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iJET International Journal of Emerging Technologies in Learning

iJET | eISSN: 1863-0383 | Vol. 18 No. 24 (2023) | OPEN ACCESS

https://doi.org/10.3991/ijet.v18i24.45643

PAPER

Bilingual Teaching Environment Creation and Multi-Attribute Teaching Decisions

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ABSTRACT

With the continuous advancement of globalization, bilingual teaching has become an important component of the educational field. However, existing research methods have certain shortcomings in creating a language environment conducive to bilingual teaching and making multi-attribute teaching decisions. To solve this problem, this study conducted detailed research in three aspects. First, bilingual teaching environment creation schemes and their attribute characteristics were discussed, aiming to establish a more comprehensive and systematic language environment model. Second, evaluation indexes for the schemes were selected and weighted, aiming to establish a scientific and reasonable evaluation system. Finally, the specific implementation steps of the multi-attribute teaching decision model were elaborated, providing a comprehensive decision framework. This study not only contributes to the theoretical development of bilingual teaching but also provides a valuable reference for educational practice.

KEYWORDS

bilingual teaching, language environment, multi-attribute decisions, evaluation indexes, teaching models

1 INTRODUCTION

With the rapid development of globalization, bilingual teaching plays an increasingly important role in various stages of education [1, 2]. To meet multicultural and multilingual social needs, educators and scholars have been exploring how to implement bilingual teaching more effectively [3–5]. However, many educational institutions are faced with the challenge of creating a language environment conducive to bilingual teaching in practical applications [6–8]. The language environment affects not only the language acquisition speed of students but also their performance in cultural adaptation, emotional engagement, cognitive development, etc. [9–11]. Therefore, it is of important practical significance to study the creation of a bilingual teaching environment and its multi-attribute decision factors.

Zhao, R., Dong, N. (2023). Bilingual Teaching Environment Creation and Multi-Attribute Teaching Decisions. *International Journal of Emerging Technologies in Learning (iJET)*, 18(24), pp. 149–163. https://doi.org/10.3991/ijet.v18i24.45643

Article submitted 2023-09-06. Revision uploaded 2023-10-22. Final acceptance 2023-10-24.

Apart from textbooks and teachers, the success of bilingual teaching relies more on a comprehensive and detailed teaching decision [12, 13]. However, current studies of bilingual teaching focus more on course content and teaching methods, with less attention paid to language environment creation and multiple attributes of teaching decisions [14–17]. In-depth research on these aspects not only promotes the development of bilingual teaching theories but also provides more comprehensive and specific operation guidance for educators, thereby improving the effect of bilingual teaching.

Although studies of bilingual teaching are increasingly rich, most of the existing studies still focus on descriptive or single-attribute analysis, lacking comprehensive research on multi-attribute decision factors [18–21]. For example, some studies only focus on teaching content or methods, ignoring the influence of the teaching environment and other important factors. In addition, existing studies also lack unified evaluation indexes. Therefore, when educators are faced with multiple choices in bilingual teaching, there are no clear guidelines.

This study aimed to fill the gaps in the above studies. The main content of this study is divided into three parts. First, bilingual teaching environment creation schemes and their attribute characteristics were discussed, aiming to establish a more comprehensive and systematic language environment model. Second, evaluation indexes for the schemes were selected and weighted, aiming to establish a scientific and reasonable evaluation system. Finally, the specific implementation steps of the multi-attribute teaching decision model were elaborated, providing a comprehensive decision framework. The research on these three aspects not only contributes to the further development of bilingual teaching theories but also provides valuable reference and guidance for teaching practice.

2 BILINGUAL TEACHING ENVIRONMENT CREATION SCHEMES AND THEIR ATTRIBUTE CHARACTERISTICS

Certain principles need to be followed when creating a bilingual teaching environment. First, it is necessary to consider cultural adaptability; that is, the language environment should fully reflect the culture of the target language and mother tongue, thereby better integrating into the teaching content. Second, the created language environment should ensure that the bilingual teaching environment is consistent with educational objectives and teaching methods, thereby promoting more efficient learning. The teaching environment should also have a certain degree of flexibility to adapt to the needs of different learners and changes in different teaching stages. In addition, environmental creation should focus on meeting the personalized needs of learners and providing diverse learning resources and activities. Finally, the teaching environment should be maintained and updated easily to support long-term teaching activities.

This study provides four feasible bilingual teaching environment creation schemes.

Scheme 1: Cultural integration type of bilingual environment. The attributes of this scheme include cultural inclusion, language distribution, and textbook selection. Cultural inclusion highly emphasizes the integration and mutual respect of two or more cultures. Language distribution emphasizes the equal use of two languages for teaching and social activities. Textbook selection emphasizes the full consideration of both cultural diversity and bilingual elements.

Scheme 2: Immersive bilingual environment. The attribute of this scheme include language immersion, language skill training, and teaching methods.

Language immersion emphasizes that the target language is used for most or all teaching activities. Language skill training emphasizes the need for lots of practice in listening, speaking, reading, and writing. Teaching methods need to focus on scenario simulation and practical applications.

Scheme 3: Mixed-mode bilingual environment. The attributes of this scheme include flexible language distribution, technology integration, and diversified evaluation. Flexible language distribution emphasizes flexible language switching based on the teaching content or the language proficiency of students. Technology integration emphasizes the use of multimedia and online resources to support bilingual teaching. Diversified evaluation emphasizes the use of various evaluation methods, including formatted and unformatted evaluations.

Scheme 4: Project type of bilingual environment. The attributes of this scheme include practical orientation, teamwork, and interdisciplinary application. Practice orientation emphasizes language learning through projects or tasks. Teamwork emphasizes teamwork between students in two languages. Interdisciplinary application emphasizes the combination of language learning with other disciplinary content.

3 EVALUATION INDEX SELECTION AND WEIGHTING OF BILINGUAL TEACHING ENVIRONMENT CREATION SCHEMES

To comprehensively and scientifically evaluate the bilingual teaching environment creation schemes and provide corresponding multi-attribute teaching decisions, this study determined the following evaluation indexes for the schemes: First, teaching effect BE_1, includes BE_{11} (academic performance of students in both languages), BE_{12} (their language application ability, such as listening, speaking, reading, and writing), and BE_{13} (their activity level in the bilingual environment). Second, cultural adaptability BE_2, including BE_{21} (whether the scheme emphasizes cultural diversity and mutual respect), BE_{22} (students' understanding and acceptance of various cultures), and BE_{23} (their emotional response to bilingual teaching). Third, flexibility and adaptability BE_3, including BE_{31} (whether the scheme can be flexibly adjusted according to different teaching contents and the language proficiency of students), BE_{32} (the adaptability and acceptance of teachers and students for the scheme), and BE_{33} (whether multimedia and online resources are effectively used). Finally, practicality and operability BE_4, including BE_{41} (the complexity and cost of implementing the scheme), BE_{42} (the availability of textbooks and teaching resources), and BE_{43} (the familiarity and execution ability of teachers for the teaching scheme).

Figure 1 shows the evaluation framework for bilingual teaching environment creation schemes. The creation of the environment involves multiple attributes and indexes, and these indexes affect and depend on each other, requiring a scientific method for comprehensive consideration. Moreover, in addition to quantitative data, such as exam scores and participation, the evaluation process involves many qualitative factors, such as cultural adaptability and the professional ability of teachers. The Criteria Importance Through Intercriteria Correlation (CRITIC) method was used in this study, which processed the two types of information effectively, comprehensively considered multiple evaluation indexes, and adjusted the weight of each index according to the actual situation, thereby obtaining more comprehensive and flexible decision-making results.

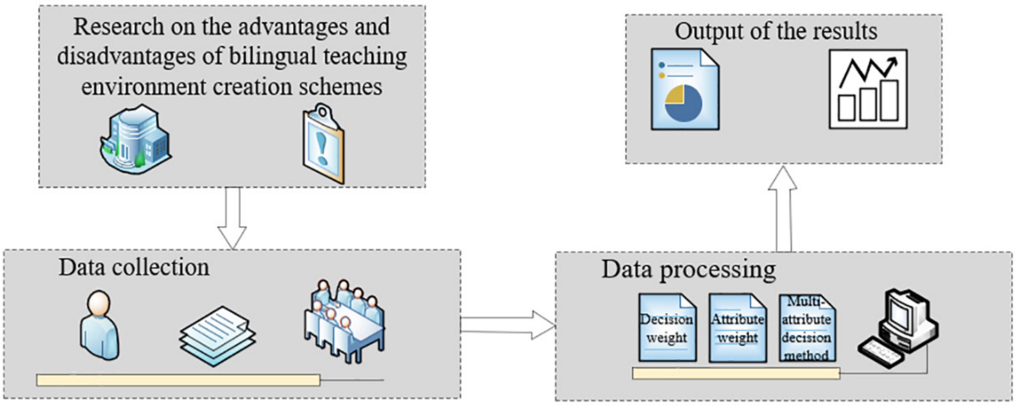

Fig. 1. Evaluation framework for bilingual teaching environment creation schemes

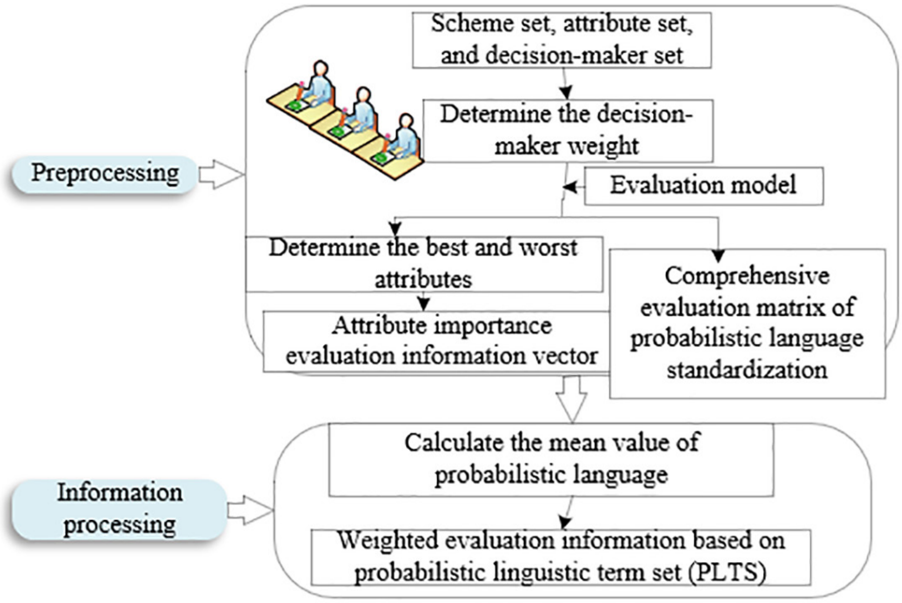

Fig. 2. Processing steps before assigning weights to multi-attribute decision indexes

Let $SM = \{SM_m, SM_2, \ldots, SM_l\}$ be the scheme set for given l alternative schemes; $SY = \{SY_1, SY_2, \ldots, SY_b\}$ be the attribute set for given b attributes; $Q = \{q_1, q_2, \ldots, q_b\}$ be the weight vector of attributes; q_k be the weight of attribute SY_k, with $\sum_{k=1}^{b} = 1$ and $q_k \geq 0$ $(k = 1, 2, \ldots, b)$; $R = \{R_1, R_2, \ldots, R_r\}$ be the expert set under the assumption of r experts; $ZZ^{(r)} = LI^r_{uk}(1, 2, \ldots, l;\ j = 1, 2, \ldots, b)$ be the constructed linguistic term group decision matrix; LI^r_{uk} be the evaluation result of the k-th attribute of scheme SM_u proposed by the r-th expert.

Figure 2 shows the processing steps before assigning weights to multi-attribute decision indexes. The specific steps for assigning weights to the evaluation indexes of bilingual teaching environment creation schemes were described as follows:

Step 1: Based on research content and objectives, the key indexes used to evaluate the bilingual teaching environment were first determined, and data related to these evaluation indexes was collected. The collected data was organized into a two-dimensional matrix, with each row representing a bilingual teaching scheme and each column representing an evaluation index. The evaluation matrix

$ZZ^{(r)} = (LI^r_{uk})_{l\times b}$ of bilingual teaching environment creation schemes was constructed as follows:

$$ZZ^{(r)} = \left[LI^r_{uk}\right]_{l\times b} = \begin{bmatrix} LI^r_{11} & LI^r_{12} \cdots & LI^r_{1b} \\ LI^r_{21} & LI^r_{22} \cdots & LI^r_{2b} \\ \vdots & \vdots \quad \vdots & \vdots \\ LI^r_{l1} & LI^r_{l2} \cdots & LI^r_{lb} \end{bmatrix} \tag{1}$$

Step 2: PLTS was used to convert raw data into probabilistic form. Based on the converted data, the probabilistic language decision matrix $ZZ(\ddot{o}) = [LI_{uk}(\ddot{p}_{uk})]_{l\times b}$ was constructed as follows:

$$ZZ(\ddot{o}) = \left[LI_{uk}(\ddot{o}_{uk})\right]_{l\times b} = \begin{bmatrix} LI_{11}(\ddot{o}_{11}) & LI_{12}(\ddot{o}_{12}) \cdots LI_{1b}(\ddot{o}_{1b}) \\ LI_{21}(\ddot{o}_{21}) & LI_{22}(\ddot{o}_{2}) \cdots LI_{2b}(\ddot{o}_{2b}) \\ \vdots & \vdots \quad \vdots \quad \vdots \\ LI_{l1}(\ddot{o}_{l1}) & LI_{l2}(\ddot{o}_{l2}) \quad LI_{lb}(\ddot{o}_{lb}) \end{bmatrix} \tag{2}$$

Step 3: The probabilistic language decision matrix was standardized, which made different indexes be compared on the same scale. Furthermore, standardized data was used to construct the comprehensive evaluation matrix $ZZ(o) = [LI_{uk}(p_{uk})]_{l\times b}$.

Step 4: After calculating the probability mean value of all bilingual teaching scheme evaluations in each index, then,

$$\bar{y}^{(j)}_k(\bar{o}^{(j)}_k) = \frac{\sum_{u=1}^{l} y^{(j)}_{uk}}{l}\left(\frac{\sum_{u=1}^{l} o^{(j)}_{uk}}{l}\right) \tag{3}$$

Step 5: The correlation coefficients between various indexes were calculated to understand their correlation.

$$\vartheta_{kt} = \frac{\sum_{u=1}^{l}\left(\sum_{j=1}^{\#ZZ(o)} y^{(j)}_{uk}o^{(j)}_{uk} - \bar{y}^{(j)}_k\bar{o}j^{(j)}_k\right)\left(\sum_{j=1}^{\#ZZ(o)} y^{(j)}_{ut}o^{(j)}_{ut} - \bar{y}^{(j)}_t\bar{o}j^{(j)}_t\right)}{\sqrt{\sum_{u=1}^{l}\left(\sum_{j=1}^{\#ZZ(o)} \varepsilon^{(j)}_{uk}o^{(j)}_{uk} - \bar{\varepsilon}^{(j)}_k\bar{o}^{(j)}_k\right)^2\left(\sum_{j=1}^{\#ZZ(o)} \varepsilon^{(j)}_{ut}o^{(j)}_{ut} - \bar{\varepsilon}^{(j)}_t\bar{o}^{(j)}_t\right)^2}} \tag{4}$$

Step 6: The standard deviation of each index was further calculated to understand its degree of variation in different teaching schemes.

$$\delta_k = \sqrt{\frac{1}{l-1}\sum_{u=1}^{l}\left(\sum_{j=1}^{\#ZZ(o)} y^{(j)}_{uk}o^{(j)}_{uk} - \bar{y}^{(j)}_k\bar{o}^{(j)}_k\right)^2} \tag{5}$$

Step 7: The exponent V_k was calculated using the following equation:

$$V_k = \delta_k\sum_{j=1}^{b}(1-\vartheta_{kt}) \tag{6}$$

Step 8: The previously calculated probabilistic language mean value, correlation coefficients, and standard deviations were used to calculate the weight of each index using the CRITIC method. Based on the calculation results, a weight vector containing all index weights was constructed. The weight vector $Q = \{q_1, q_2, ..., q_b\}$ was obtained using the following equation:

$$q_k = \frac{V_k}{\sum_{k=1}^{b} V_k} \tag{7}$$

4 SPECIFIC IMPLEMENTATION STEPS OF THE MULTI-ATTRIBUTE TEACHING DECISION MODEL

Combined with the research content and objectives of this study, the working steps of the multi-attribute teaching decision model, which was based on the evaluation of bilingual teaching environment creation schemes, were described in detail below. Figure 3 shows a schematic diagram of the multi-attribute decision process.

Step 1: Experts in several fields were invited, such as bilingual teaching, educational psychology, and management, and then were asked to give scores for various bilingual teaching schemes and evaluation indexes. An expert evaluation matrix was constructed based on Step 2 in the previous section.

Step 2: The expert evaluation matrix was standardized. Then a comprehensive evaluation matrix was generated by combining the weights of each index.

Step 3: Positive and negative ideal points were determined based on the comprehensive evaluation matrix. The distance measurement method was used to calculate the distance from each scheme to both positive and negative ideal points, represented by ZJ and FJ, respectively. Let $ZJ_k = (y_k^{(j)} o_k^{(j)} \mid j = 1, 2, \ldots, \# ZZ(o))$, $R(ZJ_k) = \{MAX_u R(LO_{uk}(o))\}$, $ZJ_k = (y_k^{(j)} o_k^{(j)} \mid k = 1, 2, \ldots, \# ZZ(o))$, and $R(ZJ_k) = \{MIN_u R(LO_{uk}(o))\}$, then there were:

$$ZJ = (ZJ_1, ZJ_2, \ldots, ZJ_b) \tag{8}$$

$$FJ = (FJ_1, FJ_2, \ldots, FJ_b) \tag{9}$$

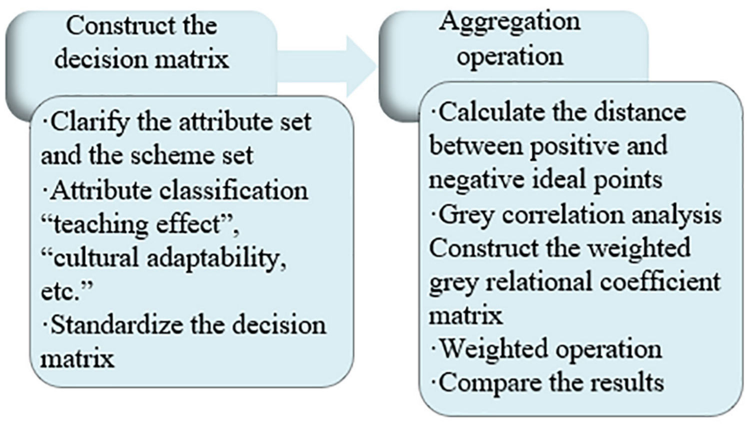

Fig. 3. Schematic diagram of the multi-attribute decision process

The distance from each scheme to both positive and negative ideal points, represented by F_{uk}^{+} and F_{uk}^{-}, respectively, calculated as follows:

$$F_{uk}^{+}=\frac{\sum_{j=1}^{\#ZZ(o)}\left|y^{(j)}o^{(j)}-y^{+(j)}o^{+(j)}\right|}{\#ZZ(o)} \tag{10}$$

$$F_{uk}^{-}=\frac{\sum_{j=1}^{\#ZZ(o)}\left|y^{(j)}o^{(j)}-y^{-(j)}o^{-(j)}\right|}{\#ZZ(o)} \tag{11}$$

Step 4: The grey relational coefficients between each scheme and positive or negative ideal points were calculated using the grey correlation analysis method. Let $\phi \in (0,1]$ be the resolution coefficient given by experts,

$$h_{uk}^{+}=\frac{\underset{u}{MIN}\,\underset{k}{MIN}\,F_{uk}^{+}+\varphi\,\underset{u}{MAX}\,\underset{k}{MAX}\,D_{uk}^{+}}{F_{uk}^{+}+\varphi\,\underset{u}{MAX}\,\underset{k}{MAX}\,F_{uk}^{+}} \tag{12}$$

$$h_{uk}^{-}=\frac{\underset{u}{MIN}\,\underset{k}{MIN}\,F_{uk}^{-}+\varphi\,\underset{u}{MAX}\,\underset{k}{MAX}\,F_{uk}^{-}}{F_{uk}^{-}+\varphi\,\underset{u}{MAX}\,\underset{k}{MAX}\,F_{uk}^{-}} \tag{13}$$

Step 5: The grey relational coefficients were aggregated, which obtained matrices $GLXS^{+} = [h_{uk}^{+}]_{l\times b}$ and $GLXS^{-} = [h_{uk}^{+}]_{l\times b}$ as follows:

$$GLXS^{+}=\begin{bmatrix} h_{11}^{+} & h_{12}^{+} & \cdots & h_{1b}^{+} \\ h_{21}^{+} & h_{12}^{+} & \cdots & h_{2b}^{+} \\ \vdots & \vdots & \ddots & \vdots \\ h_{l1}^{+} & h_{l2}^{+} & \cdots & h_{lb}^{+} \end{bmatrix} \tag{14}$$

$$GLXS^{-}=\begin{bmatrix} h_{11}^{-} & h_{12}^{-} & \cdots & h_{1b}^{-} \\ h_{21}^{-} & h_{12}^{-} & \cdots & h_{2b}^{-} \\ \vdots & \vdots & \ddots & \vdots \\ h_{l1}^{-} & h_{l2}^{-} & \cdots & h_{lb}^{-} \end{bmatrix} \tag{15}$$

The weighted grey relational coefficients were calculated based on the weight of each evaluation index. Matrices $GLXS^{+} = [q_k h_{uk}^{+}]_{l\times b}$ and $GLXS^{-} = [q_k h_{uk}^{-}]_{l\times b}$, which contained all schemes and weighted grey relational coefficients,

$$GLXS^{+}=\begin{bmatrix} q_1h_{11}^{+} & q_2h_{12}^{+} & \cdots & q_bh_{1b}^{+} \\ q_1h_{21}^{+} & q_2h_{12}^{+} & \cdots & q_bh_{2b}^{+} \\ \vdots & \vdots & \ddots & \vdots \\ q_1h_{l1}^{+} & q_2h_{l2}^{+} & \cdots & q_bh_{lb}^{+} \end{bmatrix} \tag{16}$$

$$GLXS^{-}=\begin{bmatrix} q_1h_{11}^{-} & q_2h_{12}^{-} & \cdots & q_bh_{1b}^{-} \\ q_1h_{21}^{-} & q_2h_{12}^{-} & \cdots & q_bh_{2b}^{-} \\ \vdots & \vdots & \ddots & \vdots \\ q_1h_{l1}^{-} & q_2h_{l2}^{-} & \cdots & q_bh_{lb}^{-} \end{bmatrix} \tag{17}$$

Step 6: Based on the weighted grey relational coefficient matrices, the weighted grey relational degrees between each scheme and the positive ideal point, as well as between positive and negative ideal points were calculated. Let $\bar{q}_k = q_k^2 / \sqrt{\sum_{k=1}^{b} q_k^2}$,

$$XS_u^- = \sum_{k=1}^{b} \bar{q}_k h_{uk}^+ \tag{18}$$

$$XS_u^- = \sum_{k=1}^{b} \bar{q}_k h_{uk}^- \tag{19}$$

Step 7: Based on the previous steps, the comprehensive attribute value EV_u for each scheme was calculated. The value comprehensively considered multiple factors, such as distance, grey relational coefficient, and weighted relational degree. All bilingual teaching environment creation schemes were ranked based on their comprehensive attribute values. The smaller the EV_u value, the worse the bilingual teaching environment creation scheme. On the contrary, the higher the EV_u value, the better the scheme.

$$EV_u = \frac{XS_u^+}{XS_u^+ + XS_u^-} = \frac{\sum_{k=1}^{b} \bar{q}_k h_{uk}^+}{\sum_{k=1}^{b} \bar{q}_k h_{uk}^+ + \sum_{k=1}^{b} \bar{q}_k h_{uk}^-} \tag{20}$$

5 EXPERIMENTAL RESULTS AND ANALYSIS

In the multi-attribute teaching decision model, the standard deviation serves as an important weighting reference for evaluation indexes, which helps quantify the degree of dispersion of those indexes. It can be observed from the Table 1 that the standard deviation value of the teaching effect dimension fluctuates between 0.0552 and 0.0978, indicating a certain degree of dispersion in the three sub-indexes within this dimension. Especially, the standard deviation of BE_{13} is 0.0978, which is the highest in this dimension, indicating that this index leads to greater fluctuations in evaluation. The standard deviation value of the cultural adaptability dimension is concentrated between 0.0812 and 0.0961. Overall, this range is relatively concentrated, indicating that the three sub-indexes of cultural adaptability are relatively stable. The standard deviation of flexibility and adaptability is between 0.0879 and 0.0956, which is also relatively stable, indicating that the sub-indexes within this dimension are relatively balanced, without any sub-index being particularly prominent or lagging behind. The standard deviation value of practicality and operability is the most significant. Especially, the standard deviation of BE_{42} is only 0.0182, which is much lower than other indexes. This indicates that the index is relatively stable, but it also means that its importance in scheme evaluation is underestimated. According to the above analysis, the high standard deviation means that the index exhibits significant differences in different teaching environments and samples, which should be given special attention in weight assignment. The low standard deviation indicates that the index is relatively stable in all scenarios, but whether it is underestimated should be considered in weight assignment.

Table 1. Calculation of standard deviation

Standard deviation	BE_{11}	BE_{12}	BE_{13}	BE_{21}	BE_{22}	BE_{23}
	0.0552	0.0663	00978	0.0961	0.0812	0.0923
Standard deviation	BE_{31}	BE_{32}	BE_{33}	BE_{41}	BE_{42}	BE_{43}
	0.0879	0.0956	0.0889	0.0712	0.0182	0.0812

Table 2. Attribute weight matrix

Attribute weight	BE_{11}	BE_{12}	BE_{13}	BE_{21}	BE_{22}	BE_{23}
	0.0456	0.1254	0.1481	0.0689	0.0831	0.1125
Attribute weight	BE_{31}	BE_{32}	BE_{33}	BE_{41}	BE_{42}	BE_{43}
	0.0889	0.1356	0.0915	0.0768	0.0088	0.0721

The following analysis can be made according to the attribute weight matrix in Table 2. BE_{13} has the highest weight (0.1481) in the BE_1 sub-index, which is consistent with its high standard deviation (0.0978), indicating that the activity level of students is considered one of the most critical factors in bilingual teaching. BE_{23} has a relatively high weight (0.1125) in the BE_2 sub-index, indicating that students' emotional response to bilingual teaching plays an important role in the evaluation. BE_{32} has the highest weight (0.1356) in the BE_3 sub-index, which means that the adaptability and acceptance of teachers and students are quite important in the bilingual teaching scheme evaluation. BE_{42} has an extremely low (0.0088) weight in the BE_4 sub-index because its standard deviation is extremely low (0.0182), indicating that this index performs stably in various schemes. However, its low weight also means that it is ignored in multi-attribute teaching decisions. It can be seen from the above analysis that the distribution of the attribute weight matrix is roughly consistent with the observed results of previous standard deviation, i.e., indexes with a higher standard deviation usually also have higher weights, indicating the importance and influence of these indexes in the bilingual teaching environment.

In the English-bilingual teaching environment, the ranking values of schemes along with the changes in standard deviation and weight can be analyzed based on Figure 4. Schemes 1–4 are cultural integration types of bilingual environments, immersive and mixed-mode bilingual environments, and project types of bilingual environments. It can be seen from the figure that four different bilingual teaching environment schemes exhibit different ranking values when the weight and standard deviation are different. Scheme 1 has higher ranking values in all weight and standard deviation combinations, and its ranking values are significantly higher than those of other schemes especially, when the weight is 0.5 and the standard deviation is within the range of 0.7 0.9. Scheme 2 is competitive to some extent when the weight is 0.3 and the standard deviation is between 0.7 and 0.9, but its ranking values are generally lower in other combinations. Scheme 3 has lower ranking values in all cases and has the lowest ranking value, especially when the weight is 0.5. The ranking values of Scheme 4 are the lowest in all combinations, indicating that its performance is not ideal when considering different weights and standard deviations. It can be seen from the above analysis that Scheme 1 is robust and adaptable in the English bilingual teaching environment in most weight and standard deviation combinations and has the best performance, especially when the weight (e.g., 0.5) and the standard deviation (e.g., 0.9) are high, which means that the scheme is superior in the multi-attribute evaluation.

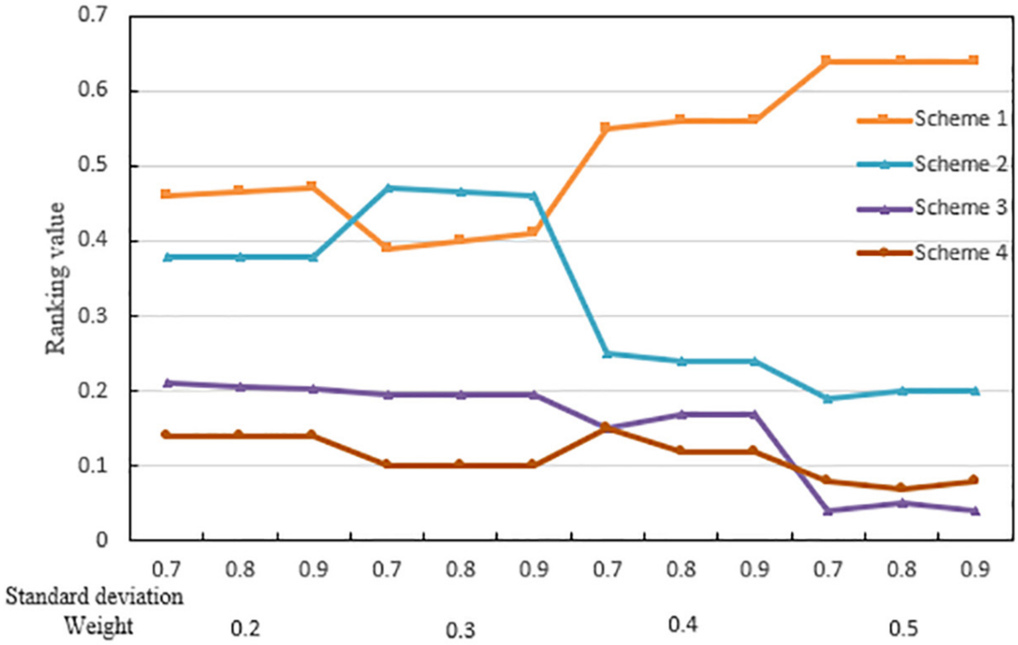

Fig. 4. Ranking values of schemes along with changes in standard deviation and weight in English bilingual teaching environment

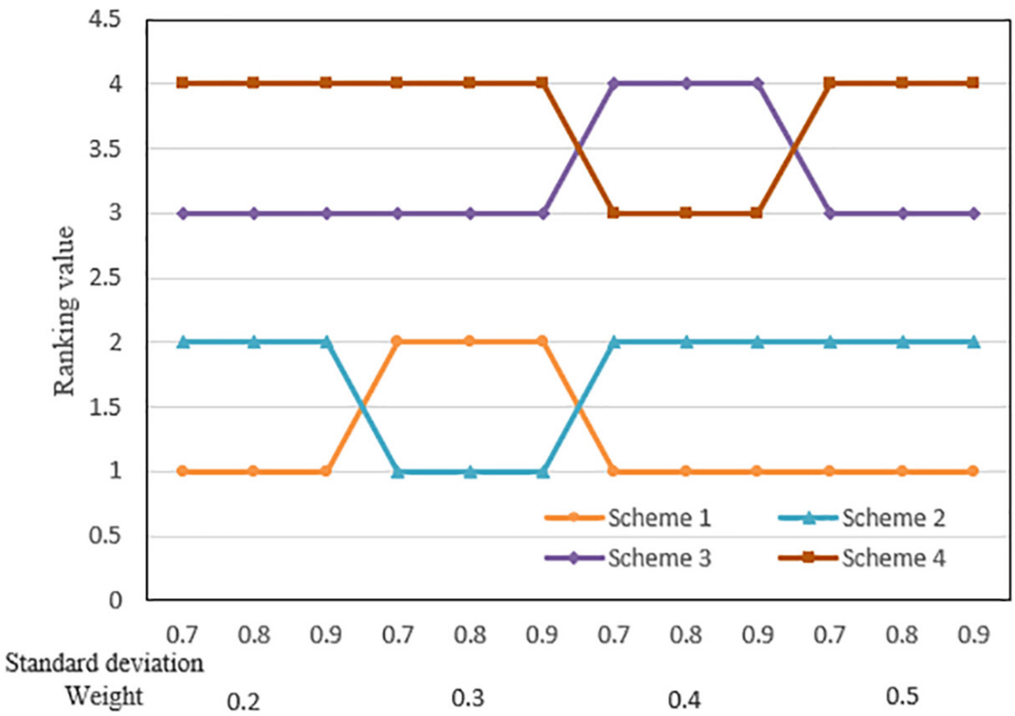

Fig. 5. Ranking values of schemes along with changes in standard deviation and weight in French bilingual teaching environment

Table 3. Corresponding comprehensive index values for all schemes

	Scheme 1	Scheme 2	Scheme 3	Scheme 4
BE_{11}	0.6689	0.3156	0.2987	0.3125
BE_{12}	0.6521	0.4456	0.5236	0.0000
BE_{13}	0.5714	0.4215	0.5789	0.0000
BE_{21}	0.6639	0.3125	0.5784	0.3215
BE_{22}	0.7698	0.0000	0.4126	0.0854
BE_{23}	0.8000	0.1628	0.2561	0.0000
BE_{31}	0.4852	0.2889	0.6523	0.0000
BE_{32}	0.6239	0.5741	0.6321	0.0000
BE_{33}	0.5216	0.6125	0.6239	0.0000
BE_{41}	0.5248	0.5863	0.6239	0.0000
BE_{42}	0.6326	0.3582	0.3251	0.5216
BE_{43}	0.5000	0.6358	0.5000	0.0000

In the French bilingual teaching environment, the ranking values of schemes, along with the changes in standard deviation and weight, can be analyzed based on Figure 5. As shown in the figure, Scheme 1 ranks first in most cases and second when the weight is 0.3, which indicates that the scheme has strong adaptability and robustness, making it an optimal or suboptimal choice in almost all cases. Scheme 2 ranks first when the weight is 0.3 and second in other cases, which means that this scheme is superior to Scheme 1 in certain specific conditions (e.g., specific weight). Scheme 3 ranks third in most cases but lowest when the weight is 0.4, which indicates that the comprehensive performance of the scheme is relatively average and requires further optimization. Scheme 4 ranks third when the weight is 0.4 and lowest in all other cases, which indicates that the performance of the scheme is generally poor in different conditions. It can be seen from the above analysis that Scheme 1 is the preferred one in most situations in the French bilingual teaching environment, and has strong performance especially in various weight and standard deviation conditions.

Table 3 shows the comprehensive values of four different bilingual teaching schemes in several evaluation indexes. It can be seen from the table that Scheme 1 has the best performance in most indexes, especially in terms of teaching effect and cultural adaptability. But this also means that it is the most complex and expensive scheme. Scheme 3 performs well in terms of flexibility and adaptability, as well as teaching effect and cultural adaptability. It is a good choice to balance various factors. Scheme 2 performs well in terms of practicality and operability, but its performance in other aspects is relatively weak. Scheme 4 has the lowest or near lowest scores in all indexes, which means that this scheme requires significant improvement. Based on these analyses, it can be concluded that Scheme 1 is the most comprehensive but also the most complex and expensive. Scheme 3 seems to be a more balanced choice, especially if resources are limited or more flexibility and adaptability are needed. Schemes 1 and 2 require more optimization and improvement. These conclusions should be combined with previous weight and standard deviation analyses to make the most comprehensive teaching decision.

Table 4. Sub-optimal comprehensive values of all schemes

	Correlation Coefficient	Exponent V_k	Sub-Optimal Comprehensive Value 1	Sub-Optimal Comprehensive Value 2
Scheme 1	0.3102	1.1524	0.6785	0.0642
Scheme 2	–0.0241	0.8236	0.1842	–0.0058
Scheme 3	0.0632	0.1129	0.1234	0.0018
Scheme 4	–0.2415	0.8125	–0.0841	–0.0274

Table 4 shows the sub-optimal comprehensive values of four different schemes, which are calculated based on their respective correlation coefficients and the exponent V_k. The sub-optimal comprehensive values are usually used for sensitivity analysis in multi-attribute decisions, thereby measuring the robustness of schemes under different assumptions or weights. As shown in the table, Scheme 1 continues to be proven to be the most comprehensive and robust scheme, suitable for various teaching environments and needs. Although Scheme 3 is slightly inferior in terms of comprehensive indexes, it is relatively robust in terms of sub-optimal comprehensive values. Therefore, it is an alternative scheme worth considering. Scheme 2 exhibits some instability and requires further optimization to improve its performance in different scenarios. Scheme 4 performs relatively poorly in all aspects and requires significant improvement or reconsideration. These conclusions are consistent with the previous weight and standard deviation analysis as well as the analysis of comprehensive index values, providing decision-makers with a more comprehensive perspective to evaluate different bilingual teaching schemes.

Table 5 shows the final comprehensive values of four different schemes. The comprehensive value is usually the weighted sum of various attributes or evaluation indexes, which is used to comprehensively evaluate the overall performance of each scheme. As shown in the table, Scheme 1 is the most comprehensive and excellent scheme, and it is recommended to give priority to it for implementation. As an alternative, Scheme 3 performs slightly better than Scheme 2, but its performance is much lower than that of Scheme 1. Although Scheme 2 is better than Scheme 4, it has mediocre performance in the overall evaluation. Scheme 4 requires significant improvement or reconsideration because its final comprehensive value is negative. This conclusion is consistent with the previous weight and standard deviation analysis, sub-optimal comprehensive value analysis, and index comprehensive value analysis, providing decision-makers with comprehensive information to make more informed and effective decisions.

Table 5. Final comprehensive value

	Final Comprehensive Value
Scheme 1	0.7841
Scheme 2	0.0584
Scheme 3	0.0669
Scheme 4	–0.2265

6 CONCLUSION

This study discussed bilingual teaching environment creation schemes and their attribute characteristics. After selecting evaluation indexes for the schemes and assigning weights, a more scientific and reasonable evaluation system was established. The specific implementation steps of the multi-attribute teaching decision model were described in detail, providing a comprehensive decision framework.

The calculation results of the standard deviation and attribute weight were provided. In English and French bilingual teaching environments, the ranking values of schemes, along with the changes in standard deviation and weight, were analyzed. This study provides a powerful decision-supporting tool that helps educators and policymakers evaluate different bilingual teaching schemes in multiple attributes and conditions. Among all the schemes considered, Scheme 4 (project-type bilingual environment) is the most recommended because it performs well in multiple key indexes. Scheme 1 requires significant improvement or reconsideration. These conclusions not only provide profound insights into the current bilingual teaching environment but also provide a valuable reference for future research and practice.

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