NSS

Neutrosophic Sets and Systems, Vol. 88, 2025

University of New Mexico

Evaluating Curriculum Alignment in University-Level Organic Chemistry Programs using N-Valued Neutrosophic Trapezoidal Numbers

Huaying Gao[1], Hongchang Liu[2]*

[1]Library and Information Center of Weifang Engineering Vocational College, Weifang, 262500, Shandong, China

[2]Agriculture and Forestry Technology College, Weifang Engineering Vocational College, Weifang, 262500, Shandong, China

*Corresponding author, E-mail: chaff123@163.com

Abstract: Curriculum alignment serves as a fundamental cornerstone in ensuring that educational programs meet both academic expectations and industry demands. In the context of university-level Organic Chemistry programs, evaluating the degree of alignment between curriculum content, teaching strategies, assessment methods, and learning outcomes is increasingly critical. As the subject plays a central role in multiple scientific disciplines, including biochemistry, medicine, and pharmaceuticals, curricular misalignment can have far-reaching consequences on student preparedness and academic progression. This paper explores various criteria for evaluating curriculum alignment in Organic Chemistry programs, providing a framework for consistent quality enhancement across academic institutions. This paper uses N-Valued Neutrosophic Trapezoidal Numbers to deal with uncertainty and vague information. We show some definitions of neutrosophic numbers and their operations. The distance between two numbers is computed with normalized numbers.

Keywords: N-Valued Neutrosophic Trapezoidal Numbers; Curriculum Alignment; Organic Chemistry Programs; Uncharity.

1. Introduction

Organic Chemistry is widely recognized as a cornerstone of scientific education, particularly within disciplines such as chemistry, biology, medicine, and environmental science. Its curriculum is often considered a rigorous challenge for undergraduate students and a gatekeeper for advanced study[1]. Given its foundational role, a well-aligned Organic Chemistry curriculum is essential for fostering academic success and preparing students for future scientific work.

Curriculum alignment refers to the coherence between educational goals, instructional methods, learning activities, and assessment strategies. For Organic Chemistry programs, alignment ensures that what is taught in lectures and laboratories directly supports the desired student outcomes and broader institutional standards[2]. Misalignment can lead to student confusion, underperformance, and a gap between theoretical knowledge and practical application.

In recent years, there has been a growing demand for universities to make their science curricula more interdisciplinary and responsive to industry changes. Organic Chemistry, traditionally taught as a highly theoretical subject, now requires integration with computational chemistry, green chemistry, and molecular biology to stay relevant[3]. Evaluating curriculum alignment in this context involves examining not only course content but also its relevance to current scientific challenges and career trajectories.

One of the significant challenges in aligning Organic Chemistry curricula is balancing depth with breadth. While foundational concepts such as reaction mechanisms and stereochemistry must be covered in detail, emerging topics like sustainable synthesis and medicinal chemistry are increasingly important[4]. A robust evaluation framework must account for these evolving academic and industry trends while preserving pedagogical rigor.

Laboratory work is another critical component of Organic Chemistry programs that require close alignment with theoretical instruction[5]. Practical experiments should reinforce core concepts while developing hands-on skills in synthesis, instrumentation, and safety procedures[6]. Evaluating the integration between lab and lecture components is essential to determine the effectiveness of the curriculum.

Assessment strategies are equally important in the alignment process. Exams, quizzes, lab reports, and project-based assessments must accurately reflect the learning objectives[7]. Poorly designed assessments may test memorization over conceptual understanding or fail to capture a student's practical abilities, thereby undermining the curriculum's purpose.

Furthermore, accreditation bodies and educational standards increasingly demand outcome-based education models[8]. These models emphasize clearly defined competencies and measurable outcomes, which necessitate frequent curriculum review and alignment. An evaluation framework grounded in data can help departments make informed decisions about course updates, instructional design, and faculty development.

Finally, curriculum alignment is not a one-time task but a dynamic, ongoing process that involves feedback from students, faculty, alumni, and industry partners. As science and society evolve, so too, academic programs must. Continuous evaluation, supported by empirical data and stakeholder engagement, is essential for maintaining academic excellence and relevance.

We must construct certain mathematical theories since it is hard to represent and solve decision-making situations that involve uncertainty. Fuzzy set theory with just one degree of membership, as presented by Zadeh [9], and intuitionistic fuzzy set theory with two degrees of membership, as introduced by Atanassov, have drawn a lot of interest lately for their ability to solve a variety of decision-making issues. Since these theories can more effectively address the fuzziness of uncertain decision-making, they have all been thoroughly researched.

A extension of the fuzzy set Zadeh and intuitionistic fuzzy sets Atanassov concepts, Smarandache [10]introduced the idea of neutrosophic sets (N-sets) in 1998 by utilizing truth-membership functions, indeterminacy-membership functions, and falsity-membership functions. The conventional neutrosophic logic was expanded upon by Smarandache in 2013 [11]to become neutrosophic refined logic, which contains many members with the potential for the same or various membership functions. The authors of Ulucay and Deli [12] proposed the idea of continuous N-valued neutrosophic trapezoidal numbers (NVNT-numbers) to leverage the notion of single-valued neutrosophic multisets to describe an unknown quantity or a quantity that is hard to measure[13], [14].

1.1 Related Work

The education of the next generation of chemists will be crucial in preparing them for future needs and empowering them to create novel solutions for present and future issues, especially considering contemporary social and ecological difficulties like climate change, energy supply, and e-mobility. However, it appears that more coordinated research efforts are needed to support university-level chemistry learning and to increase the professionalization of instructors to improve the quality of teaching, given the persistent perception of chemistry courses as challenging, the high dropout rates in these courses, which have been largely consistent, and the growing demand for well-trained chemistry graduates. As a model for others in the community, Graulich et al. [15] described in this communication the objectives of a research network supported by the German Research Foundation and the increasing demand for more cooperative research activities in higher education around academic chemistry training.

Since most STEM undergraduate programs start with general chemistry courses, it is crucial to evaluate students' understanding and implementation of learning objectives in classes like Introduction to Chemistry and Organic Chemistry. Paper-and-pencil tests are commonly used in the United States to gauge students' comprehension of the course material. In this initiative, we used individual oral examinations in place of written exams. R. Salmon et al. [16] offered advice on how to incorporate an oral exam component into student evaluation.

2. Preliminary

This section shows definitions of N-Valued Neutrosophic Trapezoidal Numbers (N-VNTNNs) to show their operations[12].

Let E be a universe and N-Set can be defined as:

$X = \{< y, T_X(y), I_X(y), F_X(y) >: y \in E\}$

Let two N-set such as: $A = \{T_A(y), I_A(y), F_A(y)\}\ and\ B = \{T_B(y), I_B(y), F_B(y)\}$, then we can show the generalized neutrosophic weighted distance measure for p>0 such as:

$$d_p(A,B) = \frac{1}{3}\left(\sum_{i=1}^{p} w_i \begin{bmatrix} |T_A(y_i) - T_B(y_i)|^r + \\ |I_A(y_i) - I_B(y_i)|^r + \\ |F_A(y_i) - F_B(y_i)|^r \end{bmatrix}^{\frac{1}{r}}\right); p = 1,2$$

The trapezoidal fuzzy multi-number ca be defined as:

$a_i^- =< (a_i, b_i, c_i, d_i); w_{a_i}^1, w_{a_i}^2, \dots, w_{a_i}^n > (i, 2, \dots, n)$

Where $w_{\overline{a_i}}^{i} \in [0,1], a_i \leq b_i \leq c_i \leq d_i$

The fuzzy multiset can be defined as:

$$u_{\overline{a_i}}^{i}(y) = \begin{cases} \frac{(y-a_i)w_{\overline{a_i}}^{i}}{b_i-a_i}, a_i \leq y < b, \\ w_{\overline{a_i}}^{i}, b_i \leq y \leq c_i, \\ \frac{(d_i-y)w_{\overline{a_i}}^{i}}{d_i-c_i}, c_i < y \leq d_i, \\ 0, \quad otherwise \end{cases}$$

The normal trapezoidal fuzzy multi-number is defined as:

$$\overline{a_j} = (a_j, b_j, c_j, d_j); \left(\alpha_{\overline{a_i}}^{1}, \alpha_{\overline{a_i}}^{2}, \ldots, \alpha_{\overline{a_i}}^{p}\right), \left(\beta_{\overline{a_i}}^{1}, \beta_{\overline{a_i}}^{2}, \ldots, \beta_{\overline{a_i}}^{p}\right), \left(\gamma_{\overline{a_i}}^{1}, \gamma_{\overline{a_i}}^{2}, \ldots, \gamma_{\overline{a_i}}^{p}\right)$$

The Euclidean distance can be computed as:

$$d(\overline{a_1}, \overline{a_2}) = \frac{1}{8p}\sum_{i=1}^{p} \begin{bmatrix} \left|(1+\alpha_{\overline{a_i}}^{i})a_1 - (1+\alpha_{\overline{a_i}}^{i})a_2\right| + \\ \left|(1+\alpha_{\overline{a_i}}^{i})b_1 - (1+\alpha_{\overline{a_i}}^{i})b_2\right| + \\ \left|(1+\alpha_{\overline{a_i}}^{i})c_1 - (1+\alpha_{\overline{a_i}}^{i})c_2\right| + \\ \left|(1+\alpha_{\overline{a_i}}^{i})d_1 - (1+\alpha_{\overline{a_i}}^{i})d_2\right| \end{bmatrix}$$

The N-VNTNN can be defined as:

$$a = \begin{pmatrix} [a, b, c, d]; \left(\alpha_{\overline{a_i}}^{1}, \alpha_{\overline{a_i}}^{2}, \ldots, \alpha_{\overline{a_i}}^{p}\right), \\ \left(\beta_{\overline{a_i}}^{1}, \beta_{\overline{a_i}}^{2}, \ldots, \beta_{\overline{a_i}}^{p}\right), \\ \left(\gamma_{\overline{a_i}}^{1}, \gamma_{\overline{a_i}}^{2}, \ldots, \gamma_{\overline{a_i}}^{p}\right) \end{pmatrix}$$

$$T_{\overline{a_i}}^{i}(y) = \begin{cases} \frac{(y-a)}{(b-a)}\alpha_{\overline{a_i}}^{i}, a \leq y \leq b \\ \alpha_{\overline{a_i}}^{i}, \quad b \leq y \leq c, \\ \frac{(d-y)}{(d-c)}\alpha_{\overline{a_i}}^{i}, \quad c < y \leq d, \\ 0, \quad otherwise \end{cases}$$

$$I_{\overline{a_i}}^{i}(y) = \begin{cases} \frac{(b-y)+\beta_{\overline{a_i}}^{i}(y-a)}{(b-a)}, a \leq y \leq b \\ \beta_{\overline{a_i}}^{i}, \quad b \leq y \leq c, \\ \frac{(y-c)+\beta_{\overline{a_i}}^{i}(d-y)}{(d-c)}, \quad c < y \leq d, \\ 1, \quad otherwise \end{cases}$$

$$F_{\overline{a_i}}^{i}(y) = \begin{cases} \frac{(b-y)+\gamma_{\overline{a_i}}^{1}(y-a)}{(b-a)}, a \leq y \leq b \\ \gamma_{\overline{a_i}}^{1}, \quad b \leq y \leq c, \\ \frac{(y-c)+\gamma_{\overline{a_i}}^{1}(d-y)}{(d-c)}, \quad c < y \leq d, \\ 1, \quad otherwise \end{cases}$$

Example of N-VNTNN

1. ([0.66, 0.72, 0.79, 0.83]; (0.7, 0.6, 0.4, 0.8), (0.5, 0.5, 0.5, 0.6), (0.4, 0.3, 0.4, 0.5))

2. ([0.58, 0.65, 0.71, 0.77]; (0.6, 0.7, 0.5, 0.7), (0.4, 0.3, 0.4, 0.5), (0.3, 0.2, 0.3, 0.4))

3. ([0.45, 0.53, 0.61, 0.68]; (0.5, 0.6, 0.6, 0.7), (0.3, 0.4, 0.5, 0.5), (0.2, 0.3, 0.3, 0.3))

4. ([0.72, 0.78, 0.81, 0.87]; (0.8, 0.7, 0.6, 0.9), (0.6, 0.5, 0.4, 0.6), (0.3, 0.2, 0.3, 0.4))

5. ([0.50, 0.56, 0.64, 0.70]; (0.6, 0.5, 0.6, 0.6), (0.4, 0.4, 0.5, 0.5), (0.3, 0.3, 0.4, 0.4))

The normalized N-VNTNN is defined as:

$$\overline{a_1} = \left(\begin{array}{c} \left[\begin{array}{c} \frac{a_1}{a_1+b_1+c_1+d_1}, \frac{b_1}{a_1+b_1+c_1+d_1}, \\ \frac{c_1}{a_1+b_1+c_1+d_1}, \frac{d_1}{a_1+b_1+c_1+d_1} \end{array} \right]; \\ \left(\alpha_{\overline{a_\iota}}^1, \alpha_{\overline{a_\iota}}^2, \dots, \alpha_{\overline{a_\iota}}^p\right), \left(\beta_{\overline{a_\iota}}^1, \beta_{\overline{a_\iota}}^2, \dots, \beta_{\overline{a_\iota}}^p\right), \left(\gamma_{\overline{a_\iota}}^1, \gamma_{\overline{a_\iota}}^2, \dots, \gamma_{\overline{a_\iota}}^p\right) \end{array} \right)$$

Example 2.

Normalize two N-VNTNN such as:

- $[a1, a2, a3, a4] = [0.50, 0.56, 0.64, 0.70$
- $\alpha = (0.6, 0.5, 0.6, 0.6)$
- $\beta = (0.4, 0.4, 0.5, 0.5)$
- $\gamma = (0.3, 0.3, 0.4, 0.4)$

Now compute for each position i=1 to 4i = 1

For i = 1:

- Sum = 0.50 + 0.6 + 0.4 + 0.3 = 1.8
- Normalized =

$$\left(\frac{0.5}{01.8}, \frac{0.6}{1.8}, \frac{0.4}{1.8}, \frac{0.3}{1.8}\right) = (0.278, 0.333, 0.222, 0.167)$$

For i = 2:

- Sum = 0.56 + 0.5 + 0.4 + 0.3 = 1.76
- Normalized =

$$\left(\frac{0.56}{1.76}, \frac{0.5}{1.76}, \frac{0.4}{1.76}, \frac{0.3}{1.76}\right) = (0.318, 0.284, 0.227, 0.170)$$

For i = 3:

- Sum = 0.64 + 0.6 + 0.5 + 0.4 = 2.14

- Normalized =

$$\left(\frac{0.64}{2.14},\frac{0.6}{2.14},\frac{0.5}{2.14},\frac{0.4}{2.14}\right) = (0.299,0.280,0.234,0.187)$$

For i = 4:

- Sum = 0.70 + 0.6 + 0.5 + 0.4 = 2.20
- Normalized =

$$(\frac{0.70}{2.20},\frac{0.6}{2.20},\frac{0.5}{2.20},\frac{0.4}{2.20}) \approx (0.318,0.273,0.227,0.182)$$

Neutrosophic Number

Raw values:

- $[a1, a2, a3, a4] = [0.72,0.78,0.81,0.87]$
- $\alpha = (0.8,0.7,0.6,0.9)$
- $\beta = (0.6,0.5,0.4,0.6)$
- $\gamma = (0.3,0.2,0.3,0.4)$

For i = 1:

- Sum = 0.72 + 0.8 + 0.6 + 0.3 = 2.42
- Normalized =

$$(\frac{0.72}{2.42},\frac{0.8}{2.42},\frac{0.6}{2.42},\frac{0.3}{2.42}) \approx (0.298,0.331,0.248,0.124)$$

For i = 2:

- Sum = 0.78 + 0.7 + 0.5 + 0.2 = 2.18
- Normalized =

$$(\frac{0.78}{2.18},\frac{0.7}{2.18},\frac{0.5}{2.18},\frac{0.2}{2.18}) \approx (0.358,0.321,0.229,0.092)$$

For i = 3:

- Sum = 0.81 + 0.6 + 0.4 + 0.3 = 2.11
- Normalized =

$$(\frac{0.81}{2.11},\frac{0.6}{2.11},\frac{0.4}{2.11},\frac{0.3}{2.11}) \approx (0.384,0.284,0.189,0.142)$$

For i = 4:

- Sum = 0.87 + 0.9 + 0.6 + 0.4 = 2.77
- Normalized =

$$(\frac{0.87}{2.77},\frac{0.9}{2.77},\frac{0.6}{2.77},\frac{0.4}{2.77}) \approx (0.314,0.325,0.217,0.144)$$

The generalized distance between $\overline{a_1}$ *and* $\overline{b_1}$

$$d_r = \left(\overline{a_1}, \overline{b_1}\right) = \frac{1}{16p}\left(\sum_{i=1}^{p} \begin{bmatrix} \left(\left|\left(1+\alpha_{\overline{a_i}}^{i} - \beta_{\overline{a_i}}^{i} - \gamma_{\overline{a_i}}^{i}\right)a_1 - \left(1+\alpha_{\overline{b_i}}^{i} - \beta_{\overline{b_i}}^{i} - \gamma_{\overline{b_i}}^{i}\right)a_2\right|\right)^r + \\ \left(\left|\left(1+\alpha_{\overline{a_i}}^{i} - \beta_{\overline{a_i}}^{i} - \gamma_{\overline{a_i}}^{i}\right)b_1 - \left(1+\alpha_{\overline{b_i}}^{i} - \beta_{\overline{b_i}}^{i} - \gamma_{\overline{b_i}}^{i}\right)b_2\right|\right)^r + \\ \left(\left|\left(1+\alpha_{\overline{a_i}}^{i} - \beta_{\overline{a_i}}^{i} - \gamma_{\overline{a_i}}^{i}\right)c_1 - \left(1+\alpha_{\overline{b_i}}^{i} - \beta_{\overline{b_i}}^{i} - \gamma_{\overline{b_i}}^{i}\right)c_2\right|\right)^r + \\ \left(\left|\left(1+\alpha_{\overline{a_i}}^{i} - \beta_{\overline{a_i}}^{i} - \gamma_{\overline{a_i}}^{i}\right)d_1 - \left(1+\alpha_{\overline{b_i}}^{i} - \beta_{\overline{b_i}}^{i} - \gamma_{\overline{b_i}}^{i}\right)d_2\right|\right)^{1/r} \end{bmatrix} \right)$$

3. Results

This section shows the results of N-VNTNN to compute the criteria weights and ranking the alternatives. we use eight criteria and seven alternatives.

[1] Alignment with national education standards
[2] Integration of interdisciplinary content
[3] Laboratory skill development opportunities
[4] Use of updated and research-driven course materials
[5] Clarity and coherence of learning outcomes
[6] Support for conceptual understanding
[7] Assessment methods aligned with learning objectives
[8] Industry and graduate school relevance

The alternatives are:

[1] Undergraduate Organic Chemistry Curriculum
[2] Honors Organic Chemistry Track
[3] Online Organic Chemistry Module
[4] Integrated Organic-Biochemistry Curriculum
[5] Standard 2-Semester Organic Chemistry Sequence
[6] Flipped Classroom Organic Chemistry Course
[7] Organic Chemistry for Pre-Medical Majors

In the first step, we let three experts evaluate the criteria and alternatives such as:

$$M_{ij} = \left(\begin{array}{c}
\begin{pmatrix}
([0.32,0.44,0.51,0.69];(0.3,0.5,0.7,0.8),(0.1,0.3,0.2,0.3),(0.6,0.3,0.5,0.6)), \\
([0.32,0.44,0.51,0.69];(0.3,0.5,0.7,0.8),(0.1,0.3,0.2,0.3),(0.6,0.3,0.5,0.6)), \\
([0.23,0.25,0.41,0.45];(0.4,0.2,0.3,0.5),(0.2,0.5,0.7,0.6),(0.7,0.5,0.6,0.8)), \\
([0.12,0.15,0.18,0.23];(0.3,0.7,0.9,0.9),(0.1,0.2,0.3,0.7),(0.3,0.4,0.7,0.5)), \\
([0.09,0.13,0.19,0.69];(0.2,0.5,0.7,0.9),(0.1,0.3,0.5,0.4),(0.6,0.7,0.8,0.8)), \\
([0.09,0.13,0.19,0.69];(0.2,0.5,0.7,0.9),(0.1,0.3,0.5,0.4),(0.6,0.7,0.8,0.8)), \\
([0.8,0.15,0.27,0.37];(0.3,0.9,0.8,0.4),(0.8,0.7,0.6,0.5),(0.1,0.1,0.4,0.3))
\end{pmatrix}, \\
\begin{pmatrix}
([0.23,0.25,0.41,0.45];(0.4,0.2,0.3,0.5),(0.2,0.5,0.7,0.6),(0.7,0.5,0.6,0.8)), \\
([0.32,0.44,0.51,0.69];(0.3,0.5,0.7,0.8),(0.1,0.3,0.2,0.3),(0.6,0.3,0.5,0.6)), \\
([0.66,0.72,0.79,0.83];(0.7,0.6,0.4,0.8),(0.5,0.5,0.5,0.6),(0.4,0.3,0.4,0.5)), \\
([0.66,0.72,0.79,0.83];(0.7,0.6,0.4,0.8),(0.5,0.5,0.5,0.6),(0.4,0.3,0.4,0.5)), \\
([0.12,0.15,0.18,0.23];(0.3,0.7,0.9,0.9),(0.1,0.2,0.3,0.7),(0.3,0.4,0.7,0.5)), \\
([0.09,0.13,0.19,0.69];(0.2,0.5,0.7,0.9),(0.1,0.3,0.5,0.4),(0.6,0.7,0.8,0.8)), \\
([0.8,0.15,0.27,0.37];(0.3,0.9,0.8,0.4),(0.8,0.7,0.6,0.5),(0.1,0.1,0.4,0.3))
\end{pmatrix}, \\
\begin{pmatrix}
([0.66,0.72,0.79,0.83];(0.7,0.6,0.4,0.8),(0.5,0.5,0.5,0.6),(0.4,0.3,0.4,0.5)), \\
([0.8,0.15,0.27,0.37];(0.3,0.9,0.8,0.4),(0.8,0.7,0.6,0.5),(0.1,0.1,0.4,0.3)), \\
([0.12,0.15,0.18,0.23];(0.3,0.7,0.9,0.9),(0.1,0.2,0.3,0.7),(0.3,0.4,0.7,0.5)), \\
([0.23,0.25,0.41,0.45];(0.4,0.2,0.3,0.5),(0.2,0.5,0.7,0.6),(0.7,0.5,0.6,0.8)), \\
([0.66,0.72,0.79,0.83];(0.7,0.6,0.4,0.8),(0.5,0.5,0.5,0.6),(0.4,0.3,0.4,0.5)), \\
([0.12,0.15,0.18,0.23];(0.3,0.7,0.9,0.9),(0.1,0.2,0.3,0.7),(0.3,0.4,0.7,0.5)), \\
([0.66,0.72,0.79,0.83];(0.7,0.6,0.4,0.8),(0.5,0.5,0.5,0.6),(0.4,0.3,0.4,0.5))
\end{pmatrix}, \\
\begin{pmatrix}
([0.12,0.15,0.18,0.23];(0.3,0.7,0.9,0.9),(0.1,0.2,0.3,0.7),(0.3,0.4,0.7,0.5)), \\
([0.09,0.13,0.19,0.69];(0.2,0.5,0.7,0.9),(0.1,0.3,0.5,0.4),(0.6,0.7,0.8,0.8)), \\
([0.09,0.13,0.19,0.69];(0.2,0.5,0.7,0.9),(0.1,0.3,0.5,0.4),(0.6,0.7,0.8,0.8)), \\
([0.32,0.44,0.51,0.69];(0.3,0.5,0.7,0.8),(0.1,0.3,0.2,0.3),(0.6,0.3,0.5,0.6)), \\
([0.23,0.25,0.41,0.45];(0.4,0.2,0.3,0.5),(0.2,0.5,0.7,0.6),(0.7,0.5,0.6,0.8)), \\
([0.09,0.13,0.19,0.69];(0.2,0.5,0.7,0.9),(0.1,0.3,0.5,0.4),(0.6,0.7,0.8,0.8)), \\
([0.8,0.15,0.27,0.37];(0.3,0.9,0.8,0.4),(0.8,0.7,0.6,0.5),(0.1,0.1,0.4,0.3))
\end{pmatrix}, \\
\begin{pmatrix}
([0.09,0.13,0.19,0.69];(0.2,0.5,0.7,0.9),(0.1,0.3,0.5,0.4),(0.6,0.7,0.8,0.8)), \\
([0.12,0.15,0.18,0.23];(0.3,0.7,0.9,0.9),(0.1,0.2,0.3,0.7),(0.3,0.4,0.7,0.5)), \\
([0.8,0.15,0.27,0.37];(0.3,0.9,0.8,0.4),(0.8,0.7,0.6,0.5),(0.1,0.1,0.4,0.3)), \\
([0.32,0.44,0.51,0.69];(0.3,0.5,0.7,0.8),(0.1,0.3,0.2,0.3),(0.6,0.3,0.5,0.6)), \\
([0.32,0.44,0.51,0.69];(0.3,0.5,0.7,0.8),(0.1,0.3,0.2,0.3),(0.6,0.3,0.5,0.6)), \\
([0.32,0.44,0.51,0.69];(0.3,0.5,0.7,0.8),(0.1,0.3,0.2,0.3),(0.6,0.3,0.5,0.6)), \\
([0.8,0.15,0.27,0.37];(0.3,0.9,0.8,0.4),(0.8,0.7,0.6,0.5),(0.1,0.1,0.4,0.3))
\end{pmatrix},
\end{array} \right),$$

$$M_{ij} = \begin{pmatrix} \begin{pmatrix} ([0.8,0.15,0.27,0.37];(0.3,0.9,0.8,0.4),(0.8,0.7,0.6,0.5),(0.1,0.1,0.4,0.3)), \\ ([0.66,0.72,0.79,0.83];(0.7,0.6,0.4,0.8),(0.5,0.5,0.5,0.6),(0.4,0.3,0.4,0.5)), \\ ([0.23,0.25,0.41,0.45];(0.4,0.2,0.3,0.5),(0.2,0.5,0.7,0.6),(0.7,0.5,0.6,0.8)), \\ ([0.32,0.44,0.51,0.69];(0.3,0.5,0.7,0.8),(0.1,0.3,0.2,0.3),(0.6,0.3,0.5,0.6)), \\ ([0.32,0.44,0.51,0.69];(0.3,0.5,0.7,0.8),(0.1,0.3,0.2,0.3),(0.6,0.3,0.5,0.6)), \\ ([0.8,0.15,0.27,0.37];(0.3,0.9,0.8,0.4),(0.8,0.7,0.6,0.5),(0.1,0.1,0.4,0.3)), \\ ([0.09,0.13,0.19,0.69];(0.2,0.5,0.7,0.9),(0.1,0.3,0.5,0.4),(0.6,0.7,0.8,0.8)) \end{pmatrix}, \\ \begin{pmatrix} ([0.32,0.44,0.51,0.69];(0.3,0.5,0.7,0.8),(0.1,0.3,0.2,0.3),(0.6,0.3,0.5,0.6)), \\ ([0.32,0.44,0.51,0.69];(0.3,0.5,0.7,0.8),(0.1,0.3,0.2,0.3),(0.6,0.3,0.5,0.6)), \\ ([0.23,0.25,0.41,0.45];(0.4,0.2,0.3,0.5),(0.2,0.5,0.7,0.6),(0.7,0.5,0.6,0.8)), \\ ([0.66,0.72,0.79,0.83];(0.7,0.6,0.4,0.8),(0.5,0.5,0.5,0.6),(0.4,0.3,0.4,0.5)), \\ ([0.12,0.15,0.18,0.23];(0.3,0.7,0.9,0.9),(0.1,0.2,0.3,0.7),(0.3,0.4,0.7,0.5)), \\ ([0.09,0.13,0.19,0.69];(0.2,0.5,0.7,0.9),(0.1,0.3,0.5,0.4),(0.6,0.7,0.8,0.8)), \\ ([0.8,0.15,0.27,0.37];(0.3,0.9,0.8,0.4),(0.8,0.7,0.6,0.5),(0.1,0.1,0.4,0.3)) \end{pmatrix}, \\ \begin{pmatrix} ([0.66,0.72,0.79,0.83];(0.7,0.6,0.4,0.8),(0.5,0.5,0.5,0.6),(0.4,0.3,0.4,0.5)), \\ ([0.12,0.15,0.18,0.23];(0.3,0.7,0.9,0.9),(0.1,0.2,0.3,0.7),(0.3,0.4,0.7,0.5)), \\ ([0.09,0.13,0.19,0.69];(0.2,0.5,0.7,0.9),(0.1,0.3,0.5,0.4),(0.6,0.7,0.8,0.8)), \\ ([0.8,0.15,0.27,0.37];(0.3,0.9,0.8,0.4),(0.8,0.7,0.6,0.5),(0.1,0.1,0.4,0.3)),' \\ ([0.32,0.44,0.51,0.69];(0.3,0.5,0.7,0.8),(0.1,0.3,0.2,0.3),(0.6,0.3,0.5,0.6)), \\ ([0.8,0.15,0.27,0.37];(0.3,0.9,0.8,0.4),(0.8,0.7,0.6,0.5),(0.1,0.1,0.4,0.3)), \\ ([0.09,0.13,0.19,0.69];(0.2,0.5,0.7,0.9),(0.1,0.3,0.5,0.4),(0.6,0.7,0.8,0.8)) \end{pmatrix} \end{pmatrix}$$

This study computes the criteria weights as shown in Figure 1.

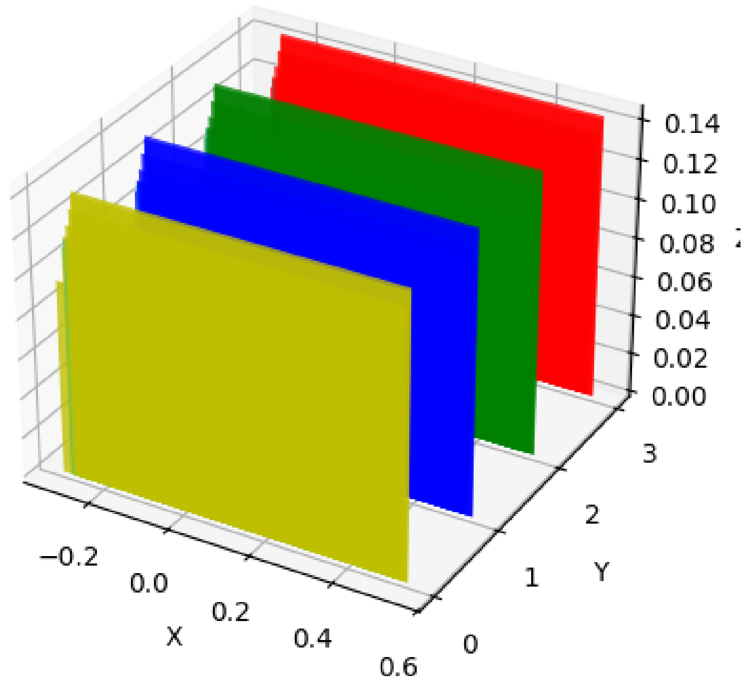

Figure 1. The criteria weights.

The evaluation matrix is normalized as shown in Figure 2.

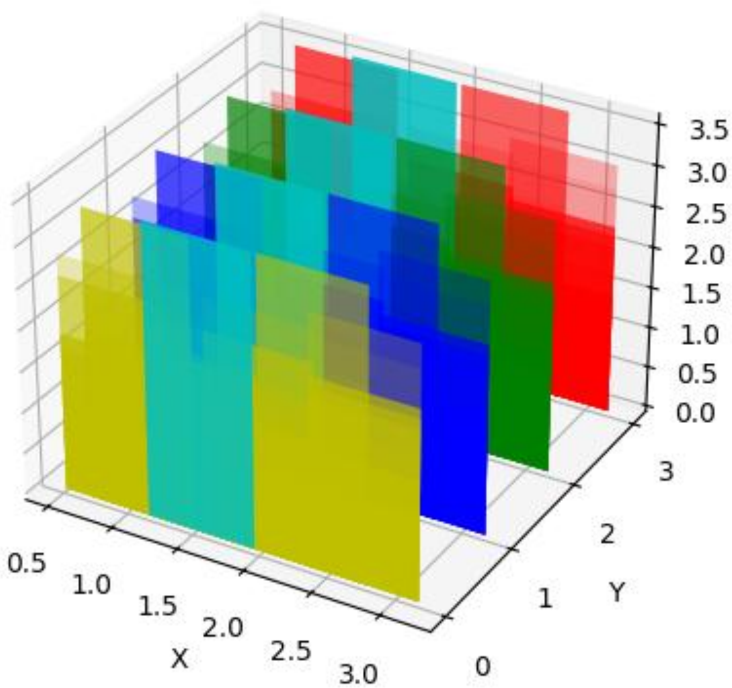

Figure 2. The normalized matrix.

The alternatives are ranked based on the highest score of weighted normalized matrix as shown in Table 1.

Table 1. Rank of alternatives.

Alternatives	Ranks
Alternative 1	6
Alternative 2	3
Alternative 3	4
Alternative 4	7
Alternative 5	2
Alternative 6	1
Alternative 7	5

The results show alternative 4 is the best and alternative 6 is the worst.

Managerial Implications

There are different managerial implications such as:

[1] Academic leaders must recognize curriculum alignment as a strategic activity rather than a routine academic task. Alignment decisions should be tied to long-term institutional goals such as graduate employability, research excellence, and accreditation readiness. This calls for establishment dedicated curriculum review committees within chemistry departments.

[2] University administrators should adopt data-driven approaches in evaluating alignment—collecting evidence from student performance metrics, course feedback, graduate outcomes, and peer benchmarking. This ensures that curriculum changes are justified and targeted rather than reactive or anecdotal.

[3] Given the interdisciplinary nature of Organic Chemistry, managers must promote collaboration between departments (e.g., biology, environmental science, and engineering) to align shared learning outcomes. Integrated syllabi and joint projects can enhance coherence across programs and reduce duplication of content.

[4] Proper alignment requires faculty training in modern pedagogical techniques and curriculum design. University managers should invest in ongoing professional development programs and incentivize participation through recognition, promotions, or teaching awards.

[5] To align curricula with real-world needs, academic leaders must systematically involve external stakeholders such as alumni, industry partners, and professional societies. Advisory boards can provide guidance on emerging trends, technical competencies, and desirable graduate attributes.

[6] Managers should ensure that assessment tools align with intended learning outcomes. Standardized rubrics and mapping tools should be used to connect course content with

institutional outcomes, thereby facilitating quality assurance and accreditation compliance.

[7] Curriculum alignment in science disciplines now requires integration with digital tools such as simulations, virtual labs, and molecular visualization software. Managers must allocate budgets and IT support to ensure that such tools are adopted and maintained effectively.

[8] Evaluating curriculum alignment should be embedded into a formal quality assurance framework with annual or biannual review cycles. Clear metrics and KPIs (Key Performance Indicators) should be set up to monitor alignment progress and ensure accountability.

[9] Managers should promote modular curriculum structures that allow for agile updates. This enables universities to respond quickly to scientific innovations, changes in accreditation standards, or industry demands without overhauling entire programs.

[10] When gaps in alignment are detected (e.g., mismatch between content complexity and student preparedness), university leaders should provide remedial support such as tutoring, workshops, or curriculum bridging modules to prevent dropouts and improve outcomes.

5. Conclusions

Evaluating curriculum alignment in university-level Organic Chemistry programs is both a strategic and educational imperative. It ensures that students acquire the knowledge, skills, and competencies required for advanced studies and professional success. By developing a comprehensive framework based on well-defined criteria including content relevance, interdisciplinary integration, lab-theory coherence, and outcome-based assessment academic institutions can uphold quality standards and foster continuous improvement. As the scientific landscape continues to evolve, the alignment of Organic Chemistry curricula must remain a priority for educators, administrators, and policy makers alike. We used the N-Valued Neutrosophic Trapezoidal Numbers to deal with uncertainty. We show definitions of N-VNTNN in this study. We use eight criteria and seven alternatives. The results show alternative 4 is the best.

References

[1] G. S. P. Villarubia and R. V Regino, "Validity and Acceptability of the Developed Supplementary Learning Module in Organic Chemistry".

[2] C. Nelle, A. Behler, L. Iovkova, K. Boettcher, C. Terkowsky, and T. Ortelt, "Chemical Education in the Era of Chemistry 4.0: Development Methodology for Virtual Laboratory Courses in Organic Chemistry," in *Online Laboratories in Engineering and Technology Education: State of the Art and Trends for the Future*, Springer, 2025, pp. 435–453.

[3] I. A. Asaki and K. Adu-Gyamfi, "Teaching organic chemistry at the high school: Which factor predicts most of the difficulties?," *Educ. Point*, vol. 2, no. 1, p. e117, 2025.

[4] A. Kenzhe, A. Bitemirova, U. Bayan, S. Bitursyn, and A. Zhorabekova, "Integrated teaching

methodology in the development of foreign language professional communicative competence on the discipline 'organic chemistry' at Kazakhstan University," in *Frontiers in Education*, Frontiers Media SA, 2025, p. 1374165.

[5] S. Pitre, "Chemistry Education at the University of Southern Mississippi Through Computation and Active Learning Methods," 2025.

[6] K. S. DeGlopper and R. L. Stowe, "Modeling students' epistemic cognition in undergraduate chemistry courses: a review," *Chem. Educ. Res. Pract.*, 2024.

[7] C. T. Cox Jr, R. Shimomura, J. T. V. E. Hall, and S. Gao, "Conjugation Amplifies Complexity: A Comparison of Problem-Solving Strategies Across the Organic Chemistry Sequence," *J. Chem. Educ.*, vol. 101, no. 7, pp. 2608–2617, 2024.

[8] S. E. Layton Jaramillo, W. A. Villamil Villar, E. Aguaded Ramírez, and J. Carrillo Rosúa, "Design and Evaluation of an Innovative Pedagogical Strategy for Undergraduate Medical Students Learning Chemistry," *J. Chem. Educ.*, vol. 101, no. 2, pp. 247–258, 2024.

[9] L. A. Zadeh, "Fuzzy sets," *Inf. Control*, vol. 8, no. 3, pp. 338–353, 1965.

[10] F. Smarandache, "Neutrosophy: neutrosophic probability, set, and logic: analytic synthesis & synthetic analysis," 1998.

[11] F. Smarandache, "n-Valued refined neutrosophic logic and its applications to physics," *Infin. study*, vol. 4, pp. 143–146, 2013.

[12] V. Uluçay and İ. Deli, "TOPSIS-Based Entropy Measure for N-Valued Neutrosophic Trapezoidal Numbers and Their Application to Multi-Criteria Decision-Making Problems," in *Analytical Decision Making and Data Envelopment Analysis: Advances and Challenges*, Springer, 2024, pp. 433–454.

[13] A. A. Elsayed and A. K. Kolankeh, "Solving single-valued trapezoidal neutrosophic linear equations: An embedding approach for uncertain systems," *J. Oper. Strateg Anal*, vol. 3, no. 1, pp. 1–13, 2025.

[14] I. Irvanizam and N. Zahara, "An improved RAFSI method based on single-valued trapezoidal neutrosophic number and its Harmonic and Arithmetic mean operators for healthcare service quality evaluation," *Expert Syst. Appl.*, vol. 248, p. 123343, 2024.

[15] N. Graulich *et al.*, "Bringing Researchers and Practitioners Together: On the Aims of a Research Network in Organic Chemistry Education," *J. Chem. Educ.*, vol. 101, no. 9, pp. 4011–4017, 2024.

[16] C. R. Salmon, P. A. Bonvallet, Y. Xue, and S. E. Ramlo, "Oral Examinations of Structure and Function in General and Organic Chemistry Courses," *J. Chem. Educ.*, vol. 101, no. 3, pp. 921–929, 2024.

Received: Dec. 25, 2024. Accepted: July 2, 2025