NSS

Neutrosophic Sets and Systems, Vol. 83, 2025

University of New Mexico

Modest Insights from Grammar to Growth: A Neutrosophic Numbers Model for Measuring English Teaching Outcomes in University Contexts in a Preliminary Approach

Yisen Zhao*

Department of Public Basic Education, Hebi Polytechnic, Hebi, 458030, China

*Corresponding author, E-mail: victory007810@163.com

Abstract: English language instruction in higher education plays a pivotal role in shaping students' academic and professional success. As global communication becomes increasingly interconnected, universities must ensure their English teaching strategies meet high standards of effectiveness and relevance. This study introduces a multi-criteria framework to evaluate English teaching outcomes, encompassing eight distinct criteria such as linguistic development, communicative confidence, and critical thinking enhancement. By comparing seven alternative course models implemented across universities, the research identifies strengths and gaps within current practices. We use the WASPAS method as a MCDM approach to rank the alternatives. The WASPAS method is used under neutrosophic numbers to overcome uncertainty and vague information. The outcomes offer actionable insights for educators and institutions aiming to elevate the quality of English language education and its alignment with student needs and global demands.

Keywords: Neutrosophic Numbers; Education; English Teaching Outcomes; university Context.

---

1. Introduction

There has never been a greater need for effective English communication skills, particularly in a world where cross-cultural cooperation, worldwide commerce, and global academics are the norm. Therefore, university English instruction must emphasize wider abilities that promote student development and societal involvement in addition to grammar and vocabulary[1], [2]. While learning objectives and course material may vary from one school to another, all prioritize effective education. To support evidence-driven pedagogical reforms, it is imperative that we abandon anecdotal assessments of quality and embrace sound, criteria-based evaluation techniques[3], [4].

The purpose of this study is to use a systematic assessment technique to evaluate the effectiveness and results of university English education. It combines learner feedback, instructional practice, and educational research to provide a thorough knowledge of what makes teaching English in a variety of learning contexts effective.

Eight carefully selected assessment criteria represent both contemporary educational objectives and conventional language acquisition benchmarks form the basis of the study. The spectrum of student development that university-level English courses promote is intended to be captured by these characteristics[5], [6].

Seven course models that are currently in use at various institutions are examined to show the assessment framework's usefulness. These options cover a range of strategies, from cutting-edge, tech-enhanced training to more traditional lecture-based techniques.

In addition to ranking each model's effectiveness in relation to the chosen criteria, the comparison analysis identifies the teaching components that have the greatest impact on student achievement. This factual basis encourages ongoing teacher development and curriculum improvement[7].

By doing this, the study adds to the larger conversation about the caliber of language instruction in higher education and provides colleges with an adaptable and scalable framework for both internal evaluation and external comparison. Additionally, it highlights how important it is to incorporate student experience as a crucial quality assurance indicator[8], [9].

The neutrosophic set (NS) notion was first proposed by Smarandache. The three components of Smarandache's NS are falsehood, indeterminacy, and truth. Membership values for truth, indeterminacy, and falsehood function independently and address issues of imprecise, uncertain, and indeterminate data[10], [11]. A novel notion of single valued neutrosophic set (SVNS) was introduced by Wang et al. who also defined the set of theoretic operators in an instance of NS known as SVNS[12], [13].

The cosine similarity measure in NSs is a specific instance of the correlation coefficient, according to Ye's [14] analysis of the correlation coefficient and enhanced correlation coefficient of NSs. Peng [15]and colleagues presented an outranking concept of simplified neutrosophic numbers and spoke about how they work.

Pawlak [16] introduced rough set theory in 1982. The study of intelligence systems with imprecise, ambiguous, or missing data is done using rough set theory. A system's concealed information is managed using the lower and upper approximation operators of RSs[17], [18]. To effectively handle uncertainty and incomplete information, a variety of hybrid models have been developed, including intuitionistic fuzzy soft, rough sets (IFSRS), neutrosophic rough sets (NRSs), fuzzy fuzzy sets (FRSs), soft fuzzy rough sets (SFRSs), soft fuzzy fuzzy sets (SRFSs), soft, rough sets (SRSs), and rough neutrosophic sets (RNSs). Two distinct mathematical approaches to uncertainty management are soft set theory and RS theory.

2. Preliminaries

This section shows the operations of the neutrosophic sets such as neutrosophic z-rough set (NZR)[19], [20].

$$A_1 \otimes A_2 = \begin{Bmatrix} \left\{\left(\overline{X_{P_1}}, \overline{X_{V_1}}\right), \left(\underline{X_{P_1}}, \underline{X_{V_1}}\right)\right\}\left\{\left(\overline{X_{P_2}}, \overline{X_{V_2}}\right), \left(\underline{X_{P_2}}, \underline{X_{V_2}}\right)\right\}, \\ \left\{\left(\overline{Y_{P_1}}, \overline{Y_{V_1}}\right), \left(\underline{Y_{P_1}}, \underline{Y_{V_1}}\right)\right\} + \left\{\left(\overline{Y_{P_2}}, \overline{Y_{V_2}}\right), \left(\underline{Y_{P_2}}, \underline{Y_{V_2}}\right)\right\} - \\ \left\{\left(\overline{Y_{P_1}}, \overline{Y_{V_1}}\right), \left(\underline{Y_{P_1}}, \underline{Y_{V_1}}\right)\right\}\left\{\left(\overline{Y_{P_2}}, \overline{Y_{V_2}}\right), \left(\underline{Y_{P_2}}, \underline{Y_{V_2}}\right)\right\}, \\ \left\{\left(\overline{Z_{P_1}}, \overline{Z_{V_1}}\right), \left(\underline{Z_{P_1}}, \underline{Z_{V_1}}\right)\right\} + \left\{\left(\overline{Z_{P_2}}, \overline{Z_{V_2}}\right), \left(\underline{Z_{P_2}}, \underline{Z_{V_2}}\right)\right\} - \\ \left\{\left(\overline{Z_{P_1}}, \overline{Z_{V_1}}\right), \left(\underline{Z_{P_1}}, \underline{Z_{V_1}}\right)\right\}\left\{\left(\overline{Z_{P_2}}, \overline{Z_{V_2}}\right), \left(\underline{Z_{P_2}}, \underline{Z_{V_2}}\right)\right\} \end{Bmatrix} \tag{1}$$

$$A_1 \oplus A_2 = \begin{Bmatrix} \left\{\left(\overline{X_{P_1}}, \overline{X_{V_1}}\right), \left(\underline{X_{P_1}}, \underline{X_{V_1}}\right)\right\} + \left\{\left(\overline{X_{P_2}}, \overline{X_{V_2}}\right), \left(\underline{X_{P_2}}, \underline{X_{V_2}}\right)\right\} - \\ \left\{\left(\overline{X_{P_1}}, \overline{X_{V_1}}\right), \left(\underline{X_{P_1}}, \underline{X_{V_1}}\right)\right\}\left\{\left(\overline{X_{P_2}}, \overline{X_{V_2}}\right), \left(\underline{X_{P_2}}, \underline{X_{V_2}}\right)\right\}, \\ \left\{\left(\overline{Y_{P_1}}, \overline{Y_{V_1}}\right), \left(\underline{Y_{P_1}}, \underline{Y_{V_1}}\right)\right\}\left\{\left(\overline{Y_{P_2}}, \overline{Y_{V_2}}\right), \left(\underline{Y_{P_2}}, \underline{Y_{V_2}}\right)\right\}, \\ \left\{\left(\overline{Z_{P_1}}, \overline{Z_{V_1}}\right), \left(\underline{Z_{P_1}}, \underline{Z_{V_1}}\right)\right\}\left\{\left(\overline{Z_{P_2}}, \overline{Z_{V_2}}\right), \left(\underline{Z_{P_2}}, \underline{Z_{V_2}}\right)\right\} \end{Bmatrix} \tag{2}$$

$$A_1^l = \begin{Bmatrix} \left\{\left(\overline{X_{P_1}}, \overline{X_{V_1}}\right), \left(\underline{X_{P_1}}, \underline{X_{V_1}}\right)\right\}^l, \\ 1 - \left(1 - \left\{\left(\overline{Y_{P_1}}, \overline{Y_{V_1}}\right), \left(\underline{Y_{P_1}}, \underline{Y_{V_1}}\right)\right\}\right)^l, \\ 1 - \left(1 - \left\{\left(\overline{Y_{P_1}}, \overline{Y_{V_1}}\right), \left(\underline{Y_{P_1}}, \underline{Y_{V_1}}\right)\right\}\right)^l \end{Bmatrix} \tag{3}$$

$$lA_1 = \begin{Bmatrix} 1 - \left(1 - \left\{\left(\overline{X_{P_1}}, \overline{X_{V_1}}\right), \left(\underline{X_{P_1}}, \underline{X_{V_1}}\right)\right\}\right)^l, \\ \left\{\left(\overline{Y_{P_1}}, \overline{Y_{V_1}}\right), \left(\underline{Y_{P_1}}, \underline{Y_{V_1}}\right)\right\}^l, \\ \left\{\left(\overline{Z_{P_1}}, \overline{Z_{V_1}}\right), \left(\underline{Z_{P_1}}, \underline{Z_{V_1}}\right)\right\}^l \end{Bmatrix} \tag{4}$$

$$l^{A_1} = \begin{Bmatrix} l^{1-\left\{\left(\overline{X_{P_1}}, \overline{X_{V_1}}\right), \left(\underline{X_{P_1}}, \underline{X_{V_1}}\right)\right\}}, \\ 1 - l^{\left\{\left(\overline{Y_{P_1}}, \overline{Y_{V_1}}\right), \left(\underline{Y_{P_1}}, \underline{Y_{V_1}}\right)\right\}}, \\ 1 - l^{\left\{\left(\overline{Z_{P_1}}, \overline{Z_{V_1}}\right), \left(\underline{Z_{P_1}}, \underline{Z_{V_1}}\right)\right\}} \end{Bmatrix} \tag{5}$$

$$NZR\ operator = \begin{Bmatrix} 1-\prod_{A=1}^{n}\left(1-\left(\overline{X_{P_1}},\overline{X_{V_1}}\right),\left(\underline{X_{P_1}},\underline{X_{V_1}}\right)\right)^{l_A}, \\ \prod_{A=1}^{n}\left(l^{\left\{\left(\overline{Y_{P_1}},\overline{Y_{V_1}}\right),\left(\underline{Y_{P_1}},\underline{Y_{V_1}}\right)\right\}}\right)^{L_A}, \\ \prod_{A=1}^{n}\left(\left(\overline{Z_{P_1}},\overline{Z_{V_1}}\right),\left(\underline{Z_{P_1}},\underline{Z_{V_1}}\right)\right)^{l_A} \end{Bmatrix} \quad (6)$$

3. WASPAS Approach

We show the steps of the WASPAS method to rank the alternatives. Create the decision matrix using the NZR between the criteria and alternatives.

Compute the criteria weights.

The weights of criteria are computed using the average method.

Compute the normalized decision matrix for positive and cost criteria.

$$q_{ij} = \frac{y_{ij}}{\max_i y_{ij}} \quad (7)$$

$$q_{ij} = \frac{y_{ij}}{\min_i y_{ij}} \quad (8)$$

Calculate the additive relative importance

$$A_i^{(1)} = \sum_{j=1}^{n} q_{ij} w_j \quad (9)$$

Calculate the multiplicative relative importance

$$A_i^{(2)} = \prod_{j=1}^{n} \left(q_{ij}\right)^{w_j} \quad (10)$$

Compute the joint generalized criterion

$$A_i = \rho A_i^{(1)} + (1-\rho) A_i^{(2)} \quad (11)$$

4. Results

This section shows the results of the proposed approach. Fig 1 shows the criteria and alternatives of this paper.

Fig 1. The criteria and alternatives.

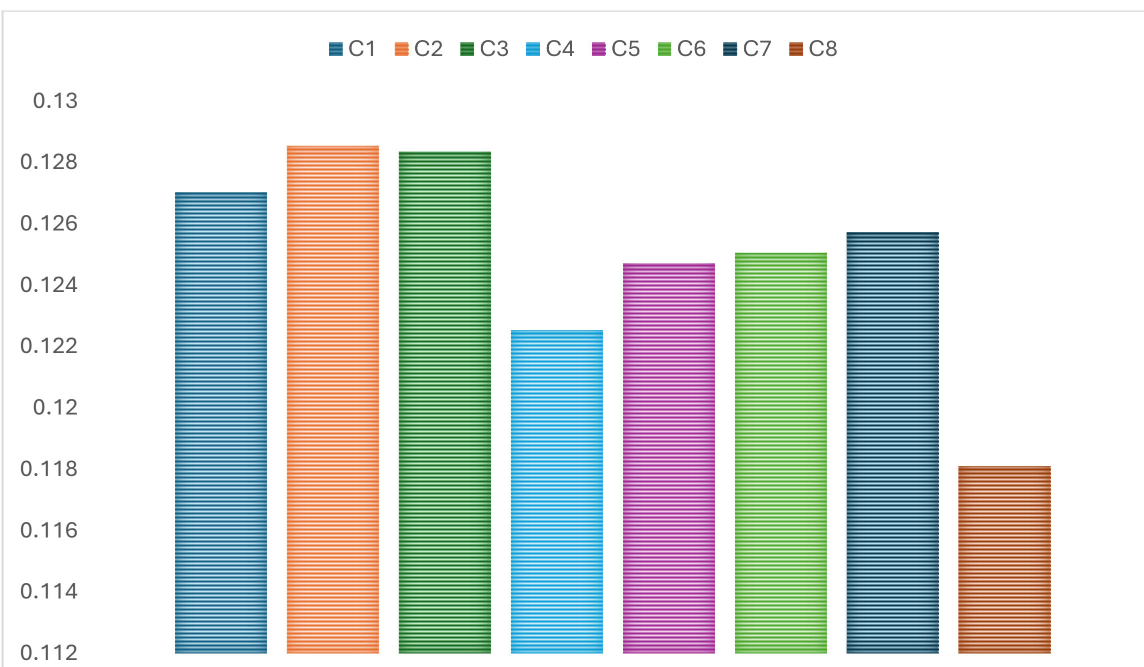

Fig 2. The weights of criteria.

Table 1. The first decision matrix.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
A_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},{0.7,0.8},{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})	({0.3,0.1},{0.7,0.3},{0.2,0.9},{0.6,0.3},{0.6,0.2},{0.8,0.9})	({0.4,0.3},{0.7,0.6},{0.5,0.1},{0.4,0.6},{0.2,0.1},{0.9,0.5})	({0.8,0.7},{0.5,0.2},{0.1,0.8},{0.4,0.7},{0.2,0.6},{0.8,0.1})
A_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})	({0.4,0.3},{0.7,0.6},{0.5,0.1},{0.4,0.6},{0.2,0.1},{0.9,0.5})	({0.3,0.1},{0.7,0.3},{0.2,0.9},{0.6,0.3},{0.6,0.2},{0.8,0.9})	({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})	({0.6,0.8},{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})
A_3	({0.1,0.3},{0.9,0.4},{0.2,0.6},{0.3,0.7},{0.7,0.8},{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})	({0.3,0.1},{0.7,0.3},{0.2,0.9},{0.6,0.3},{0.6,0.2},{0.8,0.9})	({0.1,0.3},{0.9,0.4},{0.2,0.6},{0.3,0.7},{0.7,0.8},{0.5,0.2})	({0.1,0.3},{0.9,0.4},{0.2,0.6},{0.3,0.7},{0.7,0.8},{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})
A_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},{0.7,0.8},{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})	({0.4,0.3},{0.7,0.6},{0.5,0.1},{0.4,0.6},{0.2,0.1},{0.9,0.5})	({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})	({0.3,0.1},{0.7,0.3},{0.2,0.9},{0.6,0.3},{0.6,0.2},{0.8,0.9})
A_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},{0.7,0.8},{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})	({0.4,0.3},{0.7,0.6},{0.5,0.1},{0.4,0.6},{0.2,0.1},{0.9,0.5})	({0.4,0.6},{0.7,0.3},{0.2,0.5},{0.7,0.1},{0.9,0.4},{0.6,0.1})	({0.4,0.3},{0.7,0.6},{0.5,0.1},{0.4,0.6},{0.2,0.1},{0.9,0.5})
A_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})	({0.4,0.3},{0.7,0.6},{0.5,0.1},{0.4,0.6},{0.2,0.1},{0.9,0.5})	({0.3,0.1},{0.7,0.3},{0.2,0.9},{0.6,0.3},{0.6,0.2},{0.8,0.9})	({0.1,0.5},{0.8,0.2},{0.2,0.3},{0.8,0.4},{0.7,0.5},{0.3,0.7})	({0.3,0.1},{0.7,0.3},{0.2,0.9},{0.6,0.3},{0.6,0.2},{0.8,0.9})
A_7	({0.3,0.1},{0.7,0.3},{0.2,0.9},{0.6,0.3},{0.6,0.2},{0.8,0.9})	({0.3,0.1},{0.7,0.3},{0.2,0.9},{0.6,0.3},{0.6,0.2},{0.8,0.9})	({0.8,0.7},{0.5,0.2},{0.1,0.8},{0.4,0.7},{0.2,0.6},{0.8,0.1})	({0.3,0.1},{0.7,0.3},{0.2,0.9},{0.6,0.3},{0.6,0.2},{0.8,0.9})	({0.3,0.1},{0.7,0.3},{0.2,0.9},{0.6,0.3},{0.6,0.2},{0.8,0.9})	({0.1,0.5},{0.8,0.2},{0.2,0.3},{0.8,0.4},{0.7,0.5},{0.3,0.7})	({0.3,0.1},{0.7,0.3},{0.2,0.9},{0.6,0.3},{0.6,0.2},{0.8,0.9})	({0.1,0.5},{0.8,0.2},{0.2,0.3},{0.8,0.4},{0.7,0.5},{0.3,0.7})

Table 2. The second decision matrix.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
A_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},{0.7,0.8},{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})	({0.3,0.1},{0.7,0.3},{0.2,0.9},{0.6,0.3},{0.6,0.2},{0.8,0.9})	({0.4,0.3},{0.7,0.6},{0.5,0.1},{0.4,0.6},{0.2,0.1},{0.9,0.5})	({0.8,0.7},{0.5,0.2},{0.1,0.8},{0.4,0.7},{0.2,0.6},{0.8,0.1})
A_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})	({0.4,0.3},{0.7,0.6},{0.5,0.1},{0.4,0.6},{0.2,0.1},{0.9,0.5})	({0.3,0.1},{0.7,0.3},{0.2,0.9},{0.6,0.3},{0.6,0.2},{0.8,0.9})	({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})	({0.8,0.7},{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})	({0.4,0.6},{0.7,0.3},{0.2,0.5},{0.7,0.1},{0.9,0.4},{0.6,0.1})
A_3	({0.1,0.3},{0.9,0.4},{0.2,0.6},{0.3,0.7},{0.7,0.8},{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})	({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},{0.7,0.8},{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})	({0.1,0.5},{0.8,0.2},{0.2,0.3},{0.8,0.4},{0.7,0.5},{0.3,0.7})
A_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},{0.7,0.8},{0.5,0.2})	({0.1,0.3},{0.9,0.4},{0.2,0.6},{0.3,0.7},{0.7,0.8},{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})	({0.6,0.8},{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},{0.7,0.8},{0.5,0.2})	({0.3,0.1},{0.7,0.3},{0.2,0.9},{0.6,0.3},{0.6,0.2},{0.8,0.9})
A_5	({0.4,0.3},{0.7,0.6},{0.5,0.1},{0.4,0.6},{0.2,0.1},{0.9,0.5})	({0.4,0.6},{0.7,0.3},{0.2,0.5},{0.7,0.1},{0.9,0.4},{0.6,0.1})	({0.8,0.7},{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})	({0.1,0.3},{0.9,0.4},{0.2,0.6},{0.3,0.7},{0.7,0.8},{0.5,0.2})	({0.4,0.3},{0.7,0.6},{0.5,0.1},{0.4,0.6},{0.2,0.1},{0.9,0.5})	({0.6,0.8},{0.4,0.3},{0.2,0.3},{0.6,0.4},{0.1,0.5},{0.2,0.8})	({0.1,0.5},{0.8,0.2},{0.2,0.3},{0.8,0.4},{0.7,0.5},{0.3,0.7})
A_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})	({0.4,0.3},{0.7,0.6},{0.5,0.1},{0.4,0.6},{0.2,0.1},{0.9,0.5})	({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})	({0.4,0.3},{0.7,0.6},{0.5,0.1},{0.4,0.6},{0.2,0.1},{0.9,0.5})	({0.3,0.1},{0.7,0.3},{0.2,0.9},{0.6,0.3},{0.6,0.2},{0.8,0.9})
A_7	({0.8,0.7},{0.5,0.2},{0.1,0.8},{0.4,0.7},{0.2,0.6},{0.8,0.1})	({0.8,0.7},{0.5,0.2},{0.1,0.8},{0.4,0.7},{0.2,0.6},{0.8,0.1})	({0.8,0.7},{0.5,0.2},{0.1,0.8},{0.4,0.7},{0.2,0.6},{0.8,0.1})	({0.3,0.1},{0.7,0.3},{0.2,0.9},{0.6,0.3},{0.6,0.2},{0.8,0.9})	({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})	({0.3,0.1},{0.7,0.3},{0.2,0.9},{0.6,0.3},{0.6,0.2},{0.8,0.9})	({0.1,0.5},{0.8,0.2},{0.2,0.3},{0.8,0.4},{0.7,0.5},{0.3,0.7})

Table 3. The third decision matrix.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8

A_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},{0.7,0.8}, {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})	({0.3,0.1}, {0.7,0.3},{0.2,0.9}, {0.6,0.3},{0.6,0.2}, {0.8,0.9})	({0.4,0.3}, {0.7,0.6},{0.5,0.1}, {0.4,0.6},{0.2,0.1}, {0.9,0.5})	({0.8,0.7}, {0.5,0.2},{0.1,0.8}, {0.4,0.7},{0.2,0.6}, {0.8,0.1})
A_2	({0.4,0.3}, {0.7,0.6},{0.5,0.1}, {0.4,0.6},{0.2,0.1}, {0.9,0.5})	({0.4,0.3}, {0.7,0.6},{0.5,0.1}, {0.4,0.6},{0.2,0.1}, {0.9,0.5})	({0.3,0.1}, {0.7,0.3},{0.2,0.9}, {0.6,0.3},{0.6,0.2}, {0.8,0.9})	({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})	({0.6,0.8}, {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})
A_3	({0.3,0.1}, {0.7,0.3},{0.2,0.9}, {0.6,0.3},{0.6,0.2}, {0.8,0.9})	({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})	({0.3,0.1}, {0.7,0.3},{0.2,0.9}, {0.6,0.3},{0.6,0.2}, {0.8,0.9})	({0.1,0.3}, {0.9,0.4},{0.2,0.6}, {0.3,0.7},{0.7,0.8}, {0.5,0.2})	({0.4,0.3}, {0.7,0.6},{0.5,0.1}, {0.4,0.6},{0.2,0.1}, {0.9,0.5})	({0.1,0.5}, {0.8,0.2},{0.2,0.3}, {0.8,0.4},{0.7,0.5}, {0.3,0.7})
A_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})	({0.4,0.3}, {0.7,0.6},{0.5,0.1}, {0.4,0.6},{0.2,0.1}, {0.9,0.5})	({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})	({0.3,0.1}, {0.7,0.3},{0.2,0.9}, {0.6,0.3},{0.6,0.2}, {0.8,0.9})	({0.3,0.1}, {0.7,0.3},{0.2,0.9}, {0.6,0.3},{0.6,0.2}, {0.8,0.9})
A_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})	({0.3,0.1}, {0.7,0.3},{0.2,0.9}, {0.6,0.3},{0.6,0.2}, {0.8,0.9})	({0.4,0.3}, {0.7,0.6},{0.5,0.1}, {0.4,0.6},{0.2,0.1}, {0.9,0.5})	({0.6,0.8}, {0.4,0.3},{0.2,0.3}, {0.6,0.4},{0.1,0.5}, {0.2,0.8})	({0.4,0.3}, {0.7,0.6},{0.5,0.1}, {0.4,0.6},{0.2,0.1}, {0.9,0.5})	({0.6,0.8}, {0.4,0.3},{0.2,0.3}, {0.6,0.4},{0.1,0.5}, {0.2,0.8})	({0.1,0.5}, {0.8,0.2},{0.2,0.3}, {0.8,0.4},{0.7,0.5}, {0.3,0.7})	({0.4,0.3}, {0.7,0.6},{0.5,0.1}, {0.4,0.6},{0.2,0.1}, {0.9,0.5})
A_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})	({0.3,0.1}, {0.7,0.3},{0.2,0.9}, {0.6,0.3},{0.6,0.2}, {0.8,0.9})	({0.4,0.3}, {0.7,0.6},{0.5,0.1}, {0.4,0.6},{0.2,0.1}, {0.9,0.5})	({0.3,0.1}, {0.7,0.3},{0.2,0.9}, {0.6,0.3},{0.6,0.2}, {0.8,0.9})	({0.4,0.3}, {0.7,0.6},{0.5,0.1}, {0.4,0.6},{0.2,0.1}, {0.9,0.5})	({0.4,0.6}, {0.7,0.3},{0.2,0.5}, {0.7,0.1},{0.9,0.4}, {0.6,0.1})	({0.3,0.1}, {0.7,0.3},{0.2,0.9}, {0.6,0.3},{0.6,0.2}, {0.8,0.9})
A_7	({0.1,0.3}, {0.9,0.4},{0.2,0.6}, {0.3,0.7},{0.7,0.8}, {0.5,0.2})	({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})	({0.3,0.1}, {0.7,0.3},{0.2,0.9}, {0.6,0.3},{0.6,0.2}, {0.8,0.9})	({0.1,0.5}, {0.8,0.2},{0.2,0.3}, {0.8,0.4},{0.7,0.5}, {0.3,0.7})	({0.3,0.1}, {0.7,0.3},{0.2,0.9}, {0.6,0.3},{0.6,0.2}, {0.8,0.9})	({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})

Table 4. The fourth decision matrix.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
A_1	({0.3,0.1}, {0.7,0.3},{0.2,0.9}, {0.6,0.3},{0.6,0.2}, {0.8,0.9})	({0.4,0.3}, {0.7,0.6},{0.5,0.1}, {0.4,0.6},{0.2,0.1}, {0.9,0.5})	({0.1,0.3}, {0.9,0.4},{0.2,0.6}, {0.3,0.7},{0.7,0.8}, {0.5,0.2})	({0.4,0.3}, {0.7,0.6},{0.5,0.1}, {0.4,0.6},{0.2,0.1}, {0.9,0.5})	({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})	({0.4,0.3}, {0.7,0.6},{0.5,0.1}, {0.4,0.6},{0.2,0.1}, {0.9,0.5})	({0.1,0.3}, {0.9,0.4},{0.2,0.6}, {0.3,0.7},{0.7,0.8}, {0.5,0.2})
A_2	({0.4,0.3}, {0.7,0.6},{0.5,0.1}, {0.4,0.6},{0.2,0.1}, {0.9,0.5})	({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})	({0.4,0.6}, {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})	({0.4,0.3}, {0.7,0.6},{0.5,0.1}, {0.4,0.6},{0.2,0.1}, {0.9,0.5})
A_3	({0.4,0.3}, {0.7,0.6},{0.5,0.1}, {0.4,0.6},{0.2,0.1}, {0.9,0.5})	({0.1,0.3}, {0.9,0.4},{0.2,0.6}, {0.3,0.7},{0.7,0.8}, {0.5,0.2})	({0.4,0.3}, {0.7,0.6},{0.5,0.1}, {0.4,0.6},{0.2,0.1}, {0.9,0.5})	({0.1,0.3}, {0.9,0.4},{0.2,0.6}, {0.3,0.7},{0.7,0.8}, {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})	({0.1,0.3}, {0.9,0.4},{0.2,0.6}, {0.3,0.7},{0.7,0.8}, {0.5,0.2})	({0.1,0.3}, {0.9,0.4},{0.2,0.6}, {0.3,0.7},{0.7,0.8}, {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})
A_4	({0.1,0.3}, {0.9,0.4},{0.2,0.6}, {0.3,0.7},{0.7,0.8}, {0.5,0.2})	({0.1,0.3}, {0.9,0.4},{0.2,0.6}, {0.3,0.7},{0.7,0.8}, {0.5,0.2})	({0.1,0.3}, {0.9,0.4},{0.2,0.6}, {0.3,0.7},{0.7,0.8}, {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})	({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},{0.7,0.8}, {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})	({0.1,0.5}, {0.8,0.2},{0.2,0.3}, {0.8,0.4},{0.7,0.5}, {0.3,0.7})
A_5	({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})	({0.1,0.3}, {0.9,0.4},{0.2,0.6}, {0.3,0.7},{0.7,0.8}, {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})	({0.1,0.3}, {0.9,0.4},{0.2,0.6}, {0.3,0.7},{0.7,0.8}, {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})
A_6	({0.4,0.3}, {0.7,0.6},{0.5,0.1}, {0.4,0.6},{0.2,0.1}, {0.9,0.5})	({0.4,0.3}, {0.7,0.6},{0.5,0.1}, {0.4,0.6},{0.2,0.1}, {0.9,0.5})	({0.4,0.3}, {0.7,0.6},{0.5,0.1}, {0.4,0.6},{0.2,0.1}, {0.9,0.5})	({0.1,0.3}, {0.9,0.4},{0.2,0.6}, {0.3,0.7},{0.7,0.8}, {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})	({0.4,0.3}, {0.7,0.6},{0.5,0.1}, {0.4,0.6},{0.2,0.1}, {0.9,0.5})	({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},{0.7,0.8}, {0.5,0.2})
A_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})	({0.8,0.7}, {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})	({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})	({0.1,0.3}, {0.9,0.4},{0.2,0.6}, {0.3,0.7},{0.7,0.8}, {0.5,0.2})	({0.4,0.3}, {0.7,0.6},{0.5,0.1}, {0.4,0.6},{0.2,0.1}, {0.9,0.5})

Four experts created the decision matrix between the criteria and alternatives as shown in Tables 1-4. They used the NZN to evaluate the criteria and alternatives. These numbers are converted to crisp values and combined into a single matrix. We compute the criteria weights by the average method as shown in Fig 2.

Eq. (7) is used to compute the normalized decision matrix for positive and cost criteria as shown in Fig 3.

Eq. (9) is used to calculate the additive relative importance as shown in Fig 4.

Eq. (10) is used to calculate multiplicative relative importance as shown in Fig 5.

Eq. (11) is used to compute the joint generalized criterion as shown in Fig 6. The alternatives are ranked in Fig 7.

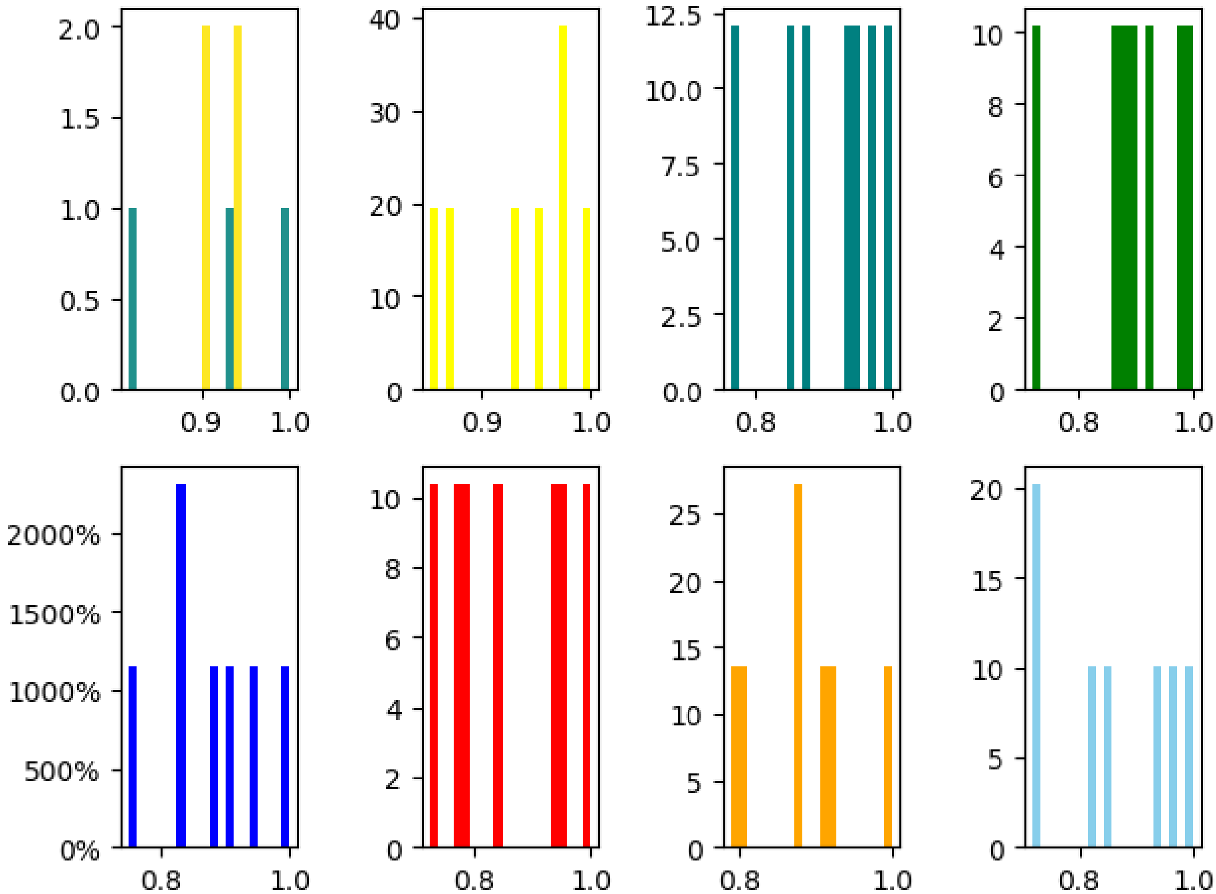

Fig 3. The normalized decision matrix.

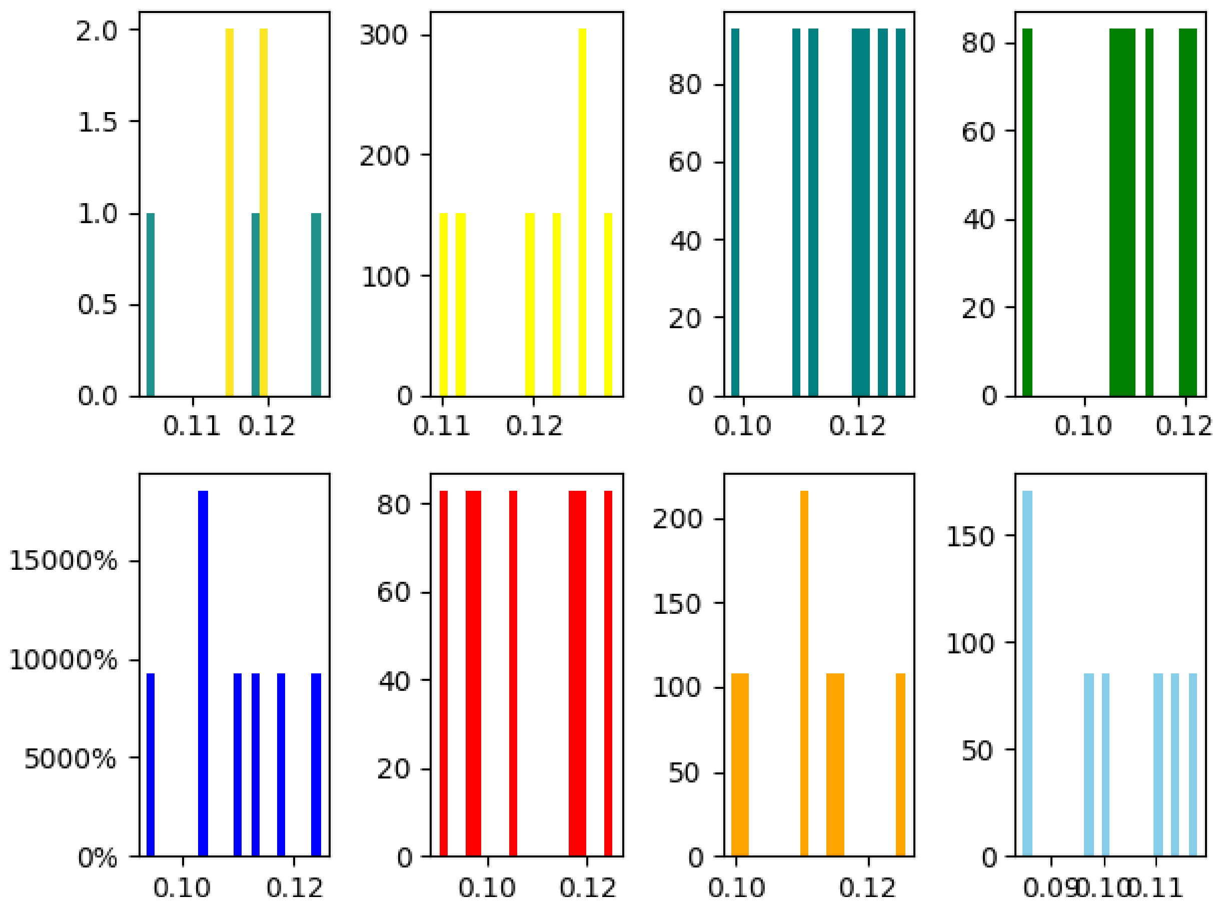

Fig 4. The additive relative importance.

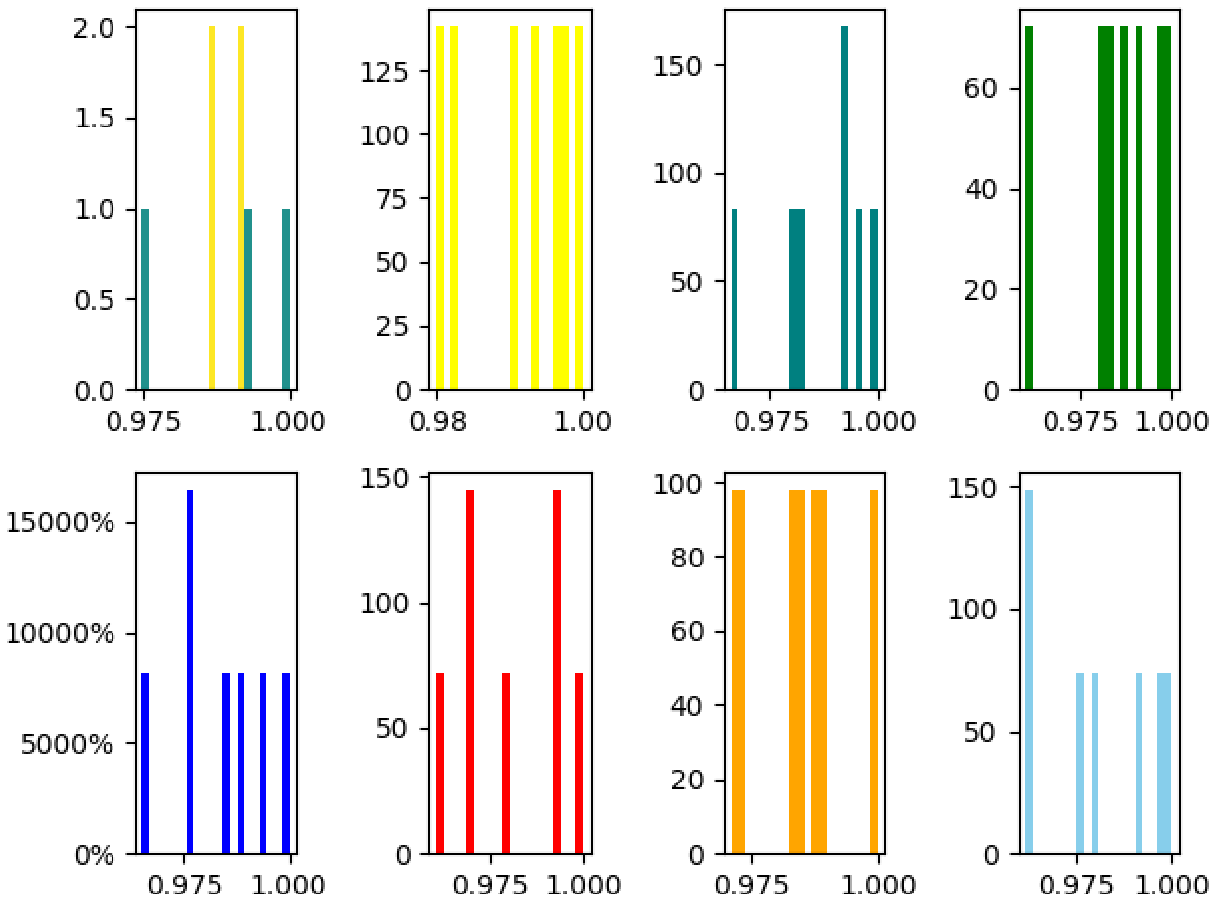

Fig 5. The multiplicative relative importance.

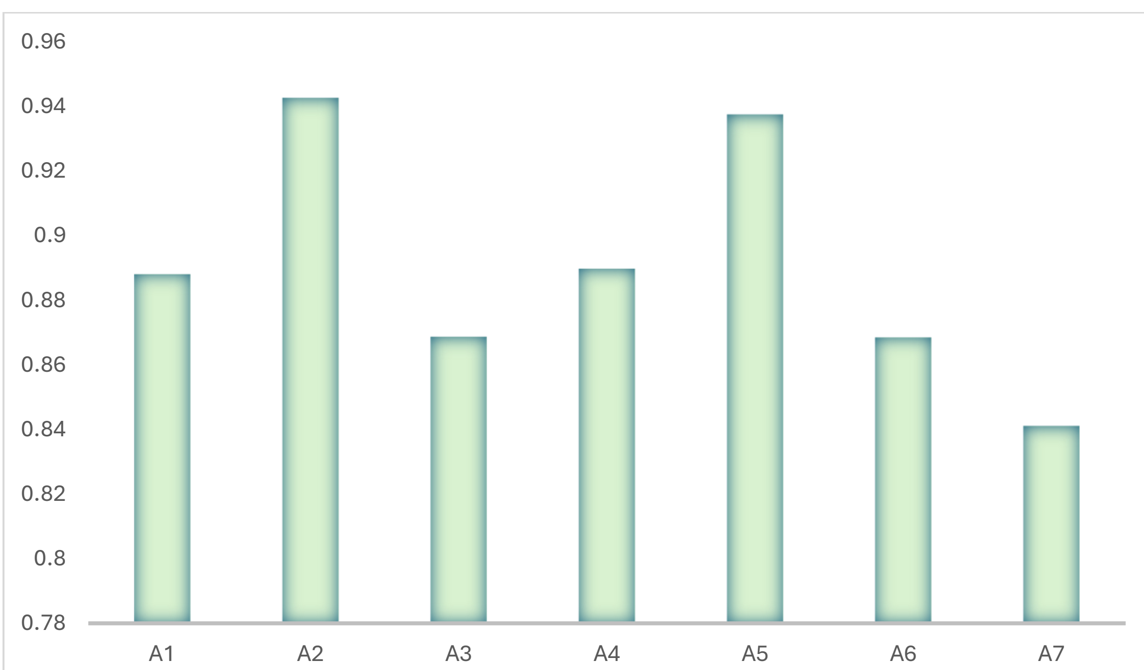

Fig 6. The joint generalized criterion.

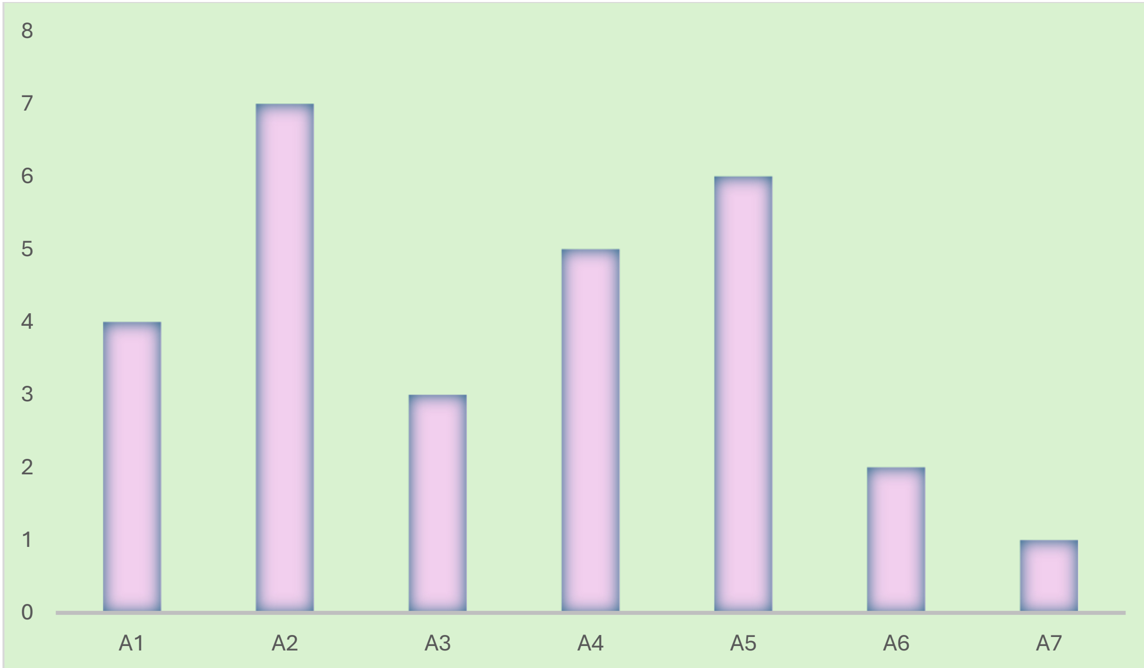

Fig 7. The rank of alternatives.

5. Analysis

This section shows the results of the sensitivity analysis. We change the parameter value of WASPAS between 0 and 1 then we rank the alternatives. The joint criterion values are shown in Fig 8. The ranks of the alternatives are shown in Fig 9.

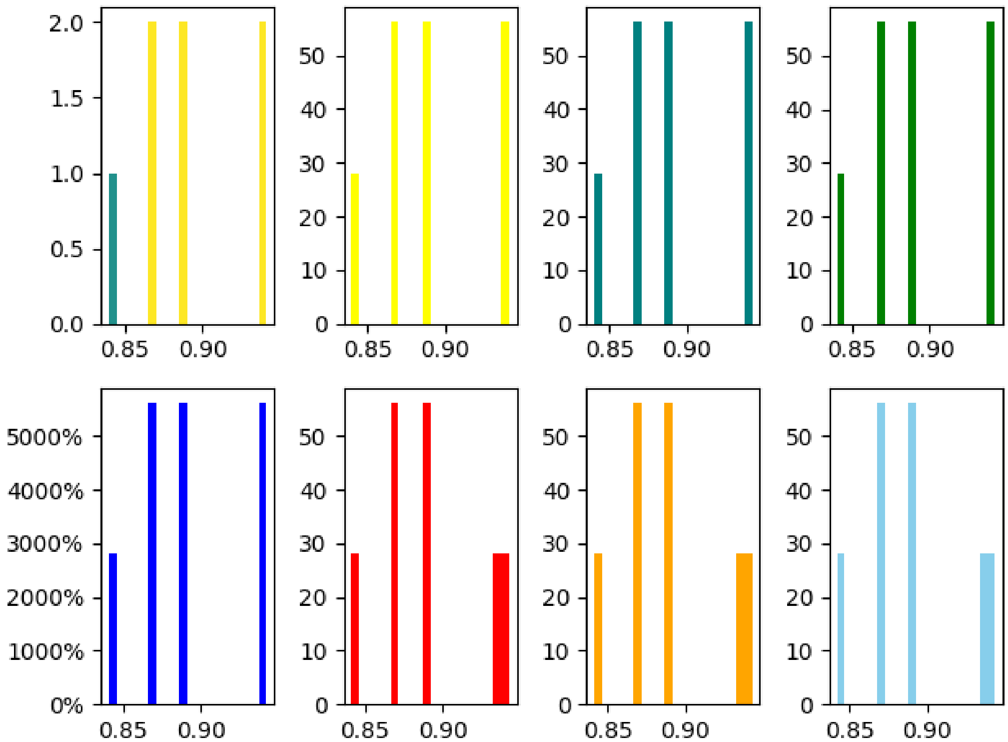

Fig 8. The different joints generalized criterion.

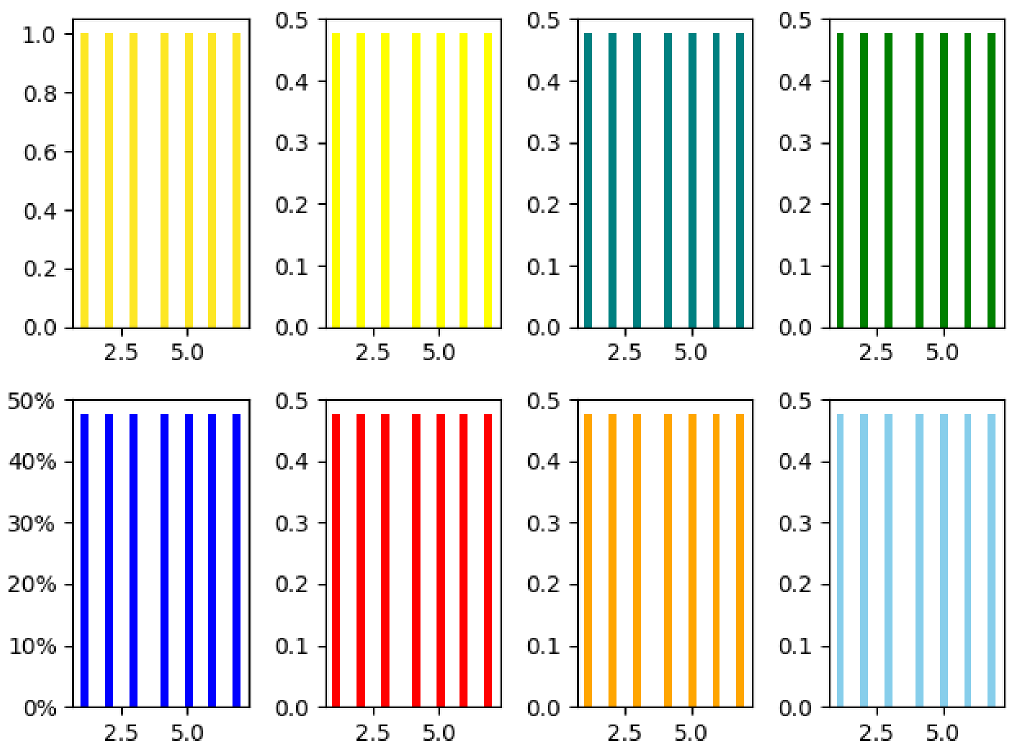

Fig 9. The different ranks of alternatives.

Fig 9 presents the ranking of seven alternatives (A1 to A7) across 11 different cases (Case 1 to Case 11). Each value in the table reflects the rank position of a specific alternative in each evaluation scenario.

- Alternatives (A1 to A7): These are seven different strategies, methods, or options being evaluated—likely in the context of a decision-making or teaching evaluation model.
- Cases (Case 1 to Case 11): Each case represents a different evaluation condition, simulation, criteria weighting scenario, or expert judgment configuration.
- A7 consistently ranks 1st across all 11 cases, indicating it is the top-performing alternative under all scenarios. This suggests A7 is the most robust or universally preferred choice.
- A6 ranks 2nd in 10 out of 11 cases, with only Case 1 ranking it 3rd. This shows strong overall performance with slight variability.
- A3 holds a stable 3rd rank across most cases, except in Case 1 where it is ranked 2nd. This implies consistent mid-high performance.
- A1, A4, A5, and A2 show no variation in their rankings:
    - A1 is consistently ranked 4th
    - A4 always 5th
    - A5 always 6th
    - A2 always 7th — indicating it is the lowest-performing option across all scenarios.
- Alternatives A6 and A7 are the top-performing options across all evaluations, making them potentially the most effective or favorable.
- Alternative A2 is the least favorable in all scenarios and may require review or revision.
- The stability of ranks suggests a high level of agreement or robustness in the evaluation method.

6. Conclusions

This study offers a data-informed framework to evaluate and improve university English teaching. By considering multidimensional outcomes—from grammar acquisition to critical thinking and learner autonomy, it provides a balanced lens for understanding instructional success. The analysis of seven course models demonstrates the diversity of pedagogical pathways and highlights the importance of aligning teaching methods with desired learning outcomes. Institutions can use this approach to drive continuous improvement, adapt to technological advancements, and better prepare students for global communication challenges. We used the WASPAS method to rank the alternatives. The neutrosophic numbers are used to overcome uncertainty and vague information. The analysis was conducted to show the ranks of the alternatives. The results show the rank of alternatives is stable in different cases. In moving from grammar to growth, the future of English education lies in fostering both language competence and intellectual agility.

References

[1] G. Liu and C. Ma, "Measuring EFL learners' use of ChatGPT in informal digital learning of English based on the technology acceptance model," *Innov. Lang. Learn. Teach.*, vol. 18, no. 2, pp. 125–138, 2024.

[2] A. Parpala, S. Lindblom-Ylänne, E. Komulainen, and N. Entwistle, "Assessing students' experiences of teaching–learning environments and approaches to learning: Validation of a questionnaire in different countries and varying contexts," *Learn. Environ. Res.*, vol. 16, pp. 201–215, 2013.

[3] S. Ghaffarian Asl and N. Osam, "A study of teacher performance in English for academic purposes course: Evaluating efficiency," *Sage Open*, vol. 11, no. 4, p. 21582440211050384, 2021.

[4] J. König, S. Lammerding, G. Nold, A. Rohde, S. Strauß, and S. Tachtsoglou, "Teachers' professional knowledge for teaching English as a foreign language: Assessing the outcomes of teacher education," *J. Teach. Educ.*, vol. 67, no. 4, pp. 320–337, 2016.

[5] R. Deem and J.-A. Baird, "The English teaching excellence (and student outcomes) framework: Intelligent accountability in higher education?," *J. Educ. Chang.*, vol. 21, no. 1, pp. 215–243, 2020.

[6] C. G. Puteri, "Second language acquisition: students' vocabulary size and their strategies for retaining it," *Aksara J. Bhs. dan Sastra*, vol. 23, no. 1, pp. 30–36, 2022.

[7] D. D. Qian and L. H. F. Lin, "The relationship between vocabulary knowledge and language proficiency," *Routledge Handb. Vocab. Stud.*, pp. 66–80, 2019.

[8] D. E. Ingram, "Measuring Outcomes and Setting Standards: A Brief Overview.," 1999.

[9] C. Kandiko Howson and A. Buckley, "Quantifying learning: Measuring student outcomes in higher education in England," *Polit. Gov.*, vol. 8, no. 2, pp. 6–14, 2020.

[10] F. Smarandache, *Practical Applications of the Independent Neutrosophic Components and of the Neutrosophic Offset Components*. Infinite Study, 2021.

[11] F. Smarandache and M. Jdid, "An Overview of Neutrosophic and Plithogenic Theories and Applications," 2023.

[12] F. Smarandache, "Foundation of superhyperstructure & neutrosophic superhyperstructure," *Neutrosophic Sets Syst.*, vol. 63, pp. 367–381, 2024.

[13] F. Smarandache, *Indeterminacy in neutrosophic theories and their applications*. Infinite Study, 2021.

[14] J. Ye, "Multicriteria decision-making method using the correlation coefficient under single-valued neutrosophic environment," *Int. J. Gen. Syst.*, vol. 42, no. 4, pp. 386–394, 2013.

[15] J. Peng, J. Wang, H. Zhang, and X. Chen, "An outranking approach for multi-criteria decision-making problems with simplified neutrosophic sets," *Appl. Soft Comput.*, vol. 25, pp. 336–346, 2014.

[16] D. Ciucci, "Back to the beginnings: Pawlak's definitions of the terms information system and rough set," *Thriving Rough Sets 10th Anniv. Profr. Zdzisław Pawlak's Life Leg. 35 Years Rough Sets*, pp. 225–235, 2017.

[17] C. Wang, C. Wang, Y. Qian, and Q. Leng, "Feature selection based on weighted fuzzy rough sets," *IEEE Trans. Fuzzy Syst.*, 2024.

[18] G. Qi, M. Atef, and B. Yang, "Fermatean fuzzy covering-based rough set and their applications in multi-attribute decision-making," *Eng. Appl. Artif. Intell.*, vol. 127, p. 107181, 2024.

[19] A. Al-Quran, N. Hassan, and E. Marei, "A novel approach to neutrosophic soft rough set under uncertainty," *Symmetry (Basel).*, vol. 11, no. 3, p. 384, 2019.

[20] M. Kamran, N. Salamat, C. Jana, and Q. Xin, "Decision-making technique with neutrosophic Z-rough set approach for sustainable industry evaluation using sine trigonometric operators," *Appl. Soft Comput.*, vol. 169, p. 112539, 2025.

Received: Nov. 14, 2024. Accepted: April 16, 2025