


Bridging Diversity and Fidelity Through a Multi-Attribute AI Framework for Collaborative Calligraphy Artistic Services Quality Evaluation

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ABSTRACT

Traditional calligraphy is a treasure of Chinese culture, distinguished by its long history and profound cultural significance. However, with the development of modern society, traditional calligraphy now faces the dual challenges of inheritance and innovation. The collaborative calligraphy artistic services quality evaluation constitutes a quintessential multi-attribute decision-making (MADM) challenge. Contemporary research has progressively integrated methodologies like TODIM approach and entropy to address such complex assessments and employs Z-numbers as a robust mechanism for representing vague and partially reliable information. The Z-number TODIM (ZN-TODIM) framework is constructed and specifically used to resolve MADM problems within Z-number information environments. The practical applicability and computational efficacy of this proposed technique are subsequently validated through a detailed numerical case study focusing on the collaborative calligraphy artistic services quality evaluation, demonstrating its utility in real-world educational management scenarios.

KEYWORDS

Multi-Attribute Decision-Making (MADM), Z-Number, TODIM Method, Collaborative Calligraphy Artistic Services Quality

INTRODUCTION

Multi-attribute decision making (MADM) is a structured analytical framework designed to support complex evaluations that involve multiple criteria and the participation of various decision makers (Deng et al., 2026; Fang & Huang, 2026; Jin et al., 2026; Zulqarnain et al., 2025). This approach is particularly appropriate for assessing the quality of collaborative calligraphy artistic services, where outcomes depend on artistic expression, cultural impact, educational value, organizational coordination, and audience engagement (Y. J. Y. Zhang & Zhu, 2025; Y. P. Zhang et al., 2025; S. H. Zhao et al., 2025; Y. S. Zhao & Chen, 2025). Such evaluations require a method capable of capturing

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diverse viewpoints while producing coherent and rational conclusions. The quality assessment of collaborative calligraphy artistic services is inherently multi-dimensional. Stakeholders such as cultural administrators, calligraphy practitioners, educators, students, and community participants often hold different expectations and priorities. For example, organizers may focus on service sustainability and cultural outreach, while participants may emphasize artistic experience and learning value (Lei et al., 2023; J. Wang et al., 2024; N. Zhang et al., 2023; Y. J. Y. Zhang et al., 2024). MADM provides a comprehensive decision-making structure that allows these varied perspectives to be considered simultaneously and integrated into a unified evaluation outcome (S. P. Singh et al., 2025; S. Singh & Singh, 2025; F. C. Tang et al., 2025; F. Wang, 2025). Through systematic processes such as criterion weighting, fuzzy or linguistic evaluation, and preference aggregation, MADM enables both qualitative and quantitative information to be analyzed in a consistent manner. This ensures that evaluation results are objective and transparent while still respecting the subjective judgments of individual evaluators (Ning et al., 2025a, 2025b; Ning et al., 2025c; Xu et al., 2026). As a result, MADM has become a reliable scientific tool for group decision making in complex cultural service assessment contexts. One of the key strengths of MADM is its comprehensive and flexible nature (Ning, 2025; Palanikumar et al., 2025a; Palanikumar et al., 2025b; Palanikumar et al., 2025c). In the evaluation of collaborative calligraphy services, multiple indicators—such as artistic quality, cultural transmission effectiveness, participant collaboration, and innovation capacity—can be examined concurrently. The method allows for the adjustment of indicator weights to reflect their relative importance, ensuring that evaluation results remain balanced and context sensitive. This flexibility also makes MADM adaptable to different service models and evolving cultural objectives. Another important advantage of MADM is its ability to balance subjective insights with objective analysis. While quantitative techniques such as scoring, normalization, and weighting provide analytical rigor, evaluators are also permitted to express their preferences regarding the importance of specific criteria (P. D. Liu et al., 2025; Lu & Cheng, 2025; Ma et al., 2025; Miao, 2025). This combination preserves methodological robustness while accommodating experiential knowledge and professional judgment.

Finally, MADM excels at integrating opinions from multiple stakeholder groups (Q. Li et al., 2025; X. Li & Lin, 2025; Shi et al., 2025; F. Wang et al., 2025; Zeng et al., 2025). In collaborative calligraphy artistic services, decision makers often differ in focus and evaluation emphasis. MADM effectively synthesizes these perspectives, producing outcomes that align strategic goals with user experience and cultural value. Consequently, it offers a practical and inclusive foundation for evaluating and improving the quality of collaborative calligraphy artistic services.

In the evaluation of collaborative calligraphy artistic services quality, MADM offers a structured and effective way to capture diverse viewpoints while producing balanced and credible results (J. J. Jiang et al., 2024; P. Jiang et al., 2024; Kara et al., 2024; Lai & Chang, 2024; Liang et al., 2024). Because service quality in this context depends on multiple interrelated factors, MADM enables evaluators to consider all relevant dimensions within a single analytical framework. First, MADM supports a comprehensive and diversified assessment structure. Collaborative calligraphy services involve artistic quality, cultural influence, educational value, participation level, and organizational coordination. By assigning appropriate weights to each criterion, MADM ensures that no single aspect dominates the evaluation, resulting in a well-rounded and systematic assessment (Ejegwa et al., 2024; Fan et al., 2024; Fu et al., 2024; Garg et al., 2024). Second, MADM accommodates the interests of multiple stakeholder groups. The quality of collaborative calligraphy services is perceived differently by administrators, instructors, students, artists, and the broader community. MADM integrates these varied expectations and preferences, allowing each group's perspective to be reflected fairly in the final evaluation outcome (Ashraf et al., 2024; Attaullah et al., 2024; Aydogdu et al., 2024; Azeem et al., 2024). This inclusive approach improves acceptance and practical relevance. Third, MADM is well suited to managing uncertainty and differences in subjective judgment. Evaluations of cultural and artistic services are often expressed in qualitative or imprecise terms. By incorporating tools such as fuzzy modeling or preference-based analysis, MADM can handle ambiguity and variation in

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