

FUZZY-BASED ENGLISH WRITING WITH KEY-BASED ASSESSMENT

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ABSTRACT

Traditional assessment methods in education often rely on rigid grading structures that may fail to capture the nuances of language skills, especially in subjective areas like writing. This article explores how fuzzy logic, a mathematical system that handles imprecision, can enhance English writing assessment by providing a more flexible, holistic view of students' abilities.

Formulation of the problem. English writing is a fairly subjective practice that, due to its interpretative nature, can often present instructors with a challenge when it comes to administering evaluations that are impartial and purely objective. This paper aims to propose a proper way of investing rigor and focus on the core principles of English writing into the process of reviewing student work through the applied integration of mathematics' fuzzy logic.

Materials and methods. The resources included in this article are a variety of robust and innovative works of academic literature that have proven their relevance and advancement to the field of mathematics and also pedagogical assessment methodology. The primary studies and their respective demonstrations of research are productively referenced throughout this paper to concretely elucidate how fuzzy logic can make a difference in forming adequate feedback for English writing students.

Results. The results point to fuzzy logic-based assessments of English writing having merit that is long overdue in English classrooms.

Conclusions. Overall, this article recognizes that fuzzy logic-based assessments of English writing are a ruthlessly efficient, convenient, and innovative strategic approach to scrutinizing student work with fairness, absence of creative bias, and extensiveness.

KEYWORDS: Fuzzy Logic; Writing Assessment; Writing Composition; COG Technique; Defuzzification.

ОЦІНЮВАННЯ АНГЛІЙСЬКОГО ПИСЬМА НА ОСНОВІ НЕЧІТКОЇ ЛОГІКИ ЗА КЛЮЧОВИМИ ПАРАМЕТРАМИ

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АНОТАЦІЯ

Традиційні методи оцінювання в освіті часто спираються на жорсткі критерії оцінювання, які можуть не враховувати тонкощі мовних навичок, особливо в суб'єктивних сферах, таких як письмо. У статті досліджується, як математичний апарат нечіткої логіки, що працює з «неточностями», може покращити оцінювання англійського письма, забезпечуючи більш гнучкий та цілісний підхід до оцінювання здібностей студентів.

Формулювання проблеми. Англійське письмо є досить суб'єктивною практикою, яка через свою інтерпретаційну природу часто утруднює викладачам проведення об'єктивного та неупередженого оцінювання. У статті пропонується можливий підхід до оцінювання, який забезпечить строгість та акцент на основних принципах англійського письма, при перевірці робіт студентів шляхом застосування математичного апарату нечіткої логіки.

Матеріали та методи. У статті використано аналіз та систематизацію наукових та науково-методичних публікацій з проблеми методології педагогічного оцінювання та основних положень нечіткої логіки.

Для цитування:	Hill J. Fuzzy-based english writing with key-based assessment. <i>Фізико-математична освіта</i> , 2024. Том 39. № 5. С. 14-19. DOI: 10.31110/fmo2024.v39i5-02
	Hill, J. (2024). Fuzzy-based english writing with key-based assessment. <i>Фізико-математична освіта</i> , 39(5), 14-19. https://doi.org/10.31110/fmo2024.v39i5-02
For citation:	Hill, J. (2024). Fuzzy-based english writing with key-based assessment. <i>Physical and Mathematical Education</i> , 39(5), 14-19. https://doi.org/10.31110/fmo2024.v39i5-02
	Hill, J. (2024). Fuzzy-based english writing with key-based assessment. <i>Fizyko-matematychna osvita – Physical and Mathematical Education</i> , 39(5), 14-19. https://doi.org/10.31110/fmo2024.v39i5-02

Результати. Оцінювання англійського письма на основі нечіткої логіки має значний потенціал, який давно слід було впровадити в навчання англійської мови.

Висновки. Оцінювання письма на основі нечіткої логіки є ефективним, зручним та інноваційним стратегічним підходом до аналізу робіт студентів, що забезпечує справедливість, відсутність творчих упереджень та всебічність оцінки.

КЛЮЧОВІ СЛОВА: нечітка логіка; оцінювання письма; композиція письма; метод центру ваги; дефазифікація.

INTRODUCTION

English writing assessment often presents a challenge due to its inherent subjectivity. Traditional grading schemes are limited in capturing the subtleties of written expression, and they frequently reduce performance to a single letter or number. However, fuzzy logic, developed to manage uncertainties in decision-making processes, offers a promising alternative. Rooted in the concept of partial membership within categories, fuzzy logic provides a structure to evaluate qualitative aspects of writing with greater flexibility, enabling assessments that reflect a range of competencies rather than fixed labels.

English writing assessment is often approached with a strong force of subjectivity targeting the important English composition assessment areas of structure, stylistic choices, authorly intentions, literary fundamentals (i.e., spelling, grammar, punctuation, syntax, etc.), and organization of ideas. The criteria with which frequently passed English writing judgments consult is often quite stringent and perhaps even too narrowed down, failing multiple times to take into account the much larger and significantly broader scope and dimension of writing as a craft (Phakiti & Leung, 2024).

MATERIALS AND METHODS

The resources included in this article are a variety of robust and innovative works of academic literature that have proven their relevance and advancement to the field of mathematics and also pedagogical assessment methodology. The primary studies and their respective demonstrations of research are productively referenced throughout this paper to concretely elucidate how fuzzy logic can make a difference in forming adequate feedback for English writing students.

RESULTS AND DISCUSSION

The results point to fuzzy logic-based assessments of English writing having merit that is long overdue in English classrooms.

1. Assessment Criteria

As mentioned, assessing English composition is a lot more complicated than those carrying out the very action of assessment or designing guidelines for such an action believe and perceive it to be. Assessing English composition, in its ideal execution, involves a multidimensional addressing of how the aforementioned elements of organization, content, mechanics, style, and grammar all play a part in rendering a written piece cohesive, robustly communicative, and coherent. With the aid of a more systematic strategy of closely examining these chief elements, teachers and practitioners of education could significantly assist developing writers in their pursuit of honing their rhetorical and communicative techniques and abilities. Systematization of English composition criteria could be tremendously advantageous to the long-term growth of written communication skills. English composition is defined as the practice of effectively and compellingly organizing, synthesizing, and combining components of English writing and rhetoric to furnish a piece of English writing that is a successful combination and concoction of an author's intentions and literary design. It is a wide-ranging craft that covers a plethora of English writing areas that make up the cohesiveness, coherence, effective expression, and effects of a written work on an intended audience. Assessing these elements is crucial in both educational and professional contexts to ensure effective communication (Dong et al., 2023; Xue, 2024).

We delve here into the primary components of English composition—*content, organization, style, mechanics, and grammar*—and discusses how each can be assessed to improve and evaluate writing. Generally, frameworks in educational assessment criteria focus on aspects like coherence, content, mechanics, and grammar, aligning with holistic models that assess language proficiency (such as the CEFR in Europe or specific rubrics in U.S. education).

Criterion 1. Content.

Content is defined as the makeup and even ingredients of a work of writing—what the work of writing contains. To assess content, one must take into consideration the thorough examination of the author's intentions, the relevance of the described makeup and ingredients in association with said intentions, the scope of these intentions or how well they are explored and expanded upon, and the nature of the ideas pertaining to what the author is trying to get across to their audience. An author's intentions can be found in their work's thesis or main message and can be further studied with the help of its supporting information such as evidence, analysis of evidence, and examples.

Content assessment criteria should adhere to evaluation principles that, overall and in general, propose that an assessor is to factor in authorly intentions and the execution of those intentions in the form of their written work's content. Additionally, said criteria must also then get more and more specific with its checking of the comprising elements and building blocks holding together the author's composition content and its presentation of the author's intended-to-be-shared thoughts. In essence, content assessment criteria should be both holistic and specific.

Criterion 2. Organization

Organization is defined as the structuring of a written work or composition. It has to do with the order of an author's logical reasoning, string of thought, clarity in elucidation of thought, and coherence in relaying ideas present in a written work's anatomical features such as its introduction, thesis, body paragraphs, and conclusion paragraph. Proper organization is key to creating a seamless transition of an author's ideas into a reader's perceptions.

Assessing organization entails evaluating the general foundation of a written work, as well as how it holds together in its more in-depth consistency. A well-organized written work should not give the reader much trouble with moving from

argument to argument, narrative to narrative, and should demonstrate unshakable focus during this process of taking a reader across its material.

Criterion 3. Style

Style is a writer's own personal touch in communicating their unique thoughts and interpretations of concepts. It includes execution of rhetoric, tone, format, vocabulary, and syntax. Style helps give authors a voice of their very own, allowing them to stand out and make an impact on readers in their own individual ways, boosting their inner conversations with said readers as well.

Assessing style entails conducting a thorough investigation of the little fragments that make up the essence of an author's written work and the effect they produce on readers when working in unison. When approaching style, a writer is to ensure that the unique accent they give to their work suits its intended audience and intended messages for said audience.

Criterion 4. Mechanics

Mechanics can be defined as the standards of basic written language. It encompasses spelling, grammar, capitalization, and punctuation, just to name some of its key areas. Proper mechanics ensure the legibility and communication efficiency of a work.

Assessing mechanics largely consists of clear and easily comprehensible criteria. Mechanics determine the clarity in an author's communication and, as terminology would suggest, mechanics are the basic gears and functions of such communication. As a matter of fact, mechanics are a top priority for authors in any kind of literary work they pursue.

Criterion 5. Grammar

Grammar in writing covers the more foundational conventions of sentential structures. Grammar encompasses article use, verb tense agreement, subject-verb agreement, sentence completion, pronoun use, order and placement of lexical items, and more. Taking a look at grammar includes taking into account the standard conventions of a written language that are more on the technical side. Errors in grammar can significantly deter an author from presenting their ideas properly to readers, and it must absolutely be tended to with utmost precision and dedication to good accuracy.

2. Principles of Fuzzy Logic

Fuzzy logic, introduced by Lotfi Zadeh (1965) extended classical binary logic to handle the concept of partial truth—truth values between "completely true" and "completely false." In fuzzy logic, variables can have degrees of membership in multiple sets, allowing for more flexible and nuanced decision-making processes.

Core Concepts

1. **Fuzzy Sets:** Instead of a crisp set where elements either belong or do not belong, fuzzy sets allow elements to have varying degrees of membership. For example, a sentence can be somewhat clear, very clear, or somewhere in between (Klir & Folger, 1988).

2. **Membership Functions:** These functions define how each element in the set is mapped to a degree of membership, ranging from 0 to 1. This allows for the assessment of writing elements in a more granular fashion (Klir & Folger, 1988).

3. **Fuzzy Rules:** Rules are used to model the relationships between different variables. In writing assessment, rules relate the quality of grammar, coherence, and content to an overall writing score (Klir & Folger, 1988).

Fuzzy logic is actively employed for evaluation of students' performance in education (Agarwal et al., 2019; Akkur & Rao, 2018; Gisolfi et al., 1992; Ivanova, 2019; Subbotin, 2014; Subbotin & Bilotskii, 2014; Subbotin et al., 2004; Wardoy, 2020; Yildiz & Baba, 2014).

Implementing fuzzy logic in writing assessment involves several steps:

1. **Defining Criteria and Membership Functions:** The first step is to define the criteria for assessment, such as clarity, coherence, creativity, grammar, and mechanics. For each criterion, membership functions are established to quantify the degree to which a piece of writing meets the criteria.

2. **Creating Fuzzy Rules:** Next, fuzzy rules are developed to describe how different criteria interact to produce an overall assessment. For example, a rule might state that if a piece of writing is highly coherent and has minor grammatical errors, it should receive a high overall score.

3. **Fuzzification and Defuzzification:** Fuzzification converts the input data (writing samples) into degrees of membership across the defined criteria. Defuzzification then translates the fuzzy output back into a crisp score or grade, providing a clear result for the writer.

Consider a scenario where fuzzy logic is applied to evaluate student essays. The assessment criteria include content, organization, style, grammar, and mechanics. Each criterion is broken down further into specific aspects such as relevance, coherence, vocabulary, and punctuation.

3. Applying the Center of Gravity Fuzzy Technique

The COG technique is a very popular in fuzzy mathematics defuzzification method (van Broekhoven & De Baets, 2006). The following described below concrete approach was developed in (Subbotin, 2014; Subbotin & Bilotskii, 2014; Subbotin et al., 2004).

For applying this technique, we correspond to each x of the universal set U an interval of values from a prefixed numerical distribution, which actually means that we replace U with a set of real intervals. Then, we construct the graph of the corresponding membership function $y=m(x)$. There is a commonly used in fuzzy logic approach to represent the fuzzy data with the pair of numbers (x_c, y_c) as the coordinates of the COG, say F_c , of the level's section S contained between the above graph and the OX axis, which we can calculate using the following well-known formulas:

$$x_c = \frac{\int_S x dx dy}{\int_S dx dy}, \quad y_c = \frac{\int_S y dx dy}{\int_S dx dy} \quad (1)$$

In fact, let G be a group of individuals participating in a certain activity and let $U=\{A, B, C, D, F\}$ be a set of linguistic labels (grades) characterizing the individuals' performance with respect to this activity as follows: A=excellent, B=very good, C=good, D=moderate (satisfactory) and F= unsatisfactory. Then, we can express G as a fuzzy set in U in the form $G = \{(x, m(x)), x \in U\}$, where $y=m(x)$ is the corresponding membership function.

We correspond to each x in U an interval of real values as follows: $F \rightarrow [0, 1)$, $D \rightarrow [1, 2)$, $C \rightarrow [2, 3)$, $B \rightarrow [3, 4)$, $A \rightarrow [4, 5]$. Consequently, we have that $y_1 = m(x) = m(F)$ for all x in $[0,1)$, $y_2 = m(x) = m(D)$ for all x in $[1,2)$, $y_3 = m(x) = m(C)$ for all x in $[2, 3)$, $y_4 = m(x) = m(B)$ for all x in $[3, 4)$ and $y_5 = m(x) = m(A)$ for all x in $[4,5]$. Then the graph of the membership function $y = m(x)$, takes the form of the bar graph of Figure 1, while the area of the level's section S contained between this graph and the OX axis is equal to the sum of the areas of the rectangles S_i , $i=1, 2, 3, 4, 5$.

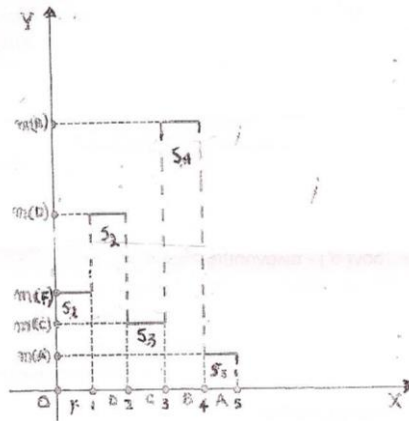


Fig. 1. Bar graphical data representation

Source: Own work.

It is straightforward then to check that in this case formulas (1) are transformed to the form:

$$x_c = \frac{1}{2} \left(\frac{y_1 + 3y_2 + 5y_3 + 7y_4 + 9y_5}{y_1 + y_2 + y_3 + y_4 + y_5} \right), y_c = \frac{1}{2} \left(\frac{y_1^2 + y_2^2 + y_3^2 + y_4^2 + y_5^2}{y_1 + y_2 + y_3 + y_4 + y_5} \right) \quad (2)$$

with $y_i = m(x_i)$, $i=1, 2, 3, 4, 5$ and $x_1=F$, $x_2=D$, $x_3=C$, $x_4=B$ and $x_5=A$.

$$\begin{aligned} \text{In fact, } \iint_S dx dy \text{ is the area of } S \text{ which is equal to } \sum_{i=1}^5 y_i. \text{ Also } \iint_S x dx dy &= \sum_{i=1}^5 \iint_{S_i} x dx dy = \sum_{i=1}^5 \int_0^{y_i} dy \int_{i-1}^i x dx = \\ &= \sum_{i=1}^5 y_i \int_{i-1}^i x dx = \sum_{i=1}^5 y_i \left[\frac{x^2}{2} \right]_{i-1}^i = \frac{1}{2} \sum_{i=1}^5 y_i [i^2 - (i-1)^2] = \frac{1}{2} \sum_{i=1}^5 (2i-1) y_i \text{ and} \\ \iint_S y dx dy &= \sum_{i=1}^5 \iint_{F_i} y dx dy = \sum_{i=1}^5 \int_0^{y_i} y dy \int_{i-1}^i dx = \sum_{i=1}^5 \int_0^{y_i} y dy = \frac{1}{2} \sum_{i=1}^5 y_i^2 \end{aligned}$$

Normalizing the membership degrees by dividing each y_i by the sum $\sum_{i=1}^5 y_i$.

In the current article we will implement a different model being feasible for the individual work assessment. It is based on the same mentioned above GOC ideas, but different in its development and applications. It will allow us to choose the satisfactory written works among submitted, and to choose the best of them.

We will consider assessment of English composition involving evaluating various qualitative aspects of writing, such as content, organization, style, mechanics, and grammar. Traditional methods of assessment can struggle with the subjective nature of these criteria. Fuzzy logic, particularly the center of gravity (COG) technique, offers a way to handle the inherent vagueness and subjectivity in writing assessments.

If (X_c, Y_c) is the coordinates of the figure's center of gravity, (x_{ci}, y_{ci}) is the coordinates of the center of gravity of the segment i , m_i is the mass of the segment i , and M is the mass of the entire figure. If we assume the mass of the region is uniformly distributed, then we can assume that that it is equal to the area of the region. Considering $x_{ci} = i - \frac{1}{2}$, $y_{ci} = \frac{y_i}{2}$, M is the sum of all m_i which is equal to the area of the corresponding rectangle, i.e. the sum of y_i , we come to the similar to (2) formulas

$$X_c = \frac{\sum_{i=1}^n (i - \frac{1}{2}) y_i}{\sum_{i=1}^n y_i}, Y_c = \frac{\sum_{i=1}^n (y_i)^2}{2 \sum_{i=1}^n y_i} \quad (3)$$

The important next here step is to define the criteria for assessment (e.g., content, organization, style, mechanics, and grammar) and create membership functions for each criterion and develop rules that describe how the various criteria interact to influence the overall assessment.

Thus:

1. Every area of assessment, e.g., content (1), organization (2), style (3), mechanics (4), and grammar (5), should be at least satisfactory (i.e. greater or equal to 1), otherwise the assessed work is unsatisfactory.

2. The rule of passing: The ordinate Y_c of the COG of the assessed work should be greater than 1. We can change this criterion, increasing the rigor. This is especially useful in some kinds of competitions. The abscise X_c is smaller (closer to 0.5) as the work is more mature.

The following example demonstrates the implementation of the above ideas.

1	3
2	2
3	2
4	1
5	3

Fig. 2

Source: Own work.

In Figure 2 we illustrate the results of the assessment of an essay. Here, the first column reflects the assessment of the content (3), the second column reflects the organization of the writing (2), the third column reflects the style (2), the fourth – mechanics (1), and the fifth – the grammar (3).

In this case, we have:

$$X_c = \frac{\sum_{i=1}^n (i - \frac{1}{2}) y_i}{\sum_{i=1}^n y_i} = \frac{26.5}{11} = 2.4091 \dots,$$

$$Y_c = \frac{\sum_{i=1}^n (y_i)^2}{2 \sum_{i=1}^n y_i} = \frac{27}{22} = 1.2272 \dots,$$

These numbers show that the writing is above the passing level and has good content, grammar, and organization skills.

Consider another essay assessment given with the table:

1	2
2	3
3	1
4	1
5	3

Fig. 3

Source: Own work.

In this case we have:

$$X_c = \frac{\sum_{i=1}^n (i - \frac{1}{2}) y_i}{\sum_{i=1}^n y_i} = 2.5$$

$$Y_c = \frac{\sum_{i=1}^n (y_i)^2}{2 \sum_{i=1}^n y_i} = 1.2.$$

As we can conclude from these assessment numbers, in the second case, the demonstrated performance is close to the first one, however since the ordinate of the COG is higher, this case is more desirable.

Consider an outlier case given with the table:

1	3
2	1
3	1
4	1
5	3

Fig. 4

Source: Own work.

Here

$$X_c = \frac{\sum_{i=1}^n (i - \frac{1}{2}) y_i}{\sum_{i=1}^n y_i} = 2.5$$

$$Y_c = \frac{\sum_{i=1}^n (y_i)^2}{2 \sum_{i=1}^n y_i} = 1.1666\dots$$

As we can see, the y-coordinate for COG is much smaller. It shows that this case is less desirable.

And the last outlier.

Consider an outlier case given with the table:

1	1
2	1
3	1
4	1
5	3

Fig. 5

Source: Own work.

Here we have:

$$Xc = \frac{\sum_1^n (i - \frac{1}{2}) y_i}{\sum_1^n y_i} = 3.0714 \dots$$

$$Yc = \frac{\sum_1^n (y_i)^2}{2 \sum_1^n y_i} = 0.9285 \dots$$

We would recommend considering the cases when the y-ordinate of GOC is less than 1 to be recognized as barely passing. Note, that x-coordinate distance from the middle number 2.5 is an indicator of uniformity of the score's distribution. In general, note that the y-coordinate is a quite sensitive indicator.

CONCLUSIONS

The center of gravity fuzzy technique provides a robust and nuanced approach to assessing English composition. The COG technique addresses many limitations of traditional assessment methods by accommodating the subjective nature of writing and providing a balanced, precise score. The implementation of this approach implies benefits for educational and professional writing assessment, making this a promising area for further exploration and development.

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Text of the article was accepted by Editorial Team 02.11.2024



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