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Neutrosophic Z-Rough Set Aggregation Operator for University English Immersive Teaching Effectiveness Evaluation Based on Virtual Reality Technology

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Abstract: Immersion language learning has revolutionary potential when Virtual Reality (VR) technology is used into university-level English education. This research assesses how well university students' English proficiency may be improved by VR-based immersive instruction. The study investigates how VR-supported learning environments enhance educational results by utilizing four primary criteria: cognitive load and usability, learning engagement, real-world communication simulation, and language competency enhancement. Eight different instructional methods, such as role-playing, virtual campus visits, and public speaking simulations, were evaluated. A neutrosophic framework was used to examine the data. The neutrosophic set is used to overcome uncertainty. We use the Neutrosophic Z-Rough Set (NZRS) to evaluate the criteria and alternatives. The aggregation operators of NZRS is used to combine different numbers. Although usability and cognitive demands are still important factors, the results show that immersive VR experiences greatly increase engagement and real-world language application. For educators and organizations looking to implement immersive technology in language training, this review offers evidence-based ideas.

Keywords: Neutrosophic Z-Rough Set Aggregation Operator; University English Immersive; Teaching Effectiveness Evaluation; Virtual Reality Technology.

1. Introduction

Smarandache [1] suggested neutrophilic sets (NSs) to deal with unknown data. Wang et al. proposed SVNSs, a unique type of normalized supersets that may be rapidly applied to real-world problems. This idea is expanded upon by several other academics in various situations.

In response to these complications, Neutrosophic Z-Rough Numbers offer a framework that enables a more heuristic assessment of ambiguity, uncertainty, and inconsistency. Decisions in this field must be based on methods that successfully correct such flaws. To clarify contradictory

and incomplete data, we integrate the periodicity of STF with the features of NZRN using sine-trigonometric functions in combination with neutrosophic Z-rough numbers[2], [3].

1.1 Motivations of this Study

New aggregation techniques have taken a prominent place in the list of characteristics defining the changing landscape of decision-making due to the increasing complexity of data and the need for final, trustworthy outcomes. In fact, aggregation operators such as averaging are widely used in applications for processing fuzzy data and associated decision-making difficulties. However, traditional approaches frequently prove to be extremely inadequate when complex data structures and the more nuanced requirements of contemporary applications are involved.

The necessity for advancements in managing complicated data sets, especially as conventional approaches could not offer enough accuracy and adaptability, serves as the driving force for this study. The contribution of neutrosophic aggregation operators, which offer more depth and flexibility in data aggregation—is covered in our work.

2. Literature Review

People are becoming more aware that grammatical proficiency is a crucial component of communicative proficiency as language study and instruction advance. Grammar instruction is both essential and the primary means of achieving communicative competence in foreign language instruction. Ma [4] primarily examined the immersive context teaching approach for college English using virtual reality technology, which is based on artificial intelligence and machine learning. Enhancing pupils' proficiency in studying English is the goal.

Two classes of first-year university students participated in a comparative teaching experiment. The experimental class used VR technology to provide immersive virtual context instruction from a constructivist standpoint, while the control group used standard multimedia tools and conventional teaching techniques. Teachers spend most of the time in the classroom, students are "immersed" in the Chinese environment most of the time, and students only passively absorb a lot of information from teachers. They also have limited opportunities to engage in information exchange and express themselves in the target language.

Since 2013, a significant amount of research has been conducted on the effects of immersive virtual reality (IVR) technology on education, thanks to the introduction of affordable, high-quality head-mounted displays (HMDs). Wu et al. [5] compiled the results about the overall impacts of IVR with HMDs in comparison to desktop virtual reality (DVR), which is less immersive, and other conventional teaching methods. The literature published between 2013 and 2019 was thoroughly searched. A total of 35 quasi-experimental studies or randomized controlled trials (RCTs) were found. To determine the pooled impact size, we performed an analysis using the random effects model (REM). To investigate the moderating impacts of various attributes, including learner stage, learning domain, learning application type, and assessment format, the studies were additionally coded.

The key content of college English teaching reform under the current new situation has been created because of numerous reforms and developments, including the reform of educational technology, the reform of the overall teaching mode, the reform of teaching methods, the improvement of teachers' comprehensive quality, etc. China will undoubtedly accomplish the significant objective of teaching reform with the use of immersive virtual reality technology and multimedia education technologies. The term "immersion virtual English teaching environment" describes a brand-new, contemporary kind of collegiate English teaching environment. Its primary goal is to resolve the present conundrum in the use of immersion English instruction [6].

3. Preliminaries

In this part, this study shows some definitions and operations about neutrosophic set to overcome uncertainty problem[7].

Definition 1

Neutrosophic set presented as:

$$a = \{(T_a(x), I_a(x), F_a(x)) : x \in X\}$$

$T_a(x), I_a(x), F_a(x)$ presents truth, indeterminacy, and falsity functions.

$$0^- \leq T_a(x) + I_a(x) + F_a(x) \leq 3^+$$

Definition 2

Single valued neutrosophic set (SVNS) presents as:

$$a = \{(T_a(x), I_a(x), F_a(x)) : x \in X\}$$

$$T_a(x), I_a(x), F_a(x) : X \to [0,1]$$

$$0 < T_a(x) + I_a(x) + F_a(x) \leq 3$$

Definition 3

SVN rough number (SV-NRN) presented as:

$$a = \left\{ \begin{pmatrix} \underline{T}(x), \underline{I}(x), \underline{F}(x) \end{pmatrix}, \\ \begin{pmatrix} \overline{T}(x), \overline{I}(x), \overline{F}(x) \end{pmatrix} \right\}$$

The score and accuracy functions can be applied as:

$$S(a) = \frac{1}{6} \left\{ \begin{matrix} 3 + \underline{T}(x) + \overline{I}(x) - \overline{F}(x) \\ -\overline{T}(x) - \underline{I}(x) - \overline{F}(x) \end{matrix} \right\}$$

$$A(a) = \frac{1}{6} \left\{ \begin{matrix} 3 + \underline{T}(x) + \overline{I}(x) + \overline{F}(x) \\ +\overline{T}(x) - \underline{I}(x) + \overline{F}(x) \end{matrix} \right\}$$

4. Neutrosophic Z-rough numbers (NZRNs)

Definition 4

SV with z rough numbers is presented as:

$$a=\left\{\left(\begin{array}{c}\left\{\left(\overline{T}_y(X),\overline{T}_z(X)\right),\left(\underline{T}_y(X),\underline{T}_z(X)\right)\right\},\\ \left\{\left(\overline{I}_y(X),\overline{I}_z(X)\right),\left(I_y(X),\underline{I}_z(X)\right)\right\},\\ \left\{\left(\overline{F}_y(X),\overline{F}_z(X)\right),\left(\underline{F}_y(X),\underline{F}_z(X)\right)\right\}\end{array}\right)\right\}$$

$$0\le\left\{\left(\begin{array}{c}\left\{\left(\overline{T}_y(X),\overline{T}_z(X)\right),\left(\underline{T}_y(X),\underline{T}_z(X)\right)\right\}+\\ \left\{\left(\overline{I}_y(X),\overline{I}_z(X)\right),\left(I_y(X),\underline{I}_z(X)\right)\right\}+\\ \left\{\left(\overline{F}_y(X),\overline{F}_z(X)\right),\left(\underline{F}_y(X),\underline{F}_z(X)\right)\right\}\end{array}\right)\right\}\le 3$$

Definition 5

Let two NZRNs and their operations be presented as:

$$a_1\cap a_2=\left\{\begin{array}{l}\inf\left(\begin{array}{c}\left\{\left(\overline{T}_{y_1}(X),\overline{T}_{z_1}(X)\right),\left(\underline{T}_{y_1}(X),\underline{T}_{z_1}(X)\right)\right\},\\ \left\{\left(\overline{T}_{y_2}(X),\overline{T}_{z_2}(X)\right),\left(\underline{T}_{y_2}(X),\underline{T}_{z_2}(X)\right)\right\}\end{array}\right),\\ \sup\left(\begin{array}{c}\left\{\left(\overline{I}_{y_1}(X),\overline{I}_{z_1}(X)\right),\left(\underline{I}_{y_1}(X),\underline{I}_{z_1}(X)\right)\right\},\\ \left\{\left(\overline{I}_{y_2}(X),\overline{I}_{z_2}(X)\right),\left(\underline{I}_{y_2}(X),\underline{I}_{z_2}(X)\right)\right\}\end{array}\right),\\ \sup\left(\begin{array}{c}\left\{\left(\overline{F}_{y_1}(X),\overline{F}_{z_1}(X)\right),\left(\underline{F}_{y_1}(X),\underline{F}_{z_1}(X)\right)\right\},\\ \left\{\left(\overline{F}_{y_2}(X),\overline{F}_{z_2}(X)\right),\left(\underline{F}_{y_2}(X),\underline{F}_{z_2}(X)\right)\right\}\end{array}\right)\end{array}\right\}$$

$$a_1\cup a_2=\left\{\begin{array}{l}\sup\left(\begin{array}{c}\left\{\left(\overline{T}_{y_1}(X),\overline{T}_{z_1}(X)\right),\left(\underline{T}_{y_1}(X),\underline{T}_{z_1}(X)\right)\right\},\\ \left\{\left(\overline{T}_{y_2}(X),\overline{T}_{z_2}(X)\right),\left(\underline{T}_{y_2}(X),\underline{T}_{z_2}(X)\right)\right\}\end{array}\right),\\ \inf\left(\begin{array}{c}\left\{\left(\overline{I}_{y_1}(X),\overline{I}_{z_1}(X)\right),\left(\underline{I}_{y_1}(X),\underline{I}_{z_1}(X)\right)\right\},\\ \left\{\left(\overline{I}_{y_2}(X),\overline{I}_{z_2}(X)\right),\left(\underline{I}_{y_2}(X),\underline{I}_{z_2}(X)\right)\right\}\end{array}\right),\\ \inf\left(\begin{array}{c}\left\{\left(\overline{F}_{y_1}(X),\overline{F}_{z_1}(X)\right),\left(\underline{F}_{y_1}(X),\underline{F}_{z_1}(X)\right)\right\},\\ \left\{\left(\overline{F}_{y_2}(X),\overline{F}_{z_2}(X)\right),\left(\underline{F}_{y_2}(X),\underline{F}_{z_2}(X)\right)\right\}\end{array}\right)\end{array}\right\}$$

Definition 6

$$a_1 \otimes a_2 = \begin{Bmatrix} \left\{\left(\overline{T}_{y_1}(X), \overline{T}_{z_1}(X)\right), \left(\underline{T}_{y_1}(X), \underline{T}_{z_1}(X)\right)\right\} \\ \left\{\left(\overline{T}_{y_2}(X), \overline{T}_{z_2}(X)\right), \left(\underline{T}_{y_2}(X), \underline{T}_{z_2}(X)\right)\right\}, \\ \left\{\left(\overline{I}_{y_1}(X), \overline{I}_{z_1}(X)\right), \left(\underline{I}_{y_1}(X), \underline{I}_{z_1}(X)\right)\right\} + \\ \left\{\left(\overline{I}_{y_2}(X), \overline{I}_{z_2}(X)\right), \left(\underline{I}_{y_2}(X), \underline{I}_{z_2}(X)\right)\right\} \\ \left\{\left(\overline{F}_{y_1}(X), \overline{F}_{z_1}(X)\right), \left(\underline{F}_{y_1}(X), \underline{F}_{z_1}(X)\right)\right\} + \\ \left\{\left(\overline{F}_{y_2}(X), \overline{F}_{z_2}(X)\right), \left(\underline{F}_{y_2}(X), \underline{F}_{z_2}(X)\right)\right\} \end{Bmatrix}$$

$$a_1 \oplus a_2 = \begin{Bmatrix} \left\{\left(\overline{T}_{y_1}(X), \overline{T}_{z_1}(X)\right), \left(\underline{T}_{y_1}(X), \underline{T}_{z_1}(X)\right)\right\} + \left\{\left(\overline{T}_{y_2}(X), \overline{T}_{z_2}(X)\right), \left(\underline{T}_{y_2}(X), \underline{T}_{z_2}(X)\right)\right\} \\ \left\{\left(\overline{T}_{y_1}(X), \overline{T}_{z_1}(X)\right), \left(\underline{T}_{y_1}(X), \underline{T}_{z_1}(X)\right)\right\}\left\{\left(\overline{T}_{y_2}(X), \overline{T}_{z_2}(X)\right), \left(\underline{T}_{y_2}(X), \underline{T}_{z_2}(X)\right)\right\}, \\ \left\{\left(\overline{I}_{y_1}(X), \overline{I}_{z_1}(X)\right), \left(\underline{I}_{y_1}(X), \underline{I}_{z_1}(X)\right)\right\} \\ \left\{\left(\overline{I}_{y_2}(X), \overline{I}_{z_2}(X)\right), \left(\underline{I}_{y_2}(X), \underline{I}_{z_2}(X)\right)\right\}, \\ \left\{\left(\overline{F}_{y_1}(X), \overline{F}_{z_1}(X)\right), \left(\underline{F}_{y_1}(X), \underline{F}_{z_1}(X)\right)\right\} \\ \left\{\left(\overline{F}_{y_2}(X), \overline{F}_{z_2}(X)\right), \left(\underline{F}_{y_2}(X), \underline{F}_{z_2}(X)\right)\right\} \end{Bmatrix}$$

5. Aggregation Operator of NZRNs

Definition 7

This part shows the algebraic averaging aggregation operator as:

$$NZRNWA(a_1, a_2, \ldots, a_n) = \sum_{j=1}^{n} l_j a_j$$

$$= \begin{Bmatrix} 1 - \prod_{j=1}^{n} \left(1 - \left\{\left(\left(\overline{T}_{y_1}(X), \overline{T}_{z_1}(X)\right)\right), \left(\underline{T}_{y_1}(X), \underline{T}_{z_1}(X)\right)\right\}\right)^{l_j}, \\ \prod_{j=1}^{n} \left(\left\{\left(\left(\overline{I}_{y_1}(X), \overline{I}_{z_1}(X)\right)\right), \left(\underline{I}_{y_1}(X), \underline{I}_{z_1}(X)\right)\right\}\right)^{l_j}, \\ \prod_{j=1}^{n} \left(\left\{\left(\left(\overline{F}_{y_1}(X), \overline{F}_{z_1}(X)\right)\right), \left(\underline{F}_{y_1}(X), \underline{F}_{z_1}(X)\right)\right\}\right)^{l_j} \end{Bmatrix}$$

Definition 8

This part shows the geometric averaging aggregation operator as:

$$NZRNWG(a_1, a_2, \ldots, a_n) = \prod_{j=1}^{n} l_j a_j$$

$$= \begin{Bmatrix} \prod_{j=1}^{n} \left(\left\{ \left(\left(\overline{T}_{y_1}(X), \overline{T}_{z_1}(X) \right) \right), \left(\underline{T}_{y_1}(X), \underline{T}_{z_1}(X) \right) \right\} \right)^{l_j}, \\ 1 - \prod_{j=1}^{n} \left(1 - \left\{ \left(\left(\overline{I}_{y_1}(X), \overline{I}_{z_1}(X) \right) \right), \left(\underline{I}_{y_1}(X), \underline{I}_{z_1}(X) \right) \right\} \right)^{l_j}, \\ 1 - \prod_{j=1}^{n} \left(1 - \left\{ \left(\left(\overline{F}_{y_1}(X), \overline{F}_{z_1}(X) \right) \right), \left(\underline{F}_{y_1}(X), \underline{F}_{z_1}(X) \right) \right\} \right)^{l_j} \end{Bmatrix}$$

Definition 9

The score function can be defined as:

$$S(a) = \begin{pmatrix} 3 + \overline{T}_{y_1}(X)\overline{T}_{z_1}(X) + \underline{T}_{y_1}(X)\underline{T}_{z_1}(X) - \overline{I}_{y_1}(X)\overline{I}_{z_1}(X) - \\ \underline{I}_{y_1}(X)\underline{I}_{z_1}(X) - \overline{F}_{y_1}(X)\overline{F}_{z_1}(X) - \underline{F}_{y_1}(X)\underline{F}_{z_1}(X) \\ \hline 6 \end{pmatrix}$$

6. Porpoise Algorithm

This section will address decision-making issues in an SVNS setting by outlining a decision-making process and using a case study to illustrate it. A decision matrix may be used to highlight issues in making judgments based on several factors. Each row in this kind of matrix represents a different choice, and each column represents a distinct set of criteria. The steps of the proposed algorithm are presented as follows:

Step 1. In terms of criteria and alternatives, SV-NZRN are used to evaluate the criteria.

Step 2. SV-NZRNs are used to evaluate alternatives.

Step 3. The SV-NZRN aggregation operator is used to combine different values into a single matrix.

Step 4. The score function is used to obtain values of each alternative.

7. Implantation of the proposed algorithm

This section shows the results of the proposed algorithm to rank the alternatives of University English Immersive Teaching Effectiveness Evaluation Based on Virtual Reality Technology. This study uses four criteria and eight alternatives such as: Language Proficiency Improvement, Learning Engagement, Real-World Communication Simulation, Cognitive Load and Usability. The alternatives are: Virtual Campus Tour in English, Role-Playing Scenarios, VR-Based Debates and Discussions, Storytelling and Narrative Building in VR, Virtual Reality Language Labs, Cultural Immersion in English-Speaking Cities, Gamified English Quests, Virtual Presentations.

In the first step, the criteria and alternatives are evaluated using the NZRNs as shown in Table 1. These numbers are used to overcome uncertainty and vague information.

In the second step, these numbers are combined into a single matrix as shown in Table 2.

In the third step, the score function is applied to obtain one score of each alternatives. The alternatives are ranked as:

$$\begin{pmatrix} Alternative 1 > Alternative\ 5\ > Alternative\ 3 > \ Alternative\ 4 > \\ Alternative\ 6\ > Alternative\ 7 > \ Alternative\ 2 > \ Alternative\ 8 \end{pmatrix}$$

Table 1. SV-NZRNs.

	$NZRC_1$	$NZRC_2$	$NZRC_3$	$NZRC_4$
$NZRA_1$	{{(0.6,0.8),(0.4,0.3)},{(0.2,0.3),(0.6,0.4)},{(0.1,0.5),(0.2,0.8),}}	{{(0.1,0.3),(0.9,0.4)},{(0.2,0.6),(0.3,0.7)},{(0.6,0.8),(0.5,0.2),}}	{{(0.8,0.7),(0.5,0.2)},{(0.1,0.8),(0.4,0.7)},{(0.2,0.6),(0.8,0.1),}}	{{(0.4,0.6),(0.7,0.3)},{(0.2,0.5),(0.7,0.1)},{(0.9,0.4),(0.6,0.1),}}
$NZRA_2$	{{(0.6,0.8),(0.4,0.3)},{(0.2,0.3),(0.6,0.4)},{(0.1,0.5),(0.2,0.8),}}	{{(0.7,0.6),(0.8,0.3)},{(0.3,0.2),(0.7,0.6)},{(0.5,0.4),(0.9,0.3),}}	{{(0.7,0.8),(0.5,0.2)},{(0.2,0.6),(0.3,0.7)},{(0.1,0.3),(0.9,0.4),}}	{{(0.1,0.5),(0.8,0.2)},{(0.2,0.3),(0.8,0.4)},{(0.7,0.5),(0.3,0.7),}}
$NZRA_3$	{{(0.1,0.3),(0.9,0.4)},{(0.2,0.6),(0.3,0.7)},{(0.6,0.8),(0.5,0.2),}}	{{(0.8,0.7),(0.5,0.2)},{(0.1,0.8),(0.4,0.7)},{(0.2,0.6),(0.8,0.1),}}	{{(0.4,0.6),(0.7,0.3)},{(0.2,0.5),(0.7,0.1)},{(0.9,0.4),(0.6,0.1),}}	{{(0.1,0.5),(0.8,0.2)},{(0.2,0.3),(0.8,0.4)},{(0.7,0.5),(0.3,0.7),}}
$NZRA_4$	{{(0.4,0.6),(0.7,0.3)},{(0.2,0.5),(0.7,0.1)},{(0.9,0.4),(0.6,0.1),}}	{{(0.8,0.7),(0.5,0.2)},{(0.1,0.8),(0.4,0.7)},{(0.2,0.6),(0.8,0.1),}}	{{(0.1,0.3),(0.9,0.4)},{(0.2,0.6),(0.3,0.7)},{(0.6,0.8),(0.5,0.2),}}	{{(0.6,0.8),(0.4,0.3)},{(0.2,0.3),(0.6,0.4)},{(0.1,0.5),(0.2,0.8),}}
$NZRA_5$	{{(0.1,0.5),(0.8,0.2)},{(0.2,0.3),(0.8,0.4)},{(0.7,0.5),(0.3,0.7),}}	{{(0.4,0.6),(0.7,0.3)},{(0.2,0.5),(0.7,0.1)},{(0.9,0.4),(0.6,0.1),}}	{{(0.8,0.7),(0.5,0.2)},{(0.1,0.8),(0.4,0.7)},{(0.2,0.6),(0.8,0.1),}}	{{(0.1,0.3),(0.9,0.4)},{(0.2,0.6),(0.3,0.7)},{(0.6,0.8),(0.5,0.2),}}
$NZRA_6$	{{(0.1,0.5),(0.8,0.2)},{(0.2,0.3),(0.8,0.4)},{(0.7,0.5),(0.3,0.7),}}	{{(0.1,0.5),(0.8,0.2)},{(0.2,0.3),(0.8,0.4)},{(0.7,0.5),(0.3,0.7),}}	{{(0.4,0.6),(0.7,0.3)},{(0.2,0.5),(0.7,0.1)},{(0.9,0.4),(0.6,0.1),}}	{{(0.1,0.5),(0.8,0.2)},{(0.2,0.3),(0.8,0.4)},{(0.7,0.5),(0.3,0.7),}}
$NZRA_7$	{{(0.7,0.8),(0.5,0.2)},{(0.2,0.6),(0.3,0.7)},{(0.1,0.3),(0.9,0.4),}}	{{(0.7,0.6),(0.8,0.3)},{(0.3,0.2),(0.7,0.6)},{(0.5,0.4),(0.9,0.3),}}	{{(0.1,0.3),(0.9,0.4)},{(0.2,0.6),(0.3,0.7)},{(0.6,0.8),(0.5,0.2),}}	{{(0.7,0.6),(0.8,0.3)},{(0.3,0.2),(0.7,0.6)},{(0.5,0.4),(0.9,0.3),}}
$NZRA_8$	{{(0.7,0.6),(0.8,0.3)},{(0.3,0.2),(0.7,0.6)},{(0.5,0.4),(0.9,0.3),}}	{{(0.6,0.8),(0.4,0.3)},{(0.2,0.3),(0.6,0.4)},{(0.1,0.5),(0.2,0.8),}}	{{(0.6,0.8),(0.4,0.3)},{(0.2,0.3),(0.6,0.4)},{(0.1,0.5),(0.2,0.8),}}	{{(0.6,0.8),(0.4,0.3)},{(0.2,0.3),(0.6,0.4)},{(0.1,0.5),(0.2,0.8),}}
	$NZRC_1$	$NZRC_2$	$NZRC_3$	$NZRC_4$
$NZRA_1$	{{(0.4,0.6),(0.7,0.3)},{(0.2,0.5),(0.7,0.1)},{(0.9,0.4),(0.6,0.1),}}	{{(0.1,0.3),(0.9,0.4)},{(0.2,0.6),(0.3,0.7)},{(0.6,0.8),(0.5,0.2),}}	{{(0.8,0.7),(0.5,0.2)},{(0.1,0.8),(0.4,0.7)},{(0.2,0.6),(0.8,0.1),}}	{{(0.4,0.6),(0.7,0.3)},{(0.2,0.5),(0.7,0.1)},{(0.9,0.4),(0.6,0.1),}}
$NZRA_2$	{{(0.8,0.7),(0.5,0.2)},{(0.1,0.8),(0.4,0.7)},{(0.2,0.6),(0.8,0.1),}}	{{(0.7,0.6),(0.8,0.3)},{(0.3,0.2),(0.7,0.6)},{(0.5,0.4),(0.9,0.3),}}	{{(0.7,0.8),(0.5,0.2)},{(0.2,0.6),(0.3,0.7)},{(0.1,0.3),(0.9,0.4),}}	{{(0.4,0.6),(0.7,0.3)},{(0.2,0.5),(0.7,0.1)},{(0.9,0.4),(0.6,0.1),}}
$NZRA_3$	{{(0.1,0.3),(0.9,0.4)},{(0.2,0.6),(0.3,0.7)},{(0.6,0.8),(0.5,0.2),}}	{{(0.8,0.7),(0.5,0.2)},{(0.1,0.8),(0.4,0.7)},{(0.2,0.6),(0.8,0.1),}}	{{(0.4,0.6),(0.7,0.3)},{(0.2,0.5),(0.7,0.1)},{(0.9,0.4),(0.6,0.1),}}	{{(0.8,0.7),(0.5,0.2)},{(0.1,0.8),(0.4,0.7)},{(0.2,0.6),(0.8,0.1),}}
$NZRA_4$	{{(0.6,0.8),(0.4,0.3)},{(0.2,0.3),(0.6,0.4)},{(0.1,0.5),(0.2,0.8),}}	{{(0.8,0.7),(0.5,0.2)},{(0.1,0.8),(0.4,0.7)},{(0.2,0.6),(0.8,0.1),}}	{{(0.1,0.3),(0.9,0.4)},{(0.2,0.6),(0.3,0.7)},{(0.6,0.8),(0.5,0.2),}}	{{(0.1,0.3),(0.9,0.4)},{(0.2,0.6),(0.3,0.7)},{(0.6,0.8),(0.5,0.2),}}
$NZRA_5$	{{(0.7,0.6),(0.8,0.3)},{(0.3,0.2),(0.7,0.6)},{(0.5,0.4),(0.9,0.3),}}	{{(0.4,0.6),(0.7,0.3)},{(0.2,0.5),(0.7,0.1)},{(0.9,0.4),(0.6,0.1),}}	{{(0.8,0.7),(0.5,0.2)},{(0.1,0.8),(0.4,0.7)},{(0.2,0.6),(0.8,0.1),}}	{{(0.6,0.8),(0.4,0.3)},{(0.2,0.3),(0.6,0.4)},{(0.1,0.5),(0.2,0.8),}}
$NZRA_6$	{{(0.4,0.6),(0.7,0.3)},{(0.2,0.5),(0.7,0.1)},{(0.9,0.4),(0.6,0.1),}}	{{(0.4,0.6),(0.7,0.3)},{(0.2,0.5),(0.7,0.1)},{(0.9,0.4),(0.6,0.1),}}	{{(0.4,0.6),(0.7,0.3)},{(0.2,0.5),(0.7,0.1)},{(0.9,0.4),(0.6,0.1),}}	{{(0.7,0.6),(0.8,0.3)},{(0.3,0.2),(0.7,0.6)},{(0.5,0.4),(0.9,0.3),}}
$NZRA_7$	{{(0.7,0.6),(0.8,0.3)},{(0.3,0.2),(0.7,0.6)},{(0.5,0.4),(0.9,0.3),}}	{{(0.1,0.3),(0.9,0.4)},{(0.2,0.6),(0.3,0.7)},{(0.6,0.8),(0.5,0.2),}}	{{(0.7,0.6),(0.8,0.3)},{(0.3,0.2),(0.7,0.6)},{(0.5,0.4),(0.9,0.3),}}	{{(0.1,0.3),(0.9,0.4)},{(0.2,0.6),(0.3,0.7)},{(0.6,0.8),(0.5,0.2),}}
$NZRA_8$	{{(0.1,0.3),(0.9,0.4)},{(0.2,0.6),(0.3,0.7)},{(0.6,0.8),(0.5,0.2),}}	{{(0.1,0.3),(0.9,0.4)},{(0.2,0.6),(0.3,0.7)},{(0.6,0.8),(0.5,0.2),}}	{{(0.1,0.3),(0.9,0.4)},{(0.2,0.6),(0.3,0.7)},{(0.6,0.8),(0.5,0.2),}}	{{(0.1,0.5),(0.8,0.2)},{(0.2,0.3),(0.8,0.4)},{(0.7,0.5),(0.3,0.7),}}
	$NZRC_1$	$NZRC_2$	$NZRC_3$	$NZRC_4$
$NZRA_1$	{{(0.6,0.8),(0.4,0.3)},{(0.2,0.3),(0.6,0.4)},{(0.1,0.5),(0.2,0.8),}}	{{(0.1,0.3),(0.9,0.4)},{(0.2,0.6),(0.3,0.7)},{(0.6,0.8),(0.5,0.2),}}	{{(0.8,0.7),(0.5,0.2)},{(0.1,0.8),(0.4,0.7)},{(0.2,0.6),(0.8,0.1),}}	{{(0.4,0.6),(0.7,0.3)},{(0.2,0.5),(0.7,0.1)},{(0.9,0.4),(0.6,0.1),}}
$NZRA_2$	{{(0.7,0.6),(0.8,0.3)},{(0.3,0.2),(0.7,0.6)},{(0.5,0.4),(0.9,0.3),}}	{{(0.7,0.6),(0.8,0.3)},{(0.3,0.2),(0.7,0.6)},{(0.5,0.4),(0.9,0.3),}}	{{(0.7,0.8),(0.5,0.2)},{(0.2,0.6),(0.3,0.7)},{(0.1,0.3),(0.9,0.4),}}	{{(0.1,0.5),(0.8,0.2)},{(0.2,0.3),(0.8,0.4)},{(0.7,0.5),(0.3,0.7),}}
$NZRA_3$	{{(0.7,0.8),(0.5,0.2)},{(0.2,0.6),(0.3,0.7)},{(0.1,0.3),(0.9,0.4),}}	{{(0.6,0.8),(0.4,0.3)},{(0.2,0.3),(0.6,0.4)},{(0.1,0.5),(0.2,0.8),}}	{{(0.4,0.6),(0.7,0.3)},{(0.2,0.5),(0.7,0.1)},{(0.9,0.4),(0.6,0.1),}}	{{(0.1,0.5),(0.8,0.2)},{(0.2,0.3),(0.8,0.4)},{(0.7,0.5),(0.3,0.7),}}
$NZRA_4$	{{(0.1,0.5),(0.8,0.2)},{(0.2,0.3),(0.8,0.4)},{(0.7,0.5),(0.3,0.7),}}	{{(0.7,0.6),(0.8,0.3)},{(0.3,0.2),(0.7,0.6)},{(0.5,0.4),(0.9,0.3),}}	{{(0.6,0.8),(0.4,0.3)},{(0.2,0.3),(0.6,0.4)},{(0.1,0.5),(0.2,0.8),}}	{{(0.6,0.8),(0.4,0.3)},{(0.2,0.3),(0.6,0.4)},{(0.1,0.5),(0.2,0.8),}}
$NZRA_5$	{{(0.4,0.6),(0.7,0.3)},{(0.2,0.5),(0.7,0.1)},{(0.9,0.4),(0.6,0.1),}}	{{(0.7,0.8),(0.5,0.2)},{(0.2,0.6),(0.3,0.7)},{(0.1,0.3),(0.9,0.4),}}	{{(0.7,0.6),(0.8,0.3)},{(0.3,0.2),(0.7,0.6)},{(0.5,0.4),(0.9,0.3),}}	{{(0.6,0.8),(0.4,0.3)},{(0.2,0.3),(0.6,0.4)},{(0.1,0.5),(0.2,0.8),}}
$NZRA_6$	{{(0.8,0.7),(0.5,0.2)},{(0.1,0.8),(0.4,0.7)},{(0.2,0.6),(0.8,0.1),}}	{{(0.1,0.5),(0.8,0.2)},{(0.2,0.3),(0.8,0.4)},{(0.7,0.5),(0.3,0.7),}}	{{(0.7,0.8),(0.5,0.2)},{(0.2,0.6),(0.3,0.7)},{(0.1,0.3),(0.9,0.4),}}	{{(0.7,0.6),(0.8,0.3)},{(0.3,0.2),(0.7,0.6)},{(0.5,0.4),(0.9,0.3),}}
$NZRA_7$	{{(0.6,0.8),(0.4,0.3)},{(0.2,0.3),(0.6,0.4)},{(0.1,0.5),(0.2,0.8),}}	{{(0.6,0.8),(0.4,0.3)},{(0.2,0.3),(0.6,0.4)},{(0.1,0.5),(0.2,0.8),}}	{{(0.6,0.8),(0.4,0.3)},{(0.2,0.3),(0.6,0.4)},{(0.1,0.5),(0.2,0.8),}}	{{(0.6,0.8),(0.4,0.3)},{(0.2,0.3),(0.6,0.4)},{(0.1,0.5),(0.2,0.8),}}
$NZRA_8$	{{(0.7,0.6),(0.8,0.3)},{(0.3,0.2),(0.7,0.6)},{(0.5,0.4),(0.9,0.3),}}	{{(0.7,0.6),(0.8,0.3)},{(0.3,0.2),(0.7,0.6)},{(0.5,0.4),(0.9,0.3),}}	{{(0.7,0.6),(0.8,0.3)},{(0.3,0.2),(0.7,0.6)},{(0.5,0.4),(0.9,0.3),}}	{{(0.1,0.3),(0.9,0.4)},{(0.2,0.6),(0.3,0.7)},{(0.6,0.8),(0.5,0.2),}}

Table 2. Combine SV-NZRNs.

	$\overline{T}_y(X)$	$\overline{T}_z(X)$	$\underline{T}_y(X)$	$\underline{T}_z(X)$	$\overline{I}_y(X)$	$\overline{I}_z(X)$	$\underline{I}_y(X)$	$\underline{I}_z(X)$	$\overline{F}_y(X)$	$\overline{F}_z(X)$	$\underline{F}_y(X)$	$\underline{F}_z(X)$
$NZRA_1$	0.05001587	0.14776054	0.03844024	0.00899182	0.20324491	0.35938515	0.63454463	0.25548158	0.21130025	0.46773514	0.29205840	0.40368200
	7	7	4	5	8	1	8	1	8	1	5	6
$NZRA_2$	0.12639428	0.12639428	0.05591268	0.00597618	0.18483742	0.36712132	0.55507550	0.55507550	0.21877616	0.49674077	0.52754513	0.29205840
	6	6	1	1	6	2	5	5	2	6	5	5
$NZRA_3$	0.00231543	0.02435722	0.15745986	0.01067526	0.20324491	0.60307279	0.30363374	0.70250118	0.33387186	0.58008202	0.61125191	0.25548158
	8	6	4	4	8	5	9	3	7	1	3	1
$NZRA_4$	0.00798454	0.08658427	0.08028267	0.00597618	0.20324491	0.35938515	0.69773733	0.25548158	0.40158953	0.46773514	0.33387186	0.38627984
	1	2	4	1	8	1	4	1		1	7	5
$NZRA_5$	0.00932804	0.06339047	0.17806041	0.00597618	0.23234311	0.31437645	0.73414932	0.29205840	0.68303425	0.43452993	0.54845368	0.27946818
	8	2	7	1	7	6	2	5	2			
$NZRA_6$	0.01067526	0.07483980	0.10273707	0.00397602	0.16168874	0.49674077	0.61035407	0.30729971	0.50480341	0.49674077	0.52754513	0.19448331
	4	3	3	6	8	6	2			6	5	7

NZRA$_7$	0.108532425	0.147760547	0.055912681	0.005976181	0.232343117	0.333871867	0.50480341	0.555075505	0.174044419	0.39517541	0.54845368	0.461476412
NZRA$_8$	0.016442916	0.037013053	0.246591123	0.012026215	0.265607251	0.292058405	0.531146985	0.634544638	0.534699916	0.507433681	0.742096114	0.265607251
	$\overline{T}_y(X)$	$\overline{T}_z(X)$	$\underline{T}_y(X)$	$\underline{T}_z(X)$	$\overline{I}_y(X)$	$\overline{I}_z(X)$	$\underline{I}_y(X)$	$\underline{I}_z(X)$	$\overline{F}_y(X)$	$\overline{F}_z(X)$	$\underline{F}_y(X)$	$\underline{F}_z(X)$
NZRA$_1$	0.000330111	0.008991825	0.350050123	0.021589668	0.203244918	0.603072795	0.303633749	0.702501183	0.603072795	0.801787142	0.503477775	0.203244918
NZRA$_2$	0.129444283	0.077164483	0.210815513	0.008991825	0.303633749	0.203244918	0.702501183	0.603072795	0.503477775	0.403682006	0.900948744	0.303633749
NZRA$_3$	0.147760547	0.151429009	0.034171474	0.003976026	0.128629298	0.580082021	0.461476412	0.58404257	0.161688748	0.567858233	0.507433681	0.203244918
NZRA$_4$	0.178060417	0.108532425	0.070991483	0.003976026	0.147044916	0.507433681	0.485558932	0.667658864	0.275004562	0.527545135	0.833564901	0.147044916
NZRA$_5$	0.038440244	0.106039366	0.088571732	0.005976181	0.203244918	0.534699916	0.531146985	0.194483317	0.436314912	0.367121322	0.689413611	0.161688748
NZRA$_6$	0.001321773	0.052218461	0.178060417	0.003976026	0.203244918	0.359385151	0.767223231	0.255481581	0.763246347	0.467735141	0.381671684	0.369627867
NZRA$_7$	0.014059701	0.050015887	0.106039366	0.012026215	0.232343117	0.333871867	0.50480341	0.555075505	0.314376456	0.546209934	0.451751942	0.367121322
NZRA$_8$	0.014059701	0.050015887	0.106039366	0.012026215	0.232343117	0.333871867	0.50480341	0.555075505	0.314376456	0.546209934	0.451751942	0.367121322
	$\overline{T}_y(X)$	$\overline{T}_z(X)$	$\underline{T}_y(X)$	$\underline{T}_z(X)$	$\overline{I}_y(X)$	$\overline{I}_z(X)$	$\underline{I}_y(X)$	$\underline{I}_z(X)$	$\overline{F}_y(X)$	$\overline{F}_z(X)$	$\underline{F}_y(X)$	$\underline{F}_z(X)$
NZRA$_1$	0.210815513	0.129444283	0.043108587	0.002647107	0.102329299	0.801787142	0.403682006	0.702501183	0.203244918	0.603072795	0.801787142	0.102329299
NZRA$_2$	0.129444283	0.210815513	0.043108587	0.002647107	0.203244918	0.603072795	0.303633749	0.702501183	0.102329299	0.303633749	0.900948744	0.403682006
NZRA$_3$	0.021589668	0.077164483	0.129444283	0.008991825	0.203244918	0.503477775	0.702501183	0.102329299	0.900948744	0.403682006	0.603072795	0.102329299
NZRA$_4$	0.001982399	0.024357226	0.121215457	0.016101739	0.203244918	0.479766411	0.381671684	0.58404257	0.333871867	0.686593192	0.372100373	0.321143764
NZRA$_5$	0.178060417	0.108532425	0.070991483	0.003976026	0.147044916	0.507433681	0.485558932	0.667658864	0.275004562	0.527545135	0.833564901	0.147044916
NZRA$_6$	0.038440244	0.106039366	0.088571732	0.005976181	0.203244918	0.534699916	0.531146985	0.194483317	0.436314912	0.367121322	0.689413611	0.161688748
NZRA$_7$	0.014059701	0.050015887	0.106039366	0.012026215	0.232343117	0.333871867	0.50480341	0.555075505	0.314376456	0.546209934	0.451751942	0.367121322
NZRA$_8$	0.014059701	0.050015887	0.106039366	0.012026215	0.232343117	0.333871867	0.50480341	0.555075505	0.314376456	0.546209934	0.451751942	0.367121322
	$\overline{T}_y(X)$	$\overline{T}_z(X)$	$\underline{T}_y(X)$	$\underline{T}_z(X)$	$\overline{I}_y(X)$	$\overline{I}_z(X)$	$\underline{I}_y(X)$	$\underline{I}_z(X)$	$\overline{F}_y(X)$	$\overline{F}_z(X)$	$\underline{F}_y(X)$	$\underline{F}_z(X)$
NZRA$_1$	0.021589668	0.077164	0.129444	0.008992	0.203245	0.503478	0.702501	0.102329	0.900949	0.403682	0.603073	0.102329
NZRA$_2$	0.001321773	0.052218	0.17806	0.003976	0.203245	0.359385	0.767223	0.255482	0.763246	0.467735	0.381672	0.369628
NZRA$_3$	0.002647107	0.06151	0.119503	0.002647	0.161689	0.419681	0.637851	0.485559	0.464627	0.5347	0.419681	0.369628
NZRA$_4$	0.012026215	0.067936	0.050016	0.012026	0.203245	0.381672	0.479766	0.485559	0.184837	0.587949	0.275005	0.507434
NZRA$_5$	0.012026215	0.067936	0.050016	0.012026	0.203245	0.381672	0.479766	0.485559	0.184837	0.587949	0.275005	0.507434
NZRA$_6$	0.016442916	0.06339	0.210816	0.005976	0.265607	0.232343	0.734149	0.527545	0.562604	0.43453	0.626975	0.40159
NZRA$_7$	0.014059701	0.050016	0.106039	0.012026	0.232343	0.333872	0.504803	0.555076	0.314376	0.54621	0.451752	0.367121
NZRA$_8$	0.001982399	0.041308	0.106039	0.007985	0.203245	0.381672	0.527545	0.485559	0.351295	0.587949	0.314376	0.485559

8. Conclusions

The study concludes that immersive virtual reality teaching models in university English instruction successfully improve language proficiency, encourage participation, and mimic authentic conversation situations. Interactive role-playing and cultural immersion scenarios received the greatest efficacy ratings out of all the alternatives that were tested. However, careful integration, intuitive design, and a balanced cognitive load are necessary for these technologies to succeed. When combined with appropriate training and curriculum alignment, virtual reality (VR) may be a useful teaching tool for universities looking to update language pedagogy. This study used the Neutrosophic Z-Rough Set Aggregation Operator to overcome uncertainty. The arithmetic operator is used to combine the numberish numbers. The score function is used to obtain crisp values. To direct pedagogical innovation and guarantee long-lasting educational effect, evaluation frameworks must be continuously improved.

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