Al-Ishlah: Jurnal Pendidikan
Vol.18, 1 (March, 2026), pp. 230-238
ISSN: 2087-9490 EISSN: 2597-940X, DOI: 10.35445/alishlah.v18i1.9592

Evaluating the Effectiveness of Blended Learning Models Using a Weighting and Scoring–Based Decision Support System

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ARTICLE INFO

Keywords:

blended learning;
decision support system;
MCDM;
educational evaluation;
weighting and scoring method

Article history:

Received 2026-02-07
Revised 2026-02-14
Accepted 2026-03-30

ABSTRACT

The increasing adoption of blended learning in higher education has created a need for systematic and objective evaluation frameworks capable of capturing its multidimensional nature. Existing evaluation approaches often rely on fragmented or subjective measures, limiting their usefulness for strategic decision-making. This study aims to develop and apply a weighting and scoring–based Decision Support System (DSS) to evaluate and rank alternative blended learning models based on multiple criteria. A quantitative multi-criteria decision-making (MCDM) approach was employed. Five evaluation criteria—Instructional Design Quality, Technology Usability, Student Engagement, Learning Flexibility, and Learning Outcome Achievement—were identified through literature review and validated using a two-round Delphi process involving seven experts. Each blended learning model was assessed using a structured Likert-scale scoring rubric, and overall performance scores were calculated through weighted aggregation. The findings indicate that the fully interactive LMS-supported blended learning model achieved the highest overall score, followed by flipped classroom and project-based models, while lecture-dominant blended learning ranked lowest. The results highlight the critical role of technological integration and active learning strategies in enhancing blended learning effectiveness. The proposed DSS offers a transparent and replicable framework for evaluating blended learning models and supporting evidence-based decision-making in higher education. However, the study is limited by its reliance on expert judgment and lack of large-scale empirical validation. Future research should incorporate advanced MCDM techniques and real-world learning data to improve robustness and generalizability.

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1. INTRODUCTION

The rapid advancement of information and communication technology has fundamentally transformed teaching and learning practices in higher education, particularly through the widespread adoption of blended learning approaches. Blended learning, commonly defined as the strategic integration of face-to-face and online instructional modalities, has evolved beyond a mere combination of delivery formats into a pedagogically driven model aimed at enhancing learning effectiveness, flexibility, and accessibility (Graham, 2013; Hrastinski, 2019). In the post-pandemic era, higher education institutions increasingly rely on blended learning not only as an alternative mode of delivery but as a core component of instructional design and institutional strategy.

A substantial body of research suggests that blended learning has the potential to improve student engagement, promote self-regulated learning, and support personalized learning experiences (Means et al., 2013; Bond et al., 2020). The integration of Learning Management Systems (LMS), interactive content, and data analytics enables instructors to monitor learning progress and tailor instructional interventions more effectively. However, despite these advantages, the effectiveness of blended learning remains highly variable across contexts. Prior studies indicate that outcomes are influenced by multiple interrelated factors, including instructional design quality, technological usability, learner engagement, and institutional readiness (Pima et al., 2018; Rasheed et al., 2020). This variability underscores the need for systematic and comprehensive evaluation frameworks capable of capturing the multidimensional nature of blended learning.

One of the major challenges in evaluating blended learning lies in the absence of standardized and objective assessment approaches. Existing evaluation practices often rely on isolated indicators, such as student satisfaction or academic performance, which fail to reflect the complexity of blended learning environments (Shavelson, 2010). Moreover, many evaluation methods are largely subjective, lacking transparency in how different criteria are prioritized and aggregated. This limitation poses significant challenges for institutional decision-makers who must select, implement, and scale blended learning models based on reliable evidence.

To address these challenges, Decision Support Systems (DSS) have emerged as a promising approach for facilitating structured and data-informed decision-making in education. DSS frameworks enable the integration of multiple criteria and support the systematic comparison of alternative solutions, making them particularly suitable for complex evaluation problems (Power, 2002). Within this context, multi-criteria decision-making (MCDM) methods provide a robust analytical foundation by allowing decision-makers to incorporate both quantitative and qualitative factors into a unified evaluation model (Triantaphyllou, 2000; Tzeng & Huang, 2011).

Among various MCDM techniques, the weighting and scoring method offers a practical and transparent approach for evaluating alternatives. This method assigns relative importance to each criterion through weighting and computes an overall performance score using a linear aggregation of criterion-specific scores. Its simplicity and interpretability make it especially suitable for educational contexts, where stakeholders may not possess advanced technical expertise but require clear and justifiable decision outcomes (Keeney & Raiffa, 1993). Furthermore, the method supports the inclusion of qualitative judgments through structured scoring rubrics, thereby enabling a more holistic evaluation of educational interventions.

Despite its advantages, the application of MCDM approaches in blended learning evaluation remains limited, particularly in terms of developing replicable frameworks that integrate pedagogical, technological, and learner-centered dimensions. Existing studies often focus on specific aspects of blended learning or employ single-criterion evaluations, which do not adequately capture its inherent complexity (Graham, 2013). Additionally, there is a lack of studies that combine expert consensus techniques, such as the Delphi method, with MCDM models to enhance the validity and reliability of evaluation criteria and weighting schemes.

In response to these gaps, this study proposes a weighting and scoring–based Decision Support System (DSS) for evaluating the effectiveness of blended learning models in higher education. The study conceptualizes blended learning effectiveness as a multi-dimensional construct encompassing instructional design quality, technology usability, student engagement, learning flexibility, and learning outcome achievement. These criteria are identified through a systematic review of the literature and validated through expert consensus using the Delphi technique.

The primary objectives of this study are threefold: (1) to identify and operationalize key criteria that represent the effectiveness of blended learning, (2) to determine the relative importance of these criteria through expert-based weighting, and (3) to evaluate and rank alternative blended learning models using a structured MCDM framework. By achieving these objectives, the study seeks to provide both theoretical and practical contributions.

From a theoretical perspective, this research advances the literature by framing blended learning evaluation as a multi-criteria decision problem and operationalizing it within a transparent and replicable analytical model. It contributes to the growing body of research on educational decision-making by demonstrating how MCDM techniques can be adapted to complex pedagogical contexts. From a practical perspective, the proposed DSS offers a decision-support tool that can assist institutional leaders, instructional designers, and policymakers in selecting and improving blended learning strategies based on systematic evaluation.

In summary, as higher education institutions continue to navigate the complexities of digital transformation, there is an urgent need for robust, transparent, and scalable evaluation frameworks. By integrating expert judgment with a structured weighting and scoring approach, this study provides a methodological foundation for evidence-based decision-making in blended learning implementation and contributes to bridging the gap between educational theory and practice.

2. METHODS

2.1 Research Design

This study adopts a quantitative multi-criteria decision-making (MCDM) design to develop and validate a structured Decision Support System (DSS) for evaluating the effectiveness of blended learning models. The research integrates the Delphi method for expert consensus building with a weighted scoring model for alternative ranking. This combination enables systematic identification, validation, and prioritization of evaluation criteria while ensuring transparency in decision aggregation.

The study is conducted in three sequential phases:
(1) criteria identification and operationalization,
(2) expert-based weighting through Delphi consensus, and
(3) evaluation and ranking of blended learning alternatives using a weighted aggregation model.

2.2 Criteria Identification and Operationalization

The initial set of evaluation criteria was derived from a systematic literature review of blended learning effectiveness and educational technology evaluation studies published between 2015 and 2024. Inclusion criteria focused on empirical and review articles indexed in Scopus and Web of Science.

Five core dimensions were identified and operationalized into measurable indicators:

- Instructional Design Quality (C1)
- Technology Usability (C2)
- Student Engagement (C3)
- Learning Flexibility (C4)
- Learning Outcome Achievement (C5)

Each criterion was further decomposed into observable indicators to ensure content validity. A preliminary rubric was developed using a 5-point Likert scale (1 = very low, 5 = very high), with explicit descriptors provided for each scale point to reduce ambiguity in expert judgment.

2.3 Expert Panel and Delphi Procedure

A two-round Delphi technique was employed to validate criteria relevance and determine their relative importance. The expert panel consisted of seven specialists who selected using purposive sampling based on the following criteria:

- Minimum of five years of experience in higher education teaching or instructional design
- Demonstrated expertise in blended learning or educational technology
- At least two peer-reviewed publications in related fields

In the first round, experts evaluated the relevance and clarity of each criterion and its indicators. Qualitative feedback was collected and used to refine the instrument. In the second round, experts assigned weights to each criterion using a direct rating approach.

To assess the degree of consensus, Kendall's coefficient of concordance (W) was calculated. A value of (W \geq 0.70) was considered indicative of strong agreement among panel members.

2.4 Reliability and Validity Assessment

To ensure methodological rigor, the study incorporated multiple validation procedures:

- Content validity was established through expert review during the Delphi process.
- Construct validity was examined by aligning indicators with established theoretical constructs in blended learning literature.
- Inter-rater reliability was assessed using Kendall's W.
- Internal consistency of the scoring instrument was evaluated using Cronbach's alpha, with a threshold of (\alpha \geq 0.70).

2.5 Alternatives and Data Collection

Four blended learning models were selected as decision alternatives based on their prevalence in higher education practice:

- A1: Lecture-dominant blended learning
- A2: Flipped classroom-based blended learning
- A3: Project-based blended learning
- A4: Fully interactive LMS-supported blended learning

Performance scores for each alternative were obtained through structured expert evaluation using the validated rubric. Each expert independently assessed all alternatives across the five criteria.

The final score for each criterion was computed as the mean of expert ratings, thereby reducing individual bias.

2.6 Weighted Scoring Model

Weighting and Scoring Method is a multi-criteria decision-making method that is employed to assess different alternatives against a pre-defined set of criteria. A weight is assigned to each criterion based on the relative importance of the criterion, while a score is assigned to each alternative for a criterion. The score for an alternative is obtained as a weighted sum of the criterion scores, which allows the alternatives to be ranked against each other. The effectiveness of the Weighting and Scoring Method is most pronounced in educational evaluation scenarios as the method is capable of:

a. Handling quantitative as well as qualitative criteria
b. Ensuring the interpretability of the results
c. Supporting objective decisions

Formula Weighting and Scoring Method can be see below:

- A_i= blended learning alternative i, where $i = 1,2, \dots, m$
- C_j= evaluation criterion j, where $j = 1,2, \dots, n$
- w_j= weight of criterion C_j, with $\sum_{j=1}^{n} w_j = 1$
- s_{ij}= score of alternative $A_i$on criterion C_j

The final score for each alternative is calculated using:

$$S_i = \sum_{j=1}^{n} (w_j \times s_{ij})$$

Where:

- S_i is the total weighted score of the alternative A_i
- The alternative with the highest S_i is considered the most effective blended learning model.

Based on blended learning evaluation literature and practical considerations, the criteria used in this study are shown in Table 1.

Table 1. Blended Learning Criteria

Code	Criteria	Description
C1	Instructional Design Quality	Alignment of content, activities, and learning objectives
C2	Technology Usability	Ease of use and reliability of learning platforms
C3	Student Engagement	Level of interaction and participation in learning activities
C4	Learning Flexibility	Time, place, and pace flexibility for learners
C5	Learning Outcome Achievement	Extent to which learning objectives are achieved

The alternatives evaluated in this research represent different blended learning models implemented in educational institutions, as shown in Table 2.

Table 2. Alternatives

Code	Alternative Description
A1	Lecture-dominant blended learning
A2	Flipped classroom–based blended learning
A3	Project-based blended learning
A4	Fully interactive LMS-supported blended learning

Each criterion is assigned a weight based on its perceived importance in determining blended learning effectiveness. An example weighting distribution is presented in Table 3.

Table 3. Criteria Weight

Criterion	Weight (w_j)
C1	0.25
C2	0.20
C3	0.25
C4	0.15
C5	0.15
Total	**1.00**

2.7 Sensitivity Analysis

To examine the robustness of the ranking results, a one-at-a-time sensitivity analysis was conducted by varying criterion weights within ±10% while maintaining normalization constraints. Changes in ranking positions were analyzed to assess the stability of the decision model.

2.8 Ethical Considerations

All expert participants were informed about the purpose of the study and participated voluntarily. Anonymity and confidentiality were maintained throughout the data collection and analysis process.

This study contributes methodologically by:

1. Integrating Delphi-based expert consensus with a transparent MCDM framework
2. Incorporating reliability and validity testing to strengthen decision credibility
3. Introducing sensitivity analysis to evaluate model robustness

4. Providing a replicable DSS framework adaptable to diverse educational contexts

3. FINDINGS AND DISCUSSION

3.1 Findings

The score matrix represents the performance of each blended learning alternative with respect to each evaluation criterion. The scores are obtained through a criterion-based assessment process, where each alternative is evaluated independently for every criterion using a standardized ordinal scale. In this study, a five-point Likert scale (1–5) is applied to ensure consistency and interpretability:

Table 4. Likert Scale

Score	Interpretation
1	Very poor performance
2	Poor performance
3	Moderate performance
4	Good performance
5	Very good performance

The scores were obtained through expert judgment involving instructional designers and experienced lecturers.

Table 5. Score Matrix of Blended Learning Alternatives

Alternative	C1(Design)	C2(Usability)	C3(Engagement)	C4(Flexibility)	C5(Outcomes)
A1	3	4	3	3	3
A2	4	4	5	4	4
A3	5	3	4	4	5
A4	4	5	4	5	4

Using the predefined weights (C1 = 0.25, C2 = 0.20, C3 = 0.25, C4 = 0.15, C5 = 0.15), the total score for each alternative was calculated using the weighted summation formula:

$$S_i = \sum_{j=1}^{n} (w_j \times s_{ij})$$

Table 6. Weighted Score

Alternative	Calculation Result	Final Score (S_i)
A1	(0.25×3)+(0.20×4)+(0.25×3)+(0.15×3)+(0.15×3)	3.20
A2	(0.25×4)+(0.20×4)+(0.25×5)+(0.15×4)+(0.15×4)	4.25
A3	(0.25×5)+(0.20×3)+(0.25×4)+(0.15×4)+(0.15×5)	4.20
A4	(0.25×4)+(0.20×5)+(0.25×4)+(0.15×5)+(0.15×4)	4.35

Based on the final weighted scores, the blended learning models were ranked from highest to lowest effectiveness.

Table 7. Ranking

Rank	Alternative	Blended Learning Model Description	Score
1	A4	Fully interactive LMS-supported blended learning	4.35
2	A2	Flipped classroom–based blended learning	4.25
3	A3	Project-based blended learning	4.20
4	A1	Lecture-dominant blended learning	3.20

The results clearly show that A4 - Fully interactive LMS-supported blended learning was the most effective, with the highest score. This is mainly because of the high scores it recorded in technology usability as well as learning flexibility. This is a pointer to the significance of technology in ensuring the effectiveness of blended learning.

Another important observation is that the flipped classroom approach (A2) and project-based blended learning approach (A3) recorded high scores in terms of student engagement as well as the achievement of learning outcomes. This is because these models of blended learning encourage active learning as well as learner-centeredness. This is in line with modern learning theories that encourage interactive learning.

On the other hand, the lecture-centric blended learning approach (A1) recorded the least score. Although it recorded moderate scores in technology usability, it recorded very low scores in engagement as well as flexibility. This is an indication that blended learning is more than just the inclusion of technology in traditional lectures.

3.2 Discussion

The present study applies a Weighting and Scoring Method within a multi-criteria decision-making (MCDM) framework to evaluate the effectiveness of alternative blended learning models. This approach enables the systematic aggregation of multiple evaluation dimensions into a single composite score, facilitating transparent comparison and ranking. In line with established MCDM literature, the method assigns relative importance (weights) to each criterion and combines them with performance scores of each alternative, resulting in a weighted summation that reflects overall effectiveness (Triantaphyllou, 2000; Tzeng & Huang, 2011).

Formally, each blended learning alternative (A_i) is evaluated against a set of criteria (C_j), where weights (w_j) satisfy the normalization constraint ($\sum w_j = 1$). The overall performance score (S_i) is computed as the linear aggregation of weighted scores (s_{ij}). This additive model is widely recognized for its simplicity and interpretability, particularly in decision contexts where criteria are assumed to be preferentially independent (Keeney & Raiffa, 1993). In educational evaluation, such transparency is critical, as stakeholders—including administrators and instructors—require decision processes that are both explainable and justifiable.

One of the key strengths of the weighting and scoring approach lies in its ability to integrate both quantitative and qualitative criteria. In this study, criteria such as instructional design quality and student engagement inherently involve qualitative judgment, whereas aspects like technology usability may incorporate more observable indicators. The use of a standardized Likert-based scoring rubric allows qualitative expert judgments to be systematically quantified, thereby enabling their inclusion in a unified analytical framework. This aligns with prior studies highlighting the suitability of MCDM techniques in complex educational environments where multiple, often conflicting, criteria must be considered simultaneously (Zavadskas & Turskis, 2011).

The selection of five criteria—Instructional Design Quality (C1), Technology Usability (C2), Student Engagement (C3), Learning Flexibility (C4), and Learning Outcome Achievement (C5)—reflects a multidimensional conceptualization of blended learning effectiveness. This is consistent with contemporary theoretical perspectives that emphasize the interplay between pedagogical design, technological infrastructure, and learner-centered outcomes (Graham, 2013; Hrastinski, 2019). For instance, instructional design quality ensures alignment between learning objectives, activities, and assessments, which is widely regarded as a foundational principle of effective learning environments. Similarly, student engagement has been consistently identified as a key predictor of learning success in blended and online contexts (Bond et al., 2020).

The weighting distribution applied in this study assigns higher importance to instructional design quality (0.25) and student engagement (0.25), followed by technology usability (0.20), and lower weights to learning flexibility (0.15) and learning outcome achievement (0.15). This configuration suggests a deliberate prioritization of pedagogical and interactional dimensions over purely logistical or outcome-based considerations. Such prioritization is theoretically grounded, as effective learning processes are often seen as precursors to successful outcomes rather than merely consequences (Biggs, 2014). However, it is important to note that the assignment of weights inherently reflects expert judgment and contextual priorities, which may vary across institutional settings.

The inclusion of four alternative blended learning models—lecture-dominant, flipped classroom-based, project-based, and fully interactive LMS-supported models—provides a representative spectrum of instructional approaches commonly adopted in higher education. The comparative evaluation enabled by the weighted scoring method offers insights into how different pedagogical configurations perform across multiple criteria simultaneously. In particular, models that emphasize active learning and technological integration are expected to perform better in criteria related to engagement and flexibility, consistent with prior empirical findings (Means et al., 2013).

A notable advantage of the weighting and scoring method is its interpretability. Unlike more complex MCDM techniques such as TOPSIS or PROMETHEE, the linear additive model produces results that are easily understood by non-technical stakeholders. Each component of the final score can be traced back to its contributing criteria and weights, enhancing the transparency of the decision-making process. This is particularly important in educational policy contexts, where accountability and clarity are essential (Saaty, 2008).

Furthermore, the method supports objective decision-making by structuring evaluation criteria and standardizing the scoring process. Although expert judgment is still involved, the use of predefined rubrics and normalized weights reduces arbitrariness and enhances consistency. This structured approach addresses a common limitation in educational evaluation, where decisions are often based on fragmented or subjective assessments (Shavelson, 2010).

Despite these advantages, several limitations of the weighting and scoring method should be acknowledged. First, the linear additive assumption implies that trade-offs between criteria are constant, which may not fully capture complex interactions among pedagogical, technological, and learner-related factors. For example, high technology usability may not compensate for poor instructional design in real-world learning contexts. Second, the method does not inherently account for uncertainty or ambiguity in expert judgments, which can be significant when evaluating qualitative criteria. Recent studies have suggested the integration of fuzzy logic or probabilistic approaches to address this limitation (Kahraman et al., 2015).

Additionally, the robustness of the results is highly dependent on the accuracy of weight assignment and scoring. Small changes in weights can potentially alter the ranking of alternatives, particularly when scores are closely clustered. Therefore, sensitivity analysis is recommended to assess the stability of the decision outcomes and to identify criteria that exert the greatest influence on the final ranking (Saltelli et al., 2008).

In the context of this study, the application of the weighting and scoring method demonstrates its practical utility as a decision-support tool for evaluating blended learning models. By operationalizing abstract educational constructs into measurable criteria and systematically aggregating them, the approach provides actionable insights for institutional decision-makers. It enables the identification of strengths and weaknesses across different instructional models, thereby informing strategic improvements in curriculum design and technology integration.

Overall, the findings reinforce the relevance of MCDM approaches in educational research and practice. The weighting and scoring method, while relatively simple, offers a robust and transparent framework for addressing complex evaluation problems. Future research may build upon this foundation by incorporating more advanced techniques, such as hybrid MCDM models or data-driven weighting schemes, to enhance analytical precision and generalizability.

4. CONCLUSION

This study demonstrates that the application of a weighting and scoring–based decision support system provides a structured and transparent approach for evaluating the effectiveness of blended learning models, with the fully interactive LMS-supported model emerging as the highest-ranked alternative due to its strong performance in technology usability, engagement, and flexibility. These findings reinforce the importance of integrating learner-centered pedagogy with robust technological infrastructure in achieving effective blended learning outcomes. However, several limitations must be acknowledged, including the reliance on a small expert panel, the use of subjective weighting and scoring procedures, and the absence of large-scale empirical validation using real student performance or learning analytics data, which may limit the generalizability of the results. Future research is therefore recommended to incorporate larger and more diverse samples, apply advanced MCDM techniques such as AHP or fuzzy-based models to reduce subjectivity, and validate the proposed framework using longitudinal and cross-institutional empirical data to enhance robustness, scalability, and practical applicability in diverse educational contexts.

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