A Neutrosophic AHP Analysis for Using Video Conferences in Smart Learning: A Systematic Review

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Abstract

There is evidence that students feel less involved in distance learning, which needs more work from their educators. While distance education allows learners to feel less reluctant and/or timid to ask questions, there is also evidence that students feel less interested in distance education. Students may obtain information and knowledge at their own pace and convenience via the use of distance education. Also, it may assist in reaching the same overall performance and ultimate score as would be achieved via face-to-face instruction. The goal of this study analyzes the performance of video conferences in smart learning. This analysis contains many criteria, so the concept of multi-criteria decision-making is integrated with the neutrosophic sets to overcome uncertain information. We used the neutrosophic AHP to show the importance of each criterion. There are seven criteria used in this paper. The findings demonstrated that the utilisation of video conferences enabled students to gain access to information and educational resources, had a positive effect on the students' constructing knowledge and critical reflection, and resulted in the students reporting an extremely positive learning experience in the context of smart learning.

Keywords: AHP; Video Conferences; Smart Education; Neutrosophic Sets; MCDM

1. Introduction:

Microsoft Teams (MS Teams) is a communication tool that is linked with Microsoft Office 365. This technological tool might be used throughout the whole institution, or it could be used only for certain programmes in smart learning. Teams has been put to use in a variety of educational contexts, including traditional classroom settings, hybrid classrooms, and fully online classrooms. The programme has several functions, like the ability to hold meetings, participate in video conferences, and save files. The participants of the MS Team can construct virtual courses and manage them in the same manner as actual classes, allowing students to engage in conversation with both their peers and their professors. This contact may actually occur via online class sessions, chat, posting, or even online evaluation. Students and teachers are able to connect online via the use of Teams in a variety of ways that are not generally seen on a conventional LMS. In addition, Microsoft Teams is regarded as a super application since it combines a number of various applications, such as online meetings, videos, chats, and evaluations, into a single software.[1]–[3]

MS Teams has a number of benefits, some of which include the desire for students to be more disciplined, the ease with which students may connect with their classmates and instructors, and the best assistance for creating an appropriate smart learning environment for students. In comparison to other communication platforms, Microsoft Teams is a superior tool for online education and smart learning. Microsoft Teams is an excellent programme for

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smart learning; it is time and resource efficient, and it helps students become more enthusiastic about their academic pursuits[4], [5].

Webex is a video conferencing and collaboration platform that allows users to conduct online meetings, webinars, and virtual classrooms. It offers features such as screen sharing, recording, virtual whiteboards, and breakout rooms, which make it a great tool for online teaching and learning. With Webex, teachers can conduct live classes and engage with students in real-time, using features like chat, polls, and quizzes. They can also share their screen to show presentations, videos, or other materials. Students can attend classes from anywhere using their computer or mobile device, and participate in discussions and group activities. Webex also provides the option for teachers to record their classes, making it easy for students to review the material later.Overall, Webex is a versatile and reliable tool for online teaching and learning, and is used by many educational institutions around the world.
Zoom is an audio and video software that allows for interactivity and is built on cloud technology. The usage of the software that was formerly reserved almost exclusively for conducting video conferences between different companies and other kinds of meetings has recently spread into the realm of education. Due in great part to the advent of Zoom technology, the days of students physically congregating in classrooms to get instruction are essentially in the past. Learners of the modern day who were born into the digital age are often acquainted with Zoom technology and the know-how to utilise it. At this current juncture, it is essential to take into consideration the effectiveness of doing remote video lessons utilising Zoom[6]–[8]. All these tools are synchronous tools which instructor-facilitated and require all participants virtual present and well engaged with course activities. [27]

The term "social studies" refers to a subject matter category that incorporates a wide range of academic fields, including "anthropology, archaeology, economics, geography, history, law, philosophy, political science, psychology, religion, and sociology, as well as appropriate from the humanities, mathematics, and natural sciences." The goal of education in the social sciences is to foster the growth of knowledgeable individuals who are equipped with the capacity for critical thought that is essential for development in-demand skills such as a critical thinking to participate effectively in building society.[26]

In order to provide a fresh perspective on ambiguity, confusion, irregularity, and inconsistency, Florantin Smarandache's neutrosophic sets expand the notion of intuitionistic fuzzy sets (IFSs), which was first presented by Atanassov. Smarandache described a neutrosophic set as having three components: truth, indeterminacy, and falsity. He also added the level of indeterminacy as a new and distinct component of fuzzy sets. When used in decision-making, neutrosophic sets have the potential to give superior outcomes due to the fact that the indeterminacy parameter helps provide a more thorough characterization of membership functions. On the other hand, using a neutrosophic set in actual scientific and technical disciplines is a more complicated endeavour. The distinction between objective fact and relative truth, as well as absolute falsity and relative falsity in logics, and, including both, among absolute membership and comparative membership, or complete non-membership and comparative non-membership, can be made with the assistance of neutrosophic logic, which is an extremely helpful tool. When neutrosophic sets are favoured, a decision maker is relieved of the need to ensure that the total number of components in a membership function for a particular event is no more than one. If those components may be considered separate, the total might reach 3 in such cases [9].

The Analytic Hierarchy Process, or AHP, was first conceived of and developed by Saaty. It is a well-known technique for dealing with difficult issues by first breaking them down into more manageable sub-issues and then combining the answers to these individual issues. Making sure that the judgements are consistent is given a significant amount of weight in this methodology, which is based on making comparisons between different pairs of experts. AHP method employed with the Neutrosophic sets to compute the weights of criteria. The neutrosophic AHP method is used to analyse the criteria of social studies and give its importance of it[10], [10], [11].

The second section of this paper presents the literature review. The third Section provides an explanation of the neutrosophic AHP method. The fourth Section provides the case study. Finally, the conclusion is presented in the last section.

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2. Literature Review:

The assessment of a teacher's teaching ability is vital for the advancement of instructors, the choice of courses by students, and the status of educational institutions. By integrating the Method for Order of Preference by Similarity to the Ideal Solution, often known as TOPSIS, with the single-valued neutrosophic set, Wu and Fang[12] were able to develop a multilevel assessment method for teaching quality in higher education. This was accomplished (SVNS). The teaching performance as well as the learning results of the students were included in an indicator system that was developed. An SVNS representation approach was suggested for the scores of the qualitative indicators. This was done to describe the ambiguity, which in turn would increase the validity and reliability of the assessment. The TOPSIS-based multilevel evaluation process, which comprised an overall assessment as well as five specialised assessments, was then used for both the qualitative information as well as the quantitative data. The previous evaluation would produce a final rank and identify the most qualified instructors who would be given more consideration for rewards and promotions. The latter would concentrate on pointing out how the instructors may improve their performance and would provide suggestions to help them deal with the difficulties they face. In conclusion, an illustrative case study was presented as a means of validating the suggested framework and illustrating the usefulness of the latter.

Mamites et al[13]. analyzed the components that affect teaching quality in order to discover the causal linkages between these variables and, ultimately, to pinpoint those ones that are most important. The neutrosophic decision-making trial and evaluation laboratory, or DEMATEL, the approach is used to simulate these characteristics in the context of public colleges in the Philippines. The DEMATEL manages the causal linkages among the aspects of teaching quality, whereas SVNSs are used to mimic the ambiguity connected with domain specialists soliciting judgements inside the DEMATEL. Using plithogenic numbers and the operators associated with them, Rodriguez et [14]al. provided a fresh approach to the examination of the topic of "Education and Society." The professors will be able to conduct the assessments by making use of normal language. In the same manner, the findings will be delivered by means of a linguistic scale, which will make it easier to interpret and depict the assessments. Castro et al. [15] investigated the factors that influence the growth of educational opportunities by means of a neutrosophic statistical analysis including the use of plithogenic sets. They analysed the educational system in Ecuador in order to understand how it affects the educational reality of the nation. They gathered the viewpoints and experiences of educators and conducted the analysis. The researchers Martinez et al. [16]processed the data using a technique called Neutrosophic Statistics, which is an extension of statistical approaches that the realm of interval values to demonstrate the effect that education has on one's quality of life. In order to examine the current level of knowledge, they made use of a questionnaire that had seven items. A novel approach to decision-making procedure using Hausdorff distance and Hausdorff similarity measures built on generalised set-valued neutrosophic quadruple integers was proposed by Sevilay[17] and colleagues. They presented an innovative approach to judgement as it relates to the influence that online learning has on the student. Yilmaz et al. [3]conducted research to determine the factors that influence the viability of distance education (DE) in universities of higher education. Additionally, they sought to recognize the differences in the viewpoints of many team members in DE by using a combined group decision making strategy that incorporated both the neutrosophic AHP and the Copeland method. An in-depth literature analysis and the views of industry professionals are used to determine the variables that influence the DE's capacity to be sustainable.

Yi Wu and colleagues[18] came up with the idea for the research to figure out how to properly weight the performance assessment indices for higher education according to the official performance assessment procedure. To determine the relative importance of each factor, they used the AHP. The purpose of their research was to assist academic institutions in improving their operational effectiveness. Using the TOPSIS, Bizzo et al. [19]proposed an educational performance evaluation of state-level units. They dealt with the epistemic ambiguity surrounding the notion of weight by making use of the greatest information entropy. According to the findings, there is a positive connection between academic achievement and gross domestic product (GDP), whereas there is a negative connection between academic achievement and infant mortality. The neutrosophic MULTIMOORA approach was introduced by Kutlu and Aydan[20] as a means of evaluating online learning software in relation to several crucial aspects that have a substantial impact on the level of satisfaction experienced by students. The purpose of their research is to draw attention to the variables that students believe are most important to ensure that the results of their online education are of good quality. They found assessment criteria, which included qualitative aspects, and we dealt with erroneous data including qualitative factors by using neutrosophic sets, which is an extension of the classic set. An investigation on the students pursuing legal careers was carried out by Carballido and colleagues[21], who looked at the higher

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education and humanistic elements. Statistics from the neutral philosophy are used here to illustrate how important these components are.

Understanding how to use current information technologies, in particular management information systems (MIS), in educational institutions has the potential to improve not only the efficiency of operations but also the promotion and development of the nation as a whole. Hosseini and colleagues[22] looked at the most significant obstacles in the way of MIS applicability. In their research, they made use of the MCDM. The research was carried out by Jasim et al. [23] to assist educators in making selections from the plethora of available multimedia options. The authors offered an overview of what exactly is meant by the term "multimedia" in the context of education and presented research evaluations of how effective these options are. They gave a thorough analysis of a selection of publications that are associated with the implementation of Multimedia in Educational Settings. In order to determine the impact that various kinds of educational multimedia approaches have from a pedagogical and instructional point of view, they used a method known as MACBETH, which is one of the MCDM methodologies. In order to justify the execution of the pedagogical approach for the development of the capacity to undertake a contribution to comprehensive education, Noel and his colleagues [24]designed and carried out the research. They assessed using a complicated approach that incorporates the Iadov neutrosophic logic, and they determined the transcendences of senior high education. Mondal and Pramanik [25]came up with a neutrosophic MCDM model for the purpose of teacher recruitment in higher education. The method is based on combination score accuracy functions. In the process of hiring new employees, eight factors derived from the views of industry professionals are taken into consideration. The criteria consist of things like academic achievement index, aptitude for teaching, topic expertise, strong academic background, leadership qualities, personality, managerial ability, and personal values. They utilised the scoring function, the accuracy function, as well as the combination score-accuracy function that SVNNs provide.

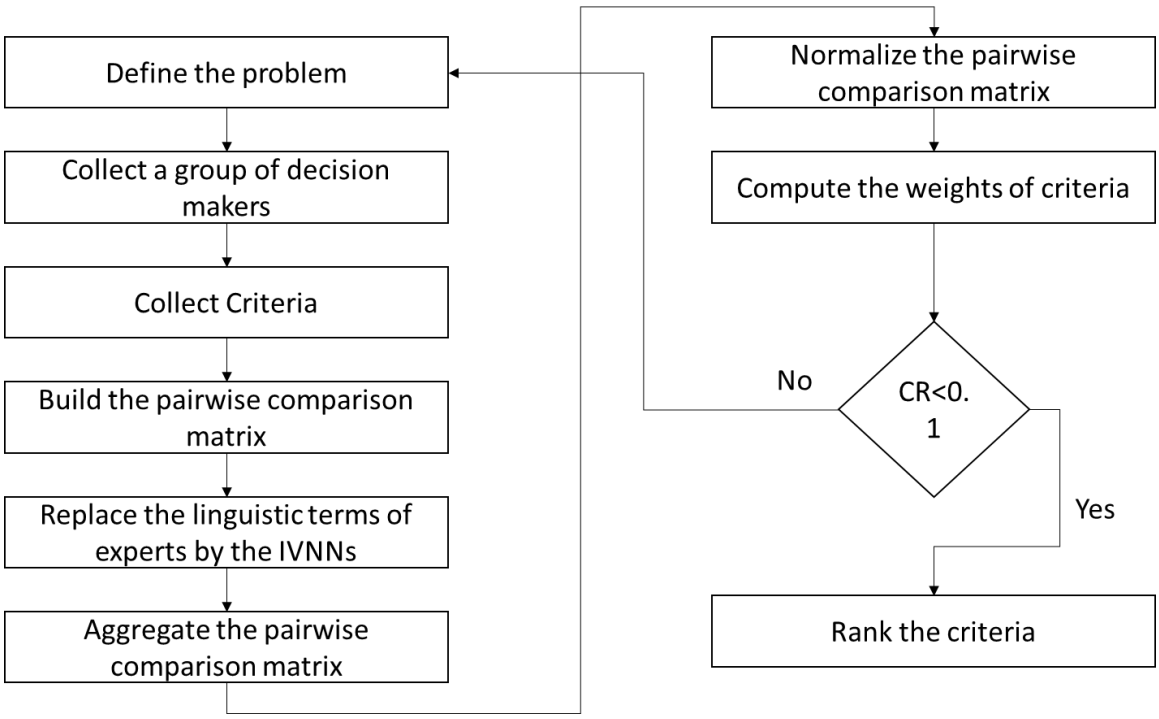

Figure 1: The framework of the neutrosophic AHP method

3. Neutrosophic AHP for analyzing educational decision making problems

The AHP methodology is founded on the logic of constructing an issue in power structures and then assessing the elements in the power structure through pairwise comparisons. Its base was laid by Myers and Alpert, and it was established and systematised by Thomas Saaty in the 1970s. Systematization is what brought the AHP method to literary works. While AHP is a strategy that is commonly used in MCDM situations, there are occasions when it is

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unable to accurately represent human reasoning. In contrast to traditional AHP, neutrosophic-AHP is able to effectively include human cognition into the decision-making process and powerfully represent uncertainty via the use of three variables. Neutrosophic approaches to the AHP technique have been used in a variety of investigations. Figure 1 shows the steps of the methodology. The neutrosophic-AHP procedure is broken down into the following phases.

Utilizing interval-valued neutrosophic sets, build the pairwise comparison matrices. Deneutrosophication of the pairwise comparison matrix is done so that the consistency may be checked. If it is found that the deneutrosophicated pairwise comparison matrix is consistent, then it is possible to say that the neutrosophic pairwise matrix is likewise consistent. The matrix representations of the pairwise comparisons of the parameters are as follows:

$$P = \begin{pmatrix} \langle [T_{11}^L, T_{11}^U], [I_{11}^L, I_{11}^U], [F_{11}^L, F_{11}^U] \rangle & \cdots & \langle [T_{1m}^L, T_{1m}^U], [I_{1m}^L, I_{1m}^U], [F_{1m}^L, F_{1m}^U] \rangle \\ \vdots & \ddots & \vdots \\ \langle [T_{m1}^L, T_{m1}^U], [I_{m1}^L, I_{m1}^U], [F_{m1}^L, F_{m1}^U] \rangle & \cdots & \langle [T_{mm}^L, T_{mm}^U], [I_{mm}^L, I_{mm}^U], [F_{mm}^L, F_{mm}^U] \rangle \end{pmatrix} \quad (1)$$

Where $i = 1,2, \dots m$ *criteria*

Compute the totals of the values in each column are as follows:

$$Sum_{ij} = \left(\left[\sum_{k=1}^m T_{kj}^L , \sum_{k=1}^m T_{kj}^U \right], \left[\sum_{k=1}^m I_{kj}^L , \sum_{k=1}^m I_{kj}^U \right], \left[\sum_{k=1}^m F_{kj}^L , \sum_{k=1}^m F_{kj}^U \right] \right) \quad (2)$$

After establishing the maximum value for each parameter, one divides each term by the element to which it is most closely related in order to produce normalised values.

$$Nor_{ij} = \left(\left[\frac{T_{kj}^L}{\sum_{k=1}^m T_{kj}^L}, \frac{T_{kj}^U}{\sum_{k=1}^m T_{kj}^U} \right], \left[\frac{I_{kj}^L}{\sum_{k=1}^m I_{kj}^L} , \frac{I_{kj}^U}{\sum_{k=1}^m I_{kj}^U} \right], \left[\frac{F_{kj}^L}{\sum_{k=1}^m F_{kj}^L}, \frac{F_{kj}^U}{\sum_{k=1}^m F_{kj}^U} \right] \right) \quad (4)$$

To get the neutrosophic important weight vector of the criterion, one calculates the mean of every row by using the formula:

$$W_j = \left(\frac{\left[\sum_{k=1}^m \frac{T_{kj}^L}{\sum_{k=1}^m T_{kj}^L}, \sum_{k=1}^m \frac{T_{kj}^U}{\sum_{k=1}^m T_{kj}^U} \right]}{m}, \frac{\left[\sum_{k=1}^m \frac{I_{kj}^L}{\sum_{k=1}^m I_{kj}^L}, \sum_{k=1}^m \frac{I_{kj}^U}{\sum_{k=1}^m I_{kj}^U} \right]}{m}, \frac{\left[\sum_{k=1}^m \frac{F_{kj}^L}{\sum_{k=1}^m F_{kj}^L}, \sum_{k=1}^m \frac{F_{kj}^U}{\sum_{k=1}^m F_{kj}^U} \right]}{m} \right) \quad (3)$$

4. Case Study on UAE students

- **Add tables and figures to analyse a case study about the student performance**

The methodology is applied to the UAE student's case study. The goal of this case study is to show the performance of video conferences in smart learning.

There are seven criteria used in this paper. Let experts evaluate these criteria. There are three experts to assess these criteria. The criteria are organized as:

1) Get access to various instructional and informational resources.
2) Encouragement and bolstering of efforts
3) Participants in the activities
4) Evaluation
5) Responses
6) Building up of one's knowledge
7) Experience

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The neutrosophic AHP method is used to compute the weights of criteria and show the importance of every criterion. The experts build the pairwise matrices by using interval-valued neutrosophic numbers as shown in tables 1-3. Then the sum of each column is to compute the normalization matrix. Then the normalization is computed by the division of each column value by each value of the criterion. The normalization matrix is shown in table 4. Then compute the weights of the criteria. The weights of the seven criteria are shown in figure 2. Criterion 7 is the highest importance and criterion 1 is the lowest importance.

Table 1: The first pairwise comparison matrix.

	$EductC_1$	$EductC_2$	$EductC_3$	$EductC_4$	$EductC_5$	$EductC_6$	$EductC_7$
$EductC_1$	1	<[0.7, 0.8] ,[0.15 ,0.25] ,[0.2 ,0.3]>	<[0.6, 0.7] ,[0.25, 0.35] ,[0.3, 0.4]>	<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>	<[0.6, 0.7] ,[0.25, 0.35] ,[0.3, 0.4]>	<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>	<[0.7, 0.8] ,[0.15 ,0.25] ,[0.2 ,0.3]>
$EductC_2$	1/<[0.7, 0.8] ,[0.15 ,0.25] ,[0.2 ,0.3]>	1	<[0.7, 0.8] ,[0.15 ,0.25] ,[0.2 ,0.3]>	<[0.6, 0.7] ,[0.25, 0.35] ,[0.3, 0.4]>	<[0.7, 0.8] ,[0.15 ,0.25] ,[0.2 ,0.3]>	<[0.3, 0.4] ,[0.65 ,0.75], [0.6, 0.7]>	<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>
$EductC_3$	1/<[0.6, 0.7] ,[0.25, 0.35] ,[0.3, 0.4]>	1/<[0.7, 0.8] ,[0.15 ,0.25] ,[0.2 ,0.3]>	1	<[0.6, 0.7] ,[0.25, 0.35] ,[0.3, 0.4]>	<[0.6, 0.7] ,[0.25, 0.35] ,[0.3, 0.4]>	<[0.7, 0.8] ,[0.15 ,0.25] ,[0.2 ,0.3]>	<[0.3, 0.4] ,[0.65 ,0.75], [0.6, 0.7]>
$EductC_4$	1/<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>	1/<[0.6, 0.7] ,[0.25, 0.35] ,[0.3, 0.4]>	1/<[0.6, 0.7] ,[0.25, 0.35] ,[0.3, 0.4]>	1	<[0.6, 0.7] ,[0.25, 0.35] ,[0.3, 0.4]>	<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>	<[0.7, 0.8] ,[0.15 ,0.25] ,[0.2 ,0.3]>
$EductC_5$	1/<[0.6, 0.7] ,[0.25, 0.35] ,[0.3, 0.4]>	1/<[0.7, 0.8] ,[0.15 ,0.25] ,[0.2 ,0.3]>	1/<[0.6, 0.7] ,[0.25, 0.35] ,[0.3, 0.4]>	1/<[0.6, 0.7] ,[0.25, 0.35] ,[0.3, 0.4]>	1	<[0.6, 0.7] ,[0.25, 0.35] ,[0.3, 0.4]>	<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>
$EductC_6$	1/<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>	1/<[0.3, 0.4] ,[0.65 ,0.75], [0.6, 0.7]>	1/<[0.7, 0.8] ,[0.15 ,0.25] ,[0.2 ,0.3]>	1/<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>	1/<[0.6, 0.7] ,[0.25, 0.35] ,[0.3, 0.4]>	1	<[0.7, 0.8] ,[0.15 ,0.25] ,[0.2 ,0.3]>
$EductC_7$	1/<[0.7, 0.8] ,[0.15 ,0.25] ,[0.2 ,0.3]>	1/<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>	1/<[0.3, 0.4] ,[0.65 ,0.75], [0.6, 0.7]>	1/<[0.7, 0.8] ,[0.15 ,0.25] ,[0.2 ,0.3]>	1/<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>	1/<[0.7, 0.8] ,[0.15 ,0.25] ,[0.2 ,0.3]>	1

Table 2: The second pairwise comparison matrix.

	$EductC_1$	$EductC_2$	$EductC_3$	$EductC_4$	$EductC_5$	$EductC_6$	$EductC_7$
$EductC_1$	1	<[0.7, 0.8] ,[0.15 ,0.25] ,[0.2 ,0.3]>	<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>	<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>	<[0.6, 0.7] ,[0.25, 0.35] ,[0.3, 0.4]>	<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>	<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>
$EductC_2$	1/<[0.7, 0.8] ,[0.15 ,0.25] ,[0.2 ,0.3]>	1	<[0.7, 0.8] ,[0.15 ,0.25] ,[0.2 ,0.3]>	<[0.6, 0.7] ,[0.25, 0.35] ,[0.3, 0.4]>	<[0.7, 0.8] ,[0.15 ,0.25] ,[0.2 ,0.3]>	<[0.3, 0.4] ,[0.65 ,0.75], [0.6, 0.7]>	<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>
$EductC_3$	<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>	1/<[0.7, 0.8] ,[0.15 ,0.25] ,[0.2 ,0.3]>	1	<[0.6, 0.7] ,[0.25, 0.35] ,[0.3, 0.4]>	<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>	<[0.7, 0.8] ,[0.15 ,0.25] ,[0.2 ,0.3]>	<[0.3, 0.4] ,[0.65 ,0.75], [0.6, 0.7]>

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$EductC_4$	1/<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>	1/<[0.6, 0.7] ,[0.25, 0.35] ,[0.3, 0.4]>	1/<[0.6, 0.7] ,[0.25, 0.35] ,[0.3, 0.4]>	1	<[0.6, 0.7] ,[0.25, 0.35] ,[0.3, 0.4]>	<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>	<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>
$EductC_5$	1/<[0.6, 0.7] ,[0.25, 0.35] ,[0.3, 0.4]>	1/<[0.7, 0.8] ,[0.15 ,0.25] ,[0.2 ,0.3]>	<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>	1/<[0.6, 0.7] ,[0.25, 0.35] ,[0.3, 0.4]>	1	<[0.6, 0.7] ,[0.25, 0.35] ,[0.3, 0.4]>	<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>
$EductC_6$	1/<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>	1/<[0.3, 0.4] ,[0.65 ,0.75], [0.6, 0.7]>	1/<[0.7, 0.8] ,[0.15 ,0.25] ,[0.2 ,0.3]>	1/<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>	1/<[0.6, 0.7] ,[0.25, 0.35] ,[0.3, 0.4]>	1	<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>
$EductC_7$	<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>	1/<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>	1/<[0.3, 0.4] ,[0.65 ,0.75], [0.6, 0.7]>	<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>	1/<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>	<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>	1

Table 3: The third pairwise comparison matrix.

	$EductC_1$	$EductC_2$	$EductC_3$	$EductC_4$	$EductC_5$	$EductC_6$	$EductC_7$
$EductC_1$	1	<[0.3, 0.4] ,[0.65 ,0.75], [0.6, 0.7]>	<[0.6, 0.7] ,[0.25, 0.35] ,[0.3, 0.4]>	<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>	<[0.3, 0.4] ,[0.65 ,0.75], [0.6, 0.7]>	<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>	<[0.3, 0.4] ,[0.65 ,0.75], [0.6, 0.7]>
$EductC_2$	1/<[0.3, 0.4] ,[0.65 ,0.75], [0.6, 0.7]>	1	<[0.7, 0.8] ,[0.15 ,0.25] ,[0.2 ,0.3]>	<[0.6, 0.7] ,[0.25, 0.35] ,[0.3, 0.4]>	<[0.7, 0.8] ,[0.15 ,0.25] ,[0.2 ,0.3]>	<[0.3, 0.4] ,[0.65 ,0.75], [0.6, 0.7]>	<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>
$EductC_3$	1/<[0.6, 0.7] ,[0.25, 0.35] ,[0.3, 0.4]>	1/<[0.7, 0.8] ,[0.15 ,0.25] ,[0.2 ,0.3]>	1	<[0.3, 0.4] ,[0.65 ,0.75], [0.6, 0.7]>	<[0.6, 0.7] ,[0.25, 0.35] ,[0.3, 0.4]>	<[0.3, 0.4] ,[0.65 ,0.75], [0.6, 0.7]>	<[0.3, 0.4] ,[0.65 ,0.75], [0.6, 0.7]>
$EductC_4$	1/<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>	1/<[0.6, 0.7] ,[0.25, 0.35] ,[0.3, 0.4]>	1/<[0.3, 0.4] ,[0.65 ,0.75], [0.6, 0.7]>	1	<[0.6, 0.7] ,[0.25, 0.35] ,[0.3, 0.4]>	<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>	<[0.7, 0.8] ,[0.15 ,0.25] ,[0.2 ,0.3]>
$EductC_5$	1/<[0.3, 0.4] ,[0.65 ,0.75], [0.6, 0.7]>	1/<[0.7, 0.8] ,[0.15 ,0.25] ,[0.2 ,0.3]>	1/<[0.6, 0.7] ,[0.25, 0.35] ,[0.3, 0.4]>	1/<[0.6, 0.7] ,[0.25, 0.35] ,[0.3, 0.4]>	1	<[0.3, 0.4] ,[0.65 ,0.75], [0.6, 0.7]>	<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>
$EductC_6$	1/<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>	1/<[0.3, 0.4] ,[0.65 ,0.75], [0.6, 0.7]>	1/<[0.3, 0.4] ,[0.65 ,0.75], [0.6, 0.7]>	1/<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>	1/<[0.3, 0.4] ,[0.65 ,0.75], [0.6, 0.7]>	1	<[0.3, 0.4] ,[0.65 ,0.75], [0.6, 0.7]>
$EductC_7$	1/<[0.3, 0.4] ,[0.65 ,0.75], [0.6, 0.7]>	1/<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>	1/<[0.3, 0.4] ,[0.65 ,0.75], [0.6, 0.7]>	1/<[0.7, 0.8] ,[0.15 ,0.25] ,[0.2 ,0.3]>	1/<[0.4, 0.5], [0.55, 0.65], [0.5, 0.6]>	1/<[0.3, 0.4] ,[0.65 ,0.75], [0.6, 0.7]>	1

Table 4: The normalization pairwise comparison matrix.

	$EductC_1$	$EductC_2$	$EductC_3$	$EductC_4$	$EductC_5$	$EductC_6$	$EductC_7$
$EductC_1$	0.068256	0.047524	0.04521	0.047324	0.062069	0.071591	0.12844
$EductC_2$	0.140845	0.083866	0.059338	0.070986	0.086897	0.053693	0.110092

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$EductC_3$	0.132719	0.119808	0.084769	0.059155	0.066207	0.10142	0.082569
$EductC_4$	0.170639	0.139776	0.188375	0.11831	0.074483	0.071591	0.165138
$EductC_5$	0.151679	0.119808	0.164828	0.197183	0.124138	0.089489	0.110092
$EductC_6$	0.170639	0.279553	0.174919	0.295775	0.275862	0.178977	0.12844
$EductC_7$	0.165222	0.209665	0.282562	0.211268	0.310345	0.433239	0.275229

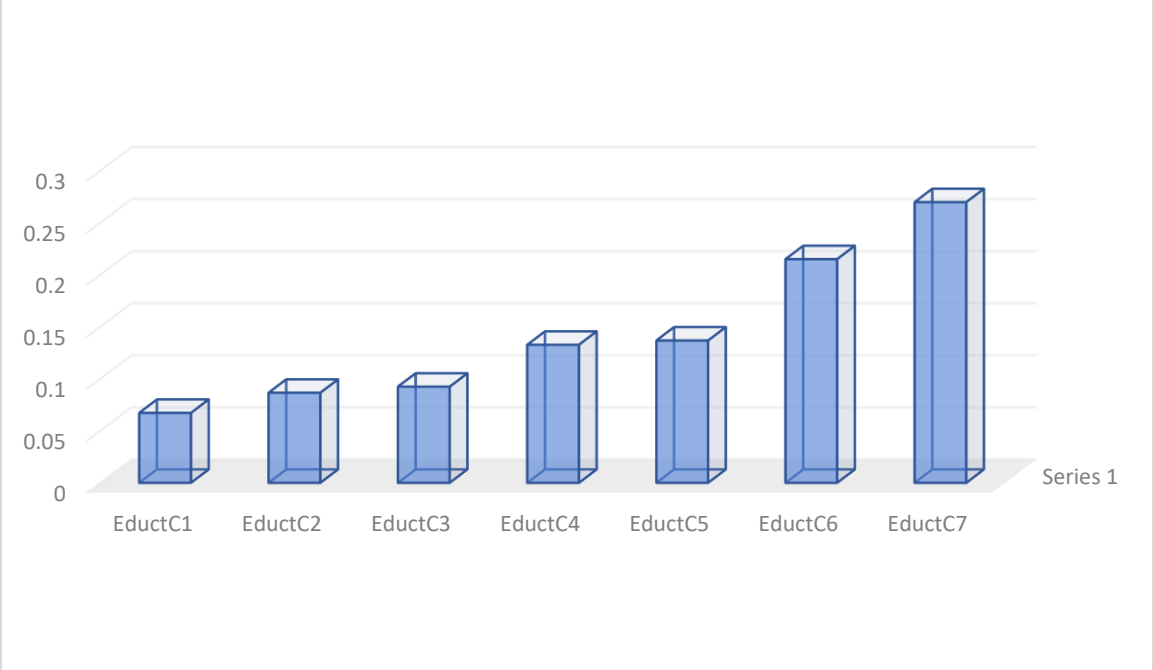

Figure 2: The weights of seven used criteria in this study

5. Conclusion

As part of this research, the neutrosophic AHP MCDM model is extended from its previous configuration of seven primary dimensions. This is done to accommodate recent changes in teaching as well as shifting education performance and to offer a methodology for assessing online teaching in higher education. The interval-valued neutrosophic-AHP approach is used first to identify the important weights of criteria, also the AHP is used to analyze the important factors that impact the performance of online education. The results show that criterion 7 is the highest importance in online learning and criterion 1 is the lowest importance in online criterion. The findings of this study have important repercussions for both academics and other public institutions that share comparable features in terms of the trajectory of higher education, particularly in social studies programs.

References

[1] L. D. Mora-Jimenez, K. Ramírez-Benavides, L. Quesada, G. Lopez, and L. A. Guerrero, "User experience in communication and collaboration platforms: a comparative study including discord, microsoft teams, and zoom," in *Information Technology and Systems: Proceedings of ICITS 2022*, Springer, 2022, pp. 52–61.

[2] K. A. Siddiqui and S. Ahmad, "Comparative Study of Alternative Teaching and Learning Tools: Google Meet, Microsoft Teams, and Zoom during COVID-19," in *Teaching in the Pandemic Era in Saudi Arabia*, Brill, 2022, pp. 120–129.

[3] H. Yilmaz, S. Karadayi-Usta, and S. Yanık, "A novel neutrosophic AHP-Copeland approach for distance education: towards sustainability," *Interactive Learning Environments*, pp. 1–23, 2022.

[4] M. M. Hamarsha and T. R. Bsharat, "The Influence of Microsoft Teams App besides Zoom App in Improving Teaching and Learning the English Language during (COVID-19) pandemic from the English Teachers' Perspectives in Palestine," *International Journal of Science and Research (IJSR)*, vol. 11, no. 1, pp. 418–424.

Doi: https://doi.org/10.54216/IJNS.200307
Received: September 05, 2022 Accepted: March 02, 2023

[5] N. Pawestri, M. R. Putri, and V. A. S. A. Pedo, "The utilization of Zoom and Microsoft Teams in maximizing the implementation of Flipped Learning and Students' Learning Experience in English for Written Business Class Bina Nusantara University," in *2022 International Conference on ICT for Smart Society (ICISS)*, 2022, pp. 1–6.

[6] M. A. H. Bin Azhar, J. Timms, and B. Tilley, "Forensic Investigations of Google Meet and Microsoft Teams–Two Popular Conferencing Tools in the Pandemic," in *Digital Forensics and Cyber Crime: 12th EAI International Conference, ICDF2C 2021, Virtual Event, Singapore, December 6-9, 2021, Proceedings*, 2022, pp. 20–34.

[7] R. Riedl, "On the stress potential of videoconferencing: definition and root causes of Zoom fatigue," *Electronic Markets*, vol. 32, no. 1, pp. 153–177, 2022.

[8] U. Işıl and E. G. ERSOY, "A new exhaustion emerged with COVID-19 and digitalization: A qualitative study on zoom fatigue," *OPUS Journal of Society Research*, vol. 19, no. 46, pp. 365–379, 2022.

[9] A. Karasan, E. Ilbahar, S. Cebi, and C. Kahraman, "Customer–oriented product design using an integrated neutrosophic AHP & DEMATEL & QFD methodology," *Applied Soft Computing*, p. 108445, 2022.

[10] B. Y. Kavus, P. G. Tas, E. Ayyildiz, and A. Taskin, "A three-level framework to evaluate airline service quality based on interval valued neutrosophic AHP considering the new dimensions," *Journal of Air Transport Management*, vol. 99, p. 102179, 2022.

[11] I. Sahmutoglu, A. Taskin, and E. Ayyildiz, "Assembly area risk assessment methodology for post-flood evacuation by integrated neutrosophic AHP-CODAS," *Natural Hazards*, pp. 1–33, 2022.

[12] F. Wu and Y. Fang, "Multilevel Evaluation of Teaching Quality in Higher Education Using Single-Valued Neutrosophic Set," *Mobile Information Systems*, vol. 2022, 2022.

[13] I. Mamites *et al.*, "Factors Influencing Teaching Quality in Universities: Analyzing Causal Relationships Based on Neutrosophic DEMATEL," *Education Research International*, vol. 2022, 2022.

[14] R. Comas Rodríguez, S. D. Álvarez Gómez, B. Villanueva, L. Karina, and K. Pérez Teruel, "A Novel Evaluative Method of the Subject 'Education and Society' of the Autonomous University of the Andes, Ecuador, based on Plithogenic Numbers," *Neutrosophic Sets and Systems*, vol. 44, no. 1, p. 5, 2021.

[15] F. Castro Sánchez, J. H. Almeida Blacio, M. G. Flores Bracho, D. R. Andrade Santamaria, and R. Sánchez Casanova, "Neutrosophic and Plithogenic Statistical Analysis in Educational Development," *Neutrosophic Sets and Systems*, vol. 44, no. 1, p. 26, 2021.

[16] R. Martínez Martínez, E. C. Mayorga Aldaz, O. Pampin Copa, and K. Peñafiel Jaramillo, "Neutrosophic Analysis of the Educational Orientation to the Diabetic Patient that reflects its impact on the Quality of Life," *Neutrosophic Sets and Systems*, vol. 44, no. 1, p. 50, 2021.

[17] S. Şahin, A. Kargın, and M. Yücel, "Hausdorff Measures on Generalized Set Valued Neutrosophic Quadruple Numbers and Decision Making Applications for Adequacy of Online Education," *Neutrosophic Sets and Systems*, vol. 40, pp. 86–116, 2021.

[18] H.-Y. Wu, J.-K. Chen, I.-S. Chen, and H.-H. Zhuo, "Ranking universities based on performance evaluation by a hybrid MCDM model," *Measurement*, vol. 45, no. 5, pp. 856–880, 2012.

[19] E. Bizzo, R. Furst, J. J. M. Antunes, P. Wanke, and F. G. Mixon Jr, "State-level educational performance in Brazil: A MCDM approach taking a governance perspective," *Journal of Multi-Criteria Decision Analysis*, vol. 29, no. 3–4, pp. 199–217, 2022.

[20] F. K. Gündoğdu and S. Aydın, "Evaluation of online education software under neutrosophic environment," *DECISION-MAKING WITH NEUTROSOPHIC SET*, p. 69.

[21] R. M. Carballido, H. Paronyan, M. A. Matos, and A. L. S. Molina, *Neutrosofic statistics applied to demonstrate the importance of humanistic and higher education components in students of legal careers*. Infinite Study, 2019.

[22] M. H. Hosseini, D. Karimzadegan, and A. Sazvar, "Identification of Management Information System (MIS) strategies barriers in higher education institutions through multi-criteria decision making (MCDM) approach: Case study of Ferdowsi University of Mashhad," *Educational Research and Reviews*, vol. 7, no. 5, p. 111, 2012.

[23] H. J. Mohammed, M. M. Kasim, E. A. Aldahneem, and A. K. Hamadi, "Evaluating Different Learning Methodologies of Multimedia in Education Using MCDM method," 2016.

[24] N. B. Hernández, N. V. Izquierdo, M. Leyva-Vázquez, and F. Smarandache, *Validation of the pedagogical strategy for the formation of the competence entrepreneurship in high education through the use of neutrosophic logic and Iadov technique*. Infinite Study, 2018.

[25] K. Mondal and S. Pramanik, "Multi-criteria group decision approaching teacher recruitment in higher

Doi: https://doi.org/10.54216/IJNS.200307
Received: September 05, 2022 Accepted: March 02, 2023

education under simplified neutrosophic environment," *Neutrosophic sets and Systems*, vol. 6, pp. 28–34, 2014.

[26] Yamagata-Lynch, L. (2014). Blending Online Asynchronous and Synchronous Learning. *International Review of Research in Open and Distributed Learning*, *15*(2), 189–212. https://doi.org/10.19173/irrodl.v15i2.1778

[27] Dumitru, D. (2019). The importance of Arts, Humanities and Culture for critical thinking development. *Studies in Higher Education*,44(2), 870-879. https://doi.org/10.1080/03075079.2019.1586345

Doi: https://doi.org/10.54216/IJNS.200307
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