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Abstract: In this study a decision making model through Neutrosophic Q-fuzzy set has been designed. During Covid-19 – Pandemic situation, education sector is stabilizing its work through online mode. Information Communication Technology (ICT) platforms offer many opportunities for the academicians and Learners. This study intends to analyse the selection of best ICT tool by fixing important criteria. The selection of optimal ICT tool is scrutinized in this study using Significant Score of a Neutrosophic fuzzy number.

Keywords: Information Communication Technology, Neutrosophic Set, Neutrosophic Q- fuzzy set, Neutrosophic Q- fuzzy decision set, Neutrosophic fuzzy number, Significant Score of a NFN

1. Introduction

Education Sector plays a vital role in the digital transformation and embraces the changes during Covid-19 Pandemic situation. In the 21st century, education sector slowly moves to the online education. Many educationists apply ICTs application in online education. Especially during lock down period, ICTs help the Academicians and Learners to balance the teaching – learning process. Yusuf M.O. [25] analyzed about the policy implications in Nigerian education system. The system offered maximum use of ICT potential in the schooling system itself. Neeti Roy [17] analyzed the ICT act as student centered - learning settings. It adopted

the general component in teaching and learning process. It helps to enhance the quality and accessibility of education. It aims to learning motivation. Sivakumar Ramaraj [19] explored role of ICT has strong impact on teaching learning in 21st Century. Vibha Thakur et al. [24] studied about transmission of ICT in the field of teaching and learning system by implementing e-learning, virtual learning, e-meeting and e-collaboration. ICT tools integrate, enhance and interact with wide coverage of learning and teaching. It helps the learners to gain the knowledge in the wider range though they are in distant mode.

Many ICT platforms and research are developed and emerged into the market. The tools support the educators to transfer the ideas into implications. During this pandemic situation, the tools act as a bridge between the learners and teachers. It is inevitable to note the application of tools in the education sector effectively. For this purpose, the researchers intend to analyze the different characteristics of ICT tools which are very commonly used in the Academic platform. To identify the optimal ICT tool, this study wants to apply Neutrosophic Q-fuzzy set. Various properties enhance the education system using ICT. The major criteria have been selected for ICT tool which shows the higher ability of it. The Criteria helps to make decision on the application of ICT tools in teaching – learning process. To improve the accuracy in decision making, several types of fuzzy sets are applied in different situations. Muthumeenakshi et al.[15,16] applied the notions fuzzy soft set and bipolar valued Q-fuzzy set to design some multi criteria decision making models. Zhikang Lu[28] used intuitionistic fuzzy values for decision-making method. Smarandache[20.21] generalized the intuitionistic fuzzy set into Neutrosophic Set. After the invention of Neutrosophic settings, the notion is explored by the authors of [7,8,9,12,14,23] in various decision making problems. Later Mohseni et al.[11] introduced MBJ – Neutrosophic structure and applied it in BCK/BCI algebras. As an initiation, Surya et al.[22] applied MBJ – Neutrosophic structure in β-algebra. Recently in [10,13,18] also the concept of Neutrosophic set is applied to evaluate the management of internal control, applications to Multi-Criteria Decision-Making, solving the Fully Neutrosophic Linear Programming Problems.

With all these motivations, this paper incorporates the application of Neutrosophic Q- fuzzy set for the ideal selection of ICT tool in the education sector.

2. Preliminaries

This section discussed the essential notations for the construction of the model in this study.

2.1 Definition: [26, 27] A fuzzy set in an nonempty set Ψ is a mapping, $\omega : \Psi \to [0,1]$ for each x in Ψ, $\omega(x)$ is called the membership value of x .

2.2 Definition: [6] An intuitionistic fuzzy set in an non – empty set Ψ is defined by the structure $A = \{ < x, \omega_A(x), \lambda_A(x) > | \, x \in \Psi\}$, where $\omega_A : \Psi \to [0,1]$ is a membership function of A and $\lambda_A : \Psi \to [0,1]$ is a non – membership function of A with $0 \leq \omega_A + \lambda_A \leq 1$.

2.3 Definition: [20, 21] The term Neutrosophic Fuzzy Set N on a nonempty set Φ is is the structure of the form $\mathrm{N} = \{< x, \zeta_{\mathrm{N}}(x), \xi_{\mathrm{N}}(x), \eta_{\mathrm{N}}(x) > | \, x \in \Phi\}$ characterized by a truth – membership function ζ_{N} , an indeterminacy membership function ξ_{N}, and a falsity – membership function η_{N}, where $\zeta_{\mathrm{N}}, \xi_{\mathrm{N}}, \eta_{\mathrm{N}} : \Phi \to [0,1]$.

2.4 Definition: [16] A Q -fuzzy subset μ in a non-empty set X is a function $\mu: X \times Q \longrightarrow [0,1]$, where Q is any non-empty set.

2.5 Definition: [16] A Q-fuzzy decision (QFD) set of X denoted by QF_X^D and is defined by $QF_X^D = \left\{ \mu_{QF_X^D}(x) \,\middle|\, x \in X \right\}$ which is a fuzzy set over X and its membership function $\mu_{QF_X^D}$ is defined by $\mu_{QF_X^D}: X \longrightarrow [0,1]$, where $\mu_{QF_X^D}(x) = \frac{1}{|\mathrm{K}|}\sum_{j=1}^{n} \mu_X(x, q_j)$. Here $q_j \in Q$ and K is number of characteristics which influences the particular population.

3. Neutrosophic Q -Fuzzy Decision Set

3.1 Definition: A Neutrosophic-Q-Fuzzy Set (NQFS) Ω, in a non-empty set Γ is defined as an object of the form $\Omega = \{< (x,q), \zeta_\Omega(x,q), \xi_\Omega(x,q), \eta_\Omega(x,q) > | \, (x,q) \in \Gamma \times Q\}$, where ζ_Ω , ξ_Ω , $\eta_\Omega : \Gamma \times Q \to [0,1]$ represents the truth membership function, intermediate membership function and false membership function of Ω respectively.

3.2 Definition: For the Neutrosophic Set $\mathrm{N} = \{< x,\ \zeta_{\mathrm{N}}(x),\ \xi_{\mathrm{N}}(x),\ \eta_{\mathrm{N}}(x) > \mid x \in \Phi\}$ in Φ, the triple $\langle \zeta_{\mathrm{N}},\ \xi_{\mathrm{N}},\ \eta_{\mathrm{N}} \rangle$ is called Neutrosophic Fuzzy Number(NFN) and is denoted by N_x.

3.3 Definition: The Significant Score of a NFN, $\mathrm{N}_x = \langle \zeta_{\mathrm{N}},\ \xi_{\mathrm{N}},\ \eta_{\mathrm{N}} \rangle$ is defined as $SS(\mathrm{N}_x) = \left(\zeta_{\mathrm{N}_x} - \eta_{\mathrm{N}_x} + \left(\frac{\xi_{\mathrm{N}_x}}{2}\right)\right)\left(1 - \left(\zeta_{N_x} - \eta_{N_x} + \left(\frac{\xi_{N_x}}{2}\right)\right)^2\right)$. This SS is used to identify an ideal solution from the various likewise objects of the given population.

3.4 Definition: A Neutrosophic Q-Fuzzy Decision (NQFD) set of Γ is defined by $NQF_{\Gamma}^{p} = \left\{ \left(\zeta_{\mathrm{N}QF_{\Gamma}^{p}}(x)\ ,\ \xi_{\mathrm{N}QF_{\Gamma}^{p}}(x)\ ,\eta_{\mathrm{N}QF_{\Gamma}^{p}}(x) \right) \middle|\ x \in \Gamma \right\}$ which is a Neutrosophic fuzzy set over Γ, where $\zeta_{\mathrm{N}QF_{\Gamma}^{p}} : \Gamma \longrightarrow [0,1]$, $\xi_{\mathrm{N}QF_{\Gamma}^{p}} : \Gamma \longrightarrow [0,1]$ and $\eta_{\mathrm{N}QF_{\Gamma}^{p}} : \Gamma \rightarrow [0,1]$ are the truth membership function, intermediate membership function and false membership function and respectively with $\zeta_{\mathrm{N}QF_{\Gamma}^{p}}(x) = \frac{1}{|\mathrm{K}|}\sum_{j=1}^{n} \zeta_{\mathrm{N}\Gamma}(x, q_j)$; $\xi_{\mathrm{N}QF_{\Gamma}^{p}}(x) = \frac{1}{|\mathrm{K}|}\sum_{j=1}^{n} \xi_{\mathrm{N}\Gamma}(x, q_j)$ and $\eta_{\mathrm{N}QF_{\Gamma}^{p}}(x) = \frac{1}{|\mathrm{K}|}\sum_{j=1}^{n} \eta_{\mathrm{N}\Gamma}(x, q_j)$. Here $q_j \in Q$ and K is number of characteristics which influences the particular population.

4. Ideal selection using Neutrosophic Q-Fuzzy Decision set

In this section, the responses from the Academicians and Learners are analyzed. The optimal selection of the ICT tool will be decided using Neutrosophic Q-Fuzzy Decision (NQFD) set. Based on the Experts' advice five major Criteria have been fixed for the ICT tool in E- Learning Process. The criteria are named as F1, F2, F3, F4 and F5 which are taken as the factor and the five different types of ICT tools are compared; E1, E2, E3, E4, E5. The commonly used ICT tools are selected based on the experts' opinion. These tools have different application strategy with wide range coverage. Here, the factors to be considered for the optimal selection process are Easy Access (F1), Advanced Features (F2), Consumption of Bytes (F3), Less Interruption (F4), and Allowable Participants (F5). For each factor, four questions were asked to the respondents. Totally twenty items were analyzed with the application of NQFD set. These twenty items directly or indirectly collate the opinion of the respondents in the education sector about the ICT application. The items are designed with the three point Likert Scale.

The Scales are Satisfied, Neutral and Dissatisfied. Satisfied referred to Truth membership value, Neutral denotes Intermediate membership value and Dissatisfied denotes False membership value.

The following procedure has been introduced for the purpose of selection.

1. Construct NQFS over X.
2. Build NQF_{Γ}^{D}.
3. Find SS (NQF_{Γ}^{D}) .
4. Interpretation.

Here $\Gamma = \{E1, E2, E3, E4, E5\}$ and $Q = \{F1, F2, F3, F4, F5\}$

Step 1: To apply NQFS for the selection of ICT tool in E-Learning process, the universal set Γ and the non-empty set Q of characteristics are designed as follows.

The responses are applied in the algorithm and values are calculated accordingly. Each characteristic is analyzed with four items in the form of statements. The google form has been structured and distributed to hundred respondents. The respondents are Academicians and Learners. The total satisfactory responses from the respondents for each statement are divided with number of respondents, i.e. 100. Likewise the total dissatisfactory and neutral responses are considered for the analysis.

Step 2: Truth, Intermediate and False Membership values have been assigned based on Step 1 Procedure. The following table shows the respective membership values for the optimal selection of ICT in E-Learning.

Table 1: Neutrosophic membership values

$\Gamma \rightarrow$ $Q \downarrow$	E_1	E_2	E_3	E_4	E_5
F_1	(0.43 ,0.23 , 0.34)	(0.36 , 0.32 , 0.32)	(0.57 , 0.21 , 0.22)	(0.70 , 0.14 , 0.16)	(0.63 , 0.21 , 0.16)
F_2	(0.45 , 0.30 , 0.25)	(0.47 , 0.32 , 0.21)	(0.52 , 0.29 , 0.19)	(0.61 , 0.21 , 0.18)	(0.53 , 0.23 , 0.24)
F_3	(0.36 , 0.42 , 0.22)	(0.41 , 0.20 , 0.39)	(0.49 , 0.24 , 0.27)	(0.69 , 0.21 , 0.10)	(0.30 , 0.50 , 0.20)
F_4	(0.38 , 0.32 , 0.30)	(0.40 , 0.21 , 0.39)	(0.60 , 0.20 , 0.20)	(0.72 , 0.21 , 0.07)	(0.50 , 0.32 , 0.18)
F_5	(0.34 , 0.31 , 0.35)	(0.31 , 0.32 , 0.37)	(0.43 , 0.32 , 0.25)	(0.82 , 0.12 , 0.06)	(0.62 , 0.21 , 0.17)

Step 3: The NQF_Γ^D has been attained using the definition 3.4.

$$NQF_\Gamma^D = \{(0.392 , 0.316, 0.292)/ E_1 , (0.390 , 0.274, 0.336)/ E_2 ,$$
$$(0.522 , 0.252, 0.226)/ E_3 , (0.708 , 0.178, 0.114)/ E_4$$
$$(0.516 , 0.294, 0.190)/ E_5 \}$$

Step 4: The Significant Score for all E_i's are identified as using the definition 3.3.

$SS(E_1) = 0.2376$

$SS(E_2) = 0.1840$

$SS(E_3) = 0.3468$

$SS(E_4) = 0.3644$

$SS(E_5) = 0.3672$

5. Conclusion

In Education Sector, ICT plays a vital role especially during Covid19 situation. Many ICT tools are in the education arena. Each ICT tool gives benefits with some unique characteristics. The very important and common usages of characters are considered as the criteria for the analysis. For the optimal selection of ICT tool, the Academicians and Learners are using different

strategies in the Technology. In this study, Neutrosophic Q-Fuzzy Decision set has been used by considering the positive, intermediate and negative values of the responses from the Academicians and Learners opinions. The values are taken in the relative measures and applied in the Neutrosophic Q-Fuzzy Decision set. The result of the analysis revealed that the ICT (E5) is the best option which includes all the important characters of Tech tool for teaching and learning at the optimal level. This application enhances the opinion results and helps in decision making in the ICT tool selection and it can be explored in other such decision making scenarios.

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