{(j)} & \mu_{n2}^{(j)} & \dots & - \end{bmatrix} \tag{3.4}$$

Matrix of the intuitionistic fuzzy preference relation is obtained:

$$R^{(j)} = (r_{ik}^{(j)})_{n\times n} = \begin{bmatrix} - & (\mu_{12}^{(j)}, \nu_{12}^{(j)}) & \dots & (\mu_{1n}^{(j)}, \nu_{1n}^{(j)}) \\ (\mu_{21}^{(j)}, \nu_{21}^{(j)}) & - & \dots & (\mu_{2n}^{(j)}, \nu_{2n}^{(j)}) \\ \vdots & \vdots & - & \vdots \\ (\mu_{n1}^{(j)}, \nu_{n1}^{(j)}) & (\mu_{n2}^{(j)}, \nu_{n2}^{(j)}) & \dots & - \end{bmatrix} \tag{3.5}$$

The IFWA operator is used in this paper. The all intuitionistic fuzzy preference index of the alternative x_i to x_k on all criteria can be derived as:

$$r(x_i, x_k) = r_{ik} = \bigoplus_{j=1}^{m} \left(\tilde{w}_j \bigotimes r_{ik}^{(j)}\right) \tag{3.6}$$

where $r(x_i, x_k) = r_{ik}$ shows the degree to which the alternative x_i is preferred to the alternative x_k all criteria. Also, r_{ik} is an IFV. $\tilde{w}_j = (\mu_{\tilde{w}j}, \nu_{\tilde{w}j})$, then according to Equation (2.2), (2.3):

$$\tilde{w}_j \bigotimes r_{ik}^{(j)} = \left(\mu_{ik}^{(j)} \mu_{\tilde{w}j}, \nu_{ik}^{(j)} + \nu_{\tilde{w}j} - \nu_{ik}^{(j)} \nu_{\tilde{w}j}\right) \tag{3.7}$$

If Equations (2.4),(3.6) and (3.7) are combined;

$$\begin{aligned} r(x_i, x_k) &= \bigoplus_{j=1}^{m}\Big(\tilde{w}_j \bigotimes r_{ik}^{(j)}\Big) \\ &= \Big(1 - \prod_{j=1}^{m}(1 - \mu_{ik}^{(j)}\mu_{\tilde{w}j}), \\ &\quad \prod_{j=1}^{m}(\nu_{ik}^{(j)} + \nu_{\tilde{w}j} - \nu_{ik}^{(j)}\nu_{\tilde{w}j})\Big) \end{aligned} \tag{3.8}$$

Overall intuitionistic fuzzy preference relationship is obtained:

$$R = (r_{ik})_{n\times n} = \begin{bmatrix} - & (\mu_{12}, \nu_{12}) & \dots & (\mu_{1n}, \nu_{1n}) \\ (\mu_{21}, \nu_{21}) & - & \dots & (\mu_{2n}, \nu_{2n}) \\ \vdots & \vdots & - & \vdots \\ (\mu_{n1}, \nu_{n1}) & (\mu_{n2}, \nu_{n2}) & \dots & - \end{bmatrix} \tag{3.9}$$

Every alternative is compared to option $(n-1)$. As a result of intuitionistic fuzzy positive and negative outranking flow are achieved:
(1) The intuitionistic fuzzy positive outranking flow:

$$\tilde{\varphi}^{+}(x_i) = \frac{1}{n-1}\bigoplus_{k=1,k\neq i}^{n} r(x_i, x_k) = \frac{1}{n-1}\bigoplus_{k=1,k\neq i}^{n} r_{ik} \tag{3.10}$$

(2) The intuitionistic fuzzy negative outranking flow:

$$\tilde{\varphi}^{-}(x_i) = \frac{1}{n-1}\bigoplus_{k=1,k\neq i}^{n} r(x_k, x_i) = \frac{1}{n-1}\bigoplus_{k=1,k\neq i}^{n} r_{ki} \tag{3.11}$$

4. Application in Education

In this study, it is aimed to present a unique system that combines intuitionistic fuzzy sets and decision-making methods in the field of education. Both the exam success and psychological characteristics of the students were taken into consideration and evaluated. Along with the exam results, their psychological characteristics were evaluated by guidance teachers. For total 9 criteria; in addition to the success of the students in Turkish, Mathematics, Science and Social courses, their characteristics such as academic motivation, text anxiety, family relationship, sociability and technology approach were rated by their guidance counselors. The values in Table 1 were determined according to the exam success of the students and the evaluation results of the guidance teachers. Guidance teachers evaluated the students with questions they prepared themselves in order to measure the social, psychological and cultural aspects of the students. The values in the table were obtained accordingly.

The alternatives and criteria that form the basis of our algorithm are as follows: $A = \{A_1, A_2, A_3, A_4, A_5, A_6, A_7, A_8, A_9, A_{10}, A_{11}, A_{12}, A_{13}, A_{14}, A_{15}\}$ being set of alternatives, each alternative represents a student. $K = \{K_1, K_2, K_3, K_4, K_5, K_6, K_7, K_8, K_9\}$ being set of criteria. The criteria are represented as follows: Turkish, Mathematics, Science, Social courses, Academic motivation, Text anxiety, Family relationship, Sociability, Technology approach.

The value of each criterion for each alternative is calculated as follows in Table 1:

	$K1$	$K2$	$K3$	$K4$	$K5$	$K6$	$K7$	$K8$	$K9$
$A1$	24	11	25	12	10	6	5	7	7
$A2$	25	12	11	1	11	11	5	8	5
$A3$	21	6, 5	19	2	6	5	5, 5	10	6
$A4$	18, 5	13	12	10	2	6	7, 5	6	6
$A5$	20	7	15	2	5	9, 33	8, 5	5	8
$A6$	18	0	9	9	2	7, 66	7	4	7
$A7$	25, 5	1	8	5	4	7	5	6	8
$A8$	19	4	15	11	7	8	5	7	4
$A9$	17, 5	10	2	10	10	9, 33	9	8	9
$A10$	22	6	1	6	5	7	8	9	7
$A11$	16, 5	8, 5	3	3	11	8, 33	8	10	9
$A12$	9	5	1	2	12	8, 33	7	9	9
$A13$	8	6	2	4	5	7	6	9	8
$A14$	8	1	5	5	7	5	5	8	5
$A15$	28	1	19	3	11	4	4	8	4

TABLE 1. Values of Alternatives by Criteria

In this study, criterion weights were calculated in linguistic terms. The weights of the criteria are as follows: Criterion 1 and Criterion 2 are very important, Criterion 3, Criterion 4, Criterion 5 are important, Criterion 6 and Criterion 7 are medium, Criterion 8 and Criterion 9 are important.
Net outranking flow values are specified as follows:

$\rho(\tilde{\varphi}(x_1)) =$	-0,00060639
$\rho(\tilde{\varphi}(x_2)) =$	-0,00002504
$\rho(\tilde{\varphi}(x_3)) =$	0,00000049
$\rho(\tilde{\varphi}(x_4)) =$	0,00000016
$\rho(\tilde{\varphi}(x_5)) =$	0,00000140
$\rho(\tilde{\varphi}(x_6)) =$	0,00013783
$\rho(\tilde{\varphi}(x_7)) =$	0,00008569
$\rho(\tilde{\varphi}(x_8)) =$	0,00000230
$\rho(\tilde{\varphi}(x_9)) =$	-0,00045314
$\rho(\tilde{\varphi}(x_{10})) =$	0,00000696
$\rho(\tilde{\varphi}(x_{11})) =$	-0,00009627
$\rho(\tilde{\varphi}(x_{12})) =$	-0,00000030
$\rho(\tilde{\varphi}(x_{13})) =$	0,00010351
$\rho(\tilde{\varphi}(x_{14})) =$	0,00155834
$\rho(\tilde{\varphi}(x_{15})) =$	0,00000004

TABLE 2. Intuitionistic Fuzzy Net Outranking Flow Values

When the students evaluated with the system created in our study are ranked according to their net flow values, the most successful student is A_1 and the least successful student is A_{14}. Students' achievements can be based on intuitionistic fuzzy net flow values. The lower the net flow value, the higher the student achievement.

5. CONCLUSION

In this study, an application of the intuitionistic fuzzy PROMETHEE method was developed to evaluate student achievements in education. A system has been created to evaluate student success in line with the students' course success and the opinions of their guidance counselors.

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References

[1] L.A. Zadeh, Fuzzy Sets , Information and Control, Vol.8, pp.338-353, (1965).
[2] K.T. Atanassov, Intuitionistic fuzzy sets, Fuzzy Sets and Systems, Vol.20, No.1, pp.87-96, (1986).
[3] K.T. Atanassov, K.T. Intuitionistic Fuzzy Sets, VII ITKR.s Session, Sofia., June, (1983).
[4] J.P. Brans, L'ingenierie de la decision: l'elaboration d'instruments d'aide a la decision. Colloq. d'aide a la decision, Universite Laval, Quebec, Canada, Aou, (1982).
[5] J.P. Brans, B. Mareschal, Chapter 5: PROMETHEE Methods. In:Multiple Criteria Decision Analysis: State of the Art Surveys. International Series in Operations Research- Management Science, Vol.78, Springer, New York, NY., (2005).
[6] J.P. Brans, P. Vincke, A Preference Ranking Organisation Method (The PROMETHEE Method for Multiple Criteria Decision Making). Management Science, Vol.31, No.6, pp.647-656, (1985).
[7] A. Albadvi, Formulating national information technology strategies: A preference ranking model using PROMETHEE method. European Journal of Operational Research, Vol.153, pp.290-296, (2004).
[8] A. Albadvi, S.K. Chaharsooghi, A. Esfahanipour, Decision making in stock trading: An application of PROMETHEE. European Journal of Operational Research, Vol.177, pp.673-683, (2007).
[9] M. Behzadian, RB. Kazemzadeh, A. Albadvi, M. Aghdasi, PROMETHEE:A comprehensive literature reviewon methodologies and applications. European Journal of Operational Research, Vol.200 pp.198-215, (2010).
[10] J.P. Brans, B. Mareschal, P. Vincke, PROMETHEE: a new family of outranking methods in multicriteria analysis. Operational Research, IFORS Vol.84, pp.477-490, (1984).
[11] G. Çuvalcıoğlu, Controlled Set Theory, Bogolyubov Readings DIF-2013, Ukraine, pp.342, (2013).
[12] G. Çuvalcıoğlu, The extension of modal operators' diagram with last operators, Notes on Intuitionistic Fuzzy Sets, Vol.19, No.3, pp.56-61 (2013).

[13] G. Çuvalcıoğlu, Some Properties of Controlled Set Theory, Notes on Intuitionistic Fuzzy Set, Vol.20, No.2, pp.37-42, (2014).

[14] G. Çuvalcıoğlu, E. Aykut, An Application Of Some Intuitionistic Fuzzy Modal Operators To Agriculture, Notes on IFS, Vol.21, No.2, pp.140-149, (2015).

[15] G. Çuvalcıoğlu, V. Bureva, A. Michalíková, Intercriteria Analysis Applied To University Ranking System Of Turkey, Notes on Intuitionistic Fuzzy Sets, Vol.25, No.4, pp.90-97, (2019).

[16] N. Halouani, H. Chabchoub, JM. Martel, PROMETHEEMD- 2T method for project selection, European Journal of Operational Research, Vol.195, pp.841-849, (2009).

[17] R. Krishankumar, KS. Ravichandran, A.B., Saeid, A New Extension to PROMETHEE Under Intuitionistic Fuzzy Environment For Solving Supplier Selection Problem With Linguistic Preferences, Vol.60, pp.564-576, (2017).

[18] H.C. Liao, Z.S. Xu, Priorities of Intuitionistic Fuzzy Preference Relation Based on Multiplicative Consistency, IEEE Transactions on Fuzzy Systems, Vol.22, No.6, pp.1669-1681, (2014).

[19] H.C. Liao, Z.S. Xu, Some Algorithms For Group Decision Making With Intuitionistic Fuzzy Preference Information, International Journal of Uncertainty Fuzziness and Knowledge-Based Systems, Vol.22, No.4, pp.505-529, (2014).

[20] H.C. Liao, Z.S. Xu, Multi-Criteria Decision Making with Intuitionistic Fuzzy PROMETHEE, Journal of Intelligent Fuzzy Systems, Vol.27, pp.1703-1717, (2014).

[21] M. Majumder, Multi Criteria Decision Making, Chapter 2, Springer, pp.35-47, (2015).

[22] E. Szmidt, J. Kacprzyk, Amount Of Information And Its Reliability In The Ranking Of Atanassov'S Intuitionistic Fuzzy Alternatives, in: E. Rakus-Andersson, R.R. Yager, N. Ichalkaranje, L. Jain, ed. Recent advances in decision making (Studies in Computational Intelligence), Berlin, Germany: Springer, pp.7-19, (2009).

[23] F. Tuğrul, M. Çitil, S. Balcı, On The Determination Students' Aptitude Using Intuitionistic Fuzzy Logic, Journal of Universal Mathematics, Vol.2, No.1, pp.36-41, (2019).

[24] F. Tuğrul, M. Çitil, B. Karasolak, M. Dağlı, Interpretation of Physical Conditions of Schools with Fuzzy Multi Criteria Decision Making, Journal of Universal Mathematics, Vol.3, No.1, pp.46-52, (2020).

[25] F. Tuğrul, Application of Intuitionistic Fuzzy Logic with a New Method in Multi Criteria Decision Making Process. Ph.D. Thesis. Kahramanmaraş Sütcü İmam University, 2021.

[26] F. Tuğrul, M. Çitil, A New Perspective on Evaluation System in Education with Intuitionistic Fuzzy Logic and PROMETHEE Algorithm. Journal of Universal Mathematics. 4(1):13-24, 2021.

[27] F. Tuğrul, Evaluation of Papers According to Offset Print Quality: The Intuitionistic Fuzzy Based Multi Criteria Decision Making Mechanism, Pigment & Resin Technology, https://doi.org/10.1108/PRT-04-2022-0059, (2022).

[28] F. Tuğrul, Personnel Selection Utilizing The Decision Making Mechanism Created with The Intuitionistic Fuzzy TOPSIS Method, Mugla Journal of Science and Technology, Vol.8, No.2, pp.16-21, (2022).

[29] F. Tuğrul, An Approach Utilizing The Intuitionistic Fuzzy TOPSIS Method To Unmanned Air Vehicle Selection, Ikonion Journal of Mathematics, Vol.4, No.2, pp.32-41, (2022).

[30] F. Tuğrul, An Evaluation of Supermarkets From the Lens of Multiple Criteria: The Intuitionistic Fuzzy TOPSIS Method, Black Sea Journal of Engineering and Science, Vol.5, No.4, pp.146-150, (2022).

[31] F. Tuğrul, An Innovative Application on Supermarket Selection Through Using Intuitionistic Fuzzy TOPSIS Method, Sakarya University Journal of Science, Vol.26, No.5, pp.2029-2039, (2022).

[32] F. Tuğrul, M. Çitil, Application of Mathematical Modeling in Multi Criteria Decision Making Process: Intuitionistic Fuzzy PROMETHEE, Journal of Mathematical Sciences and Modelling, Vol.5, No.2, pp.48-56, (2022).

[33] F. Tuğrul, M. Çitil, An Innovative Approach to the Intuitionistic Fuzzy PROMETHEE Method, New Trends in Mathematical Sciences, Vol.10, No.4, pp.63-79, (2022).

[34] Z.J. Wang, Derivation Of Intuitionistic Fuzzy Weights Based On Intuitionistic Fuzzy Preference Relations, Applied Mathematical Modelling, Vol.37, pp.6377-6388, (2013).

[35] Z.S. Xu, R.R. Yager, Some Geometric Aggregation Operators Based On Intuitionistic Fuzzy Set, International Journal of General Systems, Vol.35, pp.417-433, (2006).

[36] Z.S. Xu, Intuitionistic Fuzzy Aggregation Operators, IEEE Transactions on Fuzzy Systems, Vol.15, pp.1179-1187, (2007).

[37] Z.S. Xu, Intuitionistic Preference Relations And Their Application In Group Decision Making, Information Sciences, Vol.177, No.11, pp.2363-2379, (2007).
[38] Z.S. Xu, H.C. Liao, Intuitionistic Fuzzy Analytic Hierarchy Process, IEEE Transactions on Fuzzy Systems, Vol.22, No.4, pp.749-761, (2014).
[39] K.J. Zhang, C. Kluck, G. Achari, A Comparative Approach For Ranking Contaminated Sites Based On The Risk Assessment Paradigm Using Fuzzy PROMETHEE, Environmental Management, Vol.44, pp.952-967, (2009).

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