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Construction of Comprehensive Evaluation Index System of Indoor Environmental Creation of Rural Kindergarten: A Case Study of Rural Kindergarten in Northeast Yunnan Province

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***Abstract*:** According to the available literature, there is no report on the quantitative evaluation system of indoor environmental creation of rural kindergarten. The purpose of this study is to lay the foundation for the comprehensive quality evaluation of the indoor environmental creation of rural kindergarten. Thirty rural kindergartens in northeast Yunnan province were selected as the research material. The comprehensive quality of the rural kindergarten indoor environment was synthetically analyzed by the method of analytic hierarchy process, weighted grey correlation analysis and principal component analysis. The comprehensive evaluation index system of indoor environmental creation in rural kindergarten was established, which included 3 dimensions (indoor basic conditions, environmental support and spatial layout) and 19 indexes. The results shown that the weight coefficient of indoor basic condition index was largest (0.5396). Abundant variations have been observed in the values of these evaluation indexes among the thirty rural kindergartens, and the variation coefficient was from 0% to 101.15%. The results of principal component analysis and weighted grey correlation analysis were consistent, the comprehensive quality of indoor environmental creation in this region from high to low was small class of private kindergarten, middle class of private kindergarten, and big class of private kindergarten. Reading area (C11), role-playing area (C9), the layout of indoor activity areas (C19), language area (C8), and the basics material conditions for indoor activities (C2) were determined as the five representative indicators for the evaluation of the indoor environment creation of rural kindergarten. The evaluation index system for the indoor environment creation of rural kindergarten is scientific, reliable and comprehensive. It can provide reference and direction for improving the existing evaluation content and formulating evaluation standards.

1. Introduction

The kindergarten environment is the sum of the physical and spiritual conditions on which children's physical and mental development depends [1]. Kindergartens should create an environment that supports the physical and mental development of children and give full play to the educational effectiveness of the environment so that learners can educate themselves through interaction with the environment, which will help improve the quality of education [2,3].

The design of kindergarten interior environment in the new century=psychological+safety +personality+aesthetic+flexibility+interaction+education [4]. The environmental design of kindergartens in the future also tends to be thematic, diversified, technological and ecological, but some basic principles for the creation of kindergarten indoor environments will still apply in the long run. First, a dynamic, operable, relaxed and harmonious environment should be created for children, adhering to the principles of comprehensiveness, appropriateness, participation and consistency, combining the actual and developmental needs of young children, and constantly exploring optimization [5]. Second, the creation of kindergarten indoor environment should follow the cognitive development characteristics of young children [6]. Designing the indoor environment of kindergartens in terms of space, materials, colors, lighting and furnishing items, using the scale of children as a benchmark for space design [7]. It also articulates the teaching and research content and updates the context according to the educational objectives [8]. In addition, kindergarten is an important place for children's socialization, and the indoor environment should be created to highlight the theme, meet the needs of interaction, safety, privacy and sense of belonging, and reflect the value of environmental education [9]. Finally, the indoor environment of kindergarten should be created with cultural connotations to create an enlightening environmental space that meets the physical and mental development of children [10]. Future research should pay more attention to the evaluation of kindergarten environment creation with a view to improving teachers' ability to create environments to promote children's development [11].

At present, there is little research on the evaluation system of kindergarten environment creation, and there is not enough research on the quantitative evaluation system of kindergarten environment creation, and the quantitative evaluation system of relevant indicators is to be constructed.

Education is the pillar of the countryside, and the level of rural education is directly related to the future talent pool of our society. The revitalization of China's countryside and the modernization of rural areas cannot be achieved without the development of rural education. Rural revitalization should take the development of rural education as the grasp, and the development of rural preschool education is the focus of preschool education in China [12]. Preschool education in rural areas started late and has a weak foundation, and the uneven development of preschool education in rural areas has been a prominent problem that restricts the reform and development of local preschool education, and the quality of rural kindergartens' teaching and learning (childcare and education) is constrained by the construction of teachers and physical conditions [13]. However, the attention to rural kindergartens has been insufficient for a long time, and no research on the quantitative evaluation system of rural kindergarten environment creation has been reported in the literature.

At the beginning of 2020, Yunnan Province included universal and inclusive preschool education in the "director breakthrough project", trying to make up for the shortcomings and promoting the overall level and popularity of preschool education. With the advantage of this policy, a study on the evaluation of indoor environment creation in rural kindergartens in northeastern Yunnan Province can help improve the quality of preschool education and contribute to the revitalization of rural areas.

AHP analysis is a multi-objective decision analysis method combining qualitative and quantitative analysis proposed by Saaty, which can effectively integrate the evaluation results from different perspectives and effectively compensate for the deficiencies in the single individual evaluation process [14]. The gray correlation analysis method requires less sample size and sample pattern, and is suitable for evaluation studies with few statistical data and data without typical distribution patterns [15]. This analysis meets the need for a method for evaluating the creation of indoor environments in rural kindergartens.

This study aims to construct a scientific and effective evaluation model for the creation of indoor environment in rural kindergartens, to provide a reliable reference for the improvement of the evaluation system for the creation of indoor environment in rural kindergartens, and to promote the scientific and rationalization of the evaluation system for the creation of kindergarten environment. Therefore, based on the goal and orientation of kindergarten indoor environment creation, this study jointly applies AHP analysis and weighted gray correlation analysis to construct a comprehensive evaluation index system of indoor environment creation in rural kindergartens in three dimensions: basic conditions, environmental support, and spatial layout. Based on the constructed evaluation index system, the indoor environment creation of 30 rural kindergartens of different nature in northeast Yunnan was comprehensively evaluated. In addition, in order to promote efficient evaluation of kindergarten environment creation, this study used principal component analysis and cluster analysis to deeply analyze the regional survey results and establish representative indicators for evaluating the quality of indoor environment creation in rural kindergartens.

2. Method

2.1. Establishment of Indicator System and Hierarchy

Based on the "Early Childhood Learning Environment Rating Scale" developed by the Center for Child Development of the University of North Carolina, and with reference to the "Guidelines for the Construction of Safe and Friendly Environment in Kindergartens (Trial)", the "ICA Global Guidelines Rating Scale" and the "Building Design Specifications for Nursery Schools and Kindergartens", we initially constructed an evaluation index system for the creation of indoor environment in kindergartens, which contains 19 indicators in three guideline levels: basic conditions for the creation of indoor environment, environmental support and spatial layout (Table 1) .

An expert questionnaire was designed based on the above-mentioned preliminary evaluation indicators, and a Delphi method was used to anonymously send the questionnaire to 10 experts in the field of preschool education for their opinions. The experts scored the questions on a five-point Likert scale (very unimportant = 1, less important = 2, moderately important = 3, more important = 4, very important = 5). The mean, standard deviation, and coefficient of variation of each indicator were calculated. If the average importance of the indicator is greater than 3 and the coefficient of variation of the indicator is less than 0.25, the indicator is well coordinated and the indicator is retained [16] . Based on the analyzed data and synthesizing the opinions of the expert group, the specific influencing factors indicators in the analyzed model were revised to finalize the evaluation model of kindergarten indoor environment creation. Coefficient of variation calculation formula:

$$V_j = \frac{S_j}{M_j} \tag{1}$$

V_j: Coefficient of variation; Sj: Standard deviation; Mj: Arithmetic mean.

Table 1: A preliminary evaluation system for the creation of indoor environment in rural kindergartens

Target layer	Guideline layer	Indicator layer
Evaluation of kindergarten indoor environment creation (A)	Basic conditions for the creation of indoor environment (B1)	Supporting tools for the development of activities (C1)
		Basic facilities for activities (C2)
		Reasonably defined activity time (C3)
		Environment friendly (C4)
		Environmental health (C5)
		Environmental safety (C6)
	Indoor environment creation environmental support (B2)	Indoor wall environment (C7)
		Language area (C8)
		Role area (C9)
		Scientific area (C10)
		Reading area (C11)
		Construction area (C12)
		Performance area (C13)
		Artwork area (C14)
		Puzzle area (C15)
		Raising area (C16)
	Indoor environment creation space layout (B3)	Activity facilities and equipment and materials layout (C17)
		Indoor wall layout (C18)
		Indoor activity area layout (C19)

2.2. Determination of Evaluation Index Weights and Consistency Test

Based on the revised and determined evaluation model, an AHP questionnaire was designed and a panel of experts was asked to compare and score the criterion-level indicators and construct a judgment matrix. The questionnaire was assigned using the 1-7 scale method. The scoring status was combined to obtain a two-by-two discriminant matrix, and then MATLAB software was used to calculate the maximum eigenroots and eigenvectors of the judgment matrix and to test the consistency. The consistency test formula is as follows:

Consistency ratio indicator (CR) calculation formula:

$$CR=\frac{CI}{RI} \tag{2}$$

Consistency index (CI) calculation formula:

$$CI=\frac{\lambda_{max}-n}{n-1} \tag{3}$$

λ_{max}: maximum characteristic root; n: order. CI: consistency index; RI: random consistency index.

If the consistency ratio indicator (CR) is less than 0.1, the judgment matrix is correct and passes the test; if the CR is greater than 0.1 or negative, the judgment matrix needs to be readjusted. Finally, the weight coefficients of individual index layer to the criterion layer are calculated.

2.3. An Evaluation Trial of Indoor Environment Creation in Rural Kindergartens in Northeast Yunnan

Ten kindergarten teachers in northeast Yunnan were invited to conduct a trial of mutual evaluation of kindergarten indoor environment creation. Based on the evaluation system constructed, we evaluated the environment creation of large, medium and small classes in 30 public and 32 private kindergartens in County Z of northeast Yunnan, and one class in each school was randomly selected for the survey. One of the measures for the subjective evaluation items was a 7 point likert scale (1=a very bad thing, 4=neither good nor bad, 7=a very good thing). The questionnaire was analyzed for reliability using SPSS 19.0.

2.4. A Comprehensive Evaluation of Indoor Environment Creation in Rural Kindergartens in Northeast Yunnan Based on Grey Correlation Theory

According to the gray correlation decision theory, the correlation between the vector of indicators and the vector of relatively optimal indicators is used as a criterion for evaluating the merits of kindergarten indoor environment creation, avoiding subjective arbitrariness.

The reference series (evaluation criteria) is noted as: $x_j^0=\{x_j^0(1), x_j^0(2),...,x_j^0(n)\}$, the comparison sequence (evaluation object) is noted as: $x_i^0=\{x_i^0(1),x_i^0(2),...,x_i^0(n)\}$, the evaluation matrix is dimensionless by applying the polarization method to obtain the matrix to ensure that the scores of all columns lie in the interval [0,1].

The correlation coefficient can be found by the following equation:

$$\xi_i(k)=\frac{\min_i \min_k \Delta_i(k)+\max_i \max_k \Delta_i(k)}{\Delta_i(k)+\rho \max_i \max_k \Delta_i(k)} \tag{4}$$

Where: ρ is the discrimination coefficient, if ρ is smaller, the greater the difference between the correlation coefficients, the stronger the discrimination ability, this paper takes ρ=0.5; k=1, 2, …, n; i=1, 2, …, n; $\xi_i(k)$ is the correlation coefficient between the kth index and the kth relatively optimal index in the ith evaluation object. If the correlation coefficient of $\xi_i(k)$ is larger, it means that the kth indicator is closer to the kth relative best indicator and is the better data column in a series of comparison data.

Combined with the weight coefficients of each index determined by hierarchical analysis, the gray weighted correlation degree of each index was calculated. The greater the gray weighted correlation, the better the overall quality of kindergarten environment creation, which can be used to evaluate the quality of kindergarten indoor environment creation.

The gray weighted correlation is calculated by the formula:

$$\gamma_i=\sum_{k=1}^{n} W_k\, \xi(k) \tag{5}$$

Where: γ_i notes the gray weighted correlation of the ith evaluation object to the relatively optimal object, W_k notes the index weight coefficient, k=1, 2, ..., n; i=1, 2, ..., n.

2.5. Principal Component Analysis and Cluster Analysis

Principal component analysis was performed using SPSS 19.0 software. Firstly, the original data of 19 indicators of environmental creation items evaluated in large and small classes of 30 public and 32 private kindergartens were standardized, and the eigenvalues, contribution rates, cumulative contribution rates and eigenvectors were calculated to extract the principal components with eigenvalues greater than 1. Secondly, the model formula derived from the eigenvalues was used to calculate the principal component scores of each index; finally, the variance contribution ratio was used as the weight to derive the formula of the comprehensive evaluation model of kindergarten environment creation. Based on SPSS software, data clustering analysis was performed using Ward's minimum variance method.

3. Results

3.1. Indicator Layer Weights

The consistency ratio of the target layer to the criterion layer is 0.0088, and the indicator layer is located under the three criterion layers of basic conditions of indoor environment creation, environmental support and spatial layout, and the consistency ratio of the judgment matrix is all less than 0.1, and the weight coefficients of hierarchical analysis are reasonably assigned with good consistency. The derived synthetic weights for each indicator layer factor are shown in Table 2.

Table 2: The weight of assessment indexes

Target layer	Guideline layer	Weights	Indicator layer	Synthetic weights
Evaluation of kindergarten indoor environment creation (A)	Basic conditions for the creation of indoor environment (B1)	0.5396	Supporting tools for the development of activities (C1)	0.1287
			Basic facilities for activities (C2)	0.0602
			Reasonably defined activity time (C3)	0.0602
			Environment friendly (C4)	0.1072
			Environmental health (C5)	0.0631
			Environmental safety (C6)	0.1203
	Indoor environment creation environmental support (B2)	0.297	Indoor wall environment (C7)	0.0268
			Language area (C8)	0.05
			Role area (C9)	0.025
			Scientific area (C10)	0.0268
			Reading area (C11)	0.025
			Construction area (C12)	0.0435
			Performance area (C13)	0.025
			Artwork area (C14)	0.025
			Puzzle area (C15)	0.025
			Raising area (C16)	0.025
	Indoor environment creation space layout (B3)	0.1634	Activity facilities and equipment and materials layout (C17)	0.0409
			Indoor wall layout (C18)	0.0817
			Indoor activity area layout (C19)	0.0409

3.2. Results of the Evaluation Scale of Indoor Environment Creation in Rural Kindergartens in County Z, Northeast Yunnan

A total of 186 scoring scales were recovered from the test. The reliability analysis of the questionnaire showed that the reliability met the requirements, and the structural validity of the questionnaire was also good (Table 3).

Table 3: Questionnaire reliability and validity analysis

Kindergarten Characteristics	Number of samples	Number of projects	Standardization cronbach’s α coefficient	KMO value	Bartlett test results
Public Kindergartens	90	19	0.9365	0.712	P=0.01
Private kindergartens	96	19	0.9107	0.656	P=0.026

3.3. Coefficient of Variation of the Observed Values of Indoor Environment Creation Evaluation Indicators and Correlation Coefficient Between Indicators

The coefficient of variation is used as a statistical measure of the degree of variation and the range of variation of each observation in the index. The larger the coefficient of variation, the greater the variation among the observations of the evaluation index, and the relatively greater the potential for improvement of the quality index. Nineteen indicators of indoor environment creation were analyzed in large class, middle class, small class of 30 public and 32 private rural kindergartens, and the results and coefficients of variation of the 19 evaluation indicators were measured as shown in Figure 1. The coefficient of variation of the observed values of each indicator ranged from 0-101.15%, and there were significant differences in the coefficients of variation of the observed values of each indicator, and improving the quality of environmental creation in rural kindergartens is still an issue that needs to be focused on in the future. The average coefficient of variation of the observed values of each indicator for public kindergartens is 30.29%, and the average coefficient of variation of the observed values of each indicator for private kindergartens is 26.13%. The coefficient of variation of the observations of each indicator for large, medium, and small kindergarten classes of the same nature of operation varied widely, with the average coefficient of variation of 27.17% for private large classes, 23.49% for private middle classes, and 27.73% for private small classes, while the average coefficient of variation of 25.95% for public large classes, 33.27% for public medium classes, and 31.64% for public small classes. The average coefficient of variation was 31.64%. According to the order of the coefficient of variation of the observed values of indoor environment creation indicators in public kindergartens, the top six indicators were: large class C2 (95.32%), small class C2 (90.71%), middle class C2 (88.61%), small class C4 (77.14%), middle class C19 (65.27%), and small class C8 (61.72%). In order of the magnitude of the coefficient of variation of the observed values of the evaluation indicators of indoor environment creation in kindergartens of private nature, the top six indicators in order are: small class C2 (101.15%), large class C2 (90.28%), middle class C2 (86.86%), large class C12 (56.29%), middle class C12 (56.28%), and large class C12 (56.24%). The coefficients of variation of the observed values of the indicators of the aesthetic area (C14) in both large middle and small classes of rural kindergartens with different schooling properties were zero. Compared to private kindergartens, the coefficient of variation of the observed values of environmental safety (C6) indicators in public kindergartens is smaller, with all values being 0. The values are more stable among large and small classes in public kindergartens. In addition, there were significant differences in the quality of indoor environment creation among the eight public kindergartens for the small class environment friendly indicator (C4), the middle class indoor activity area layout indicator (C19), and the small class language area indicator (C8).

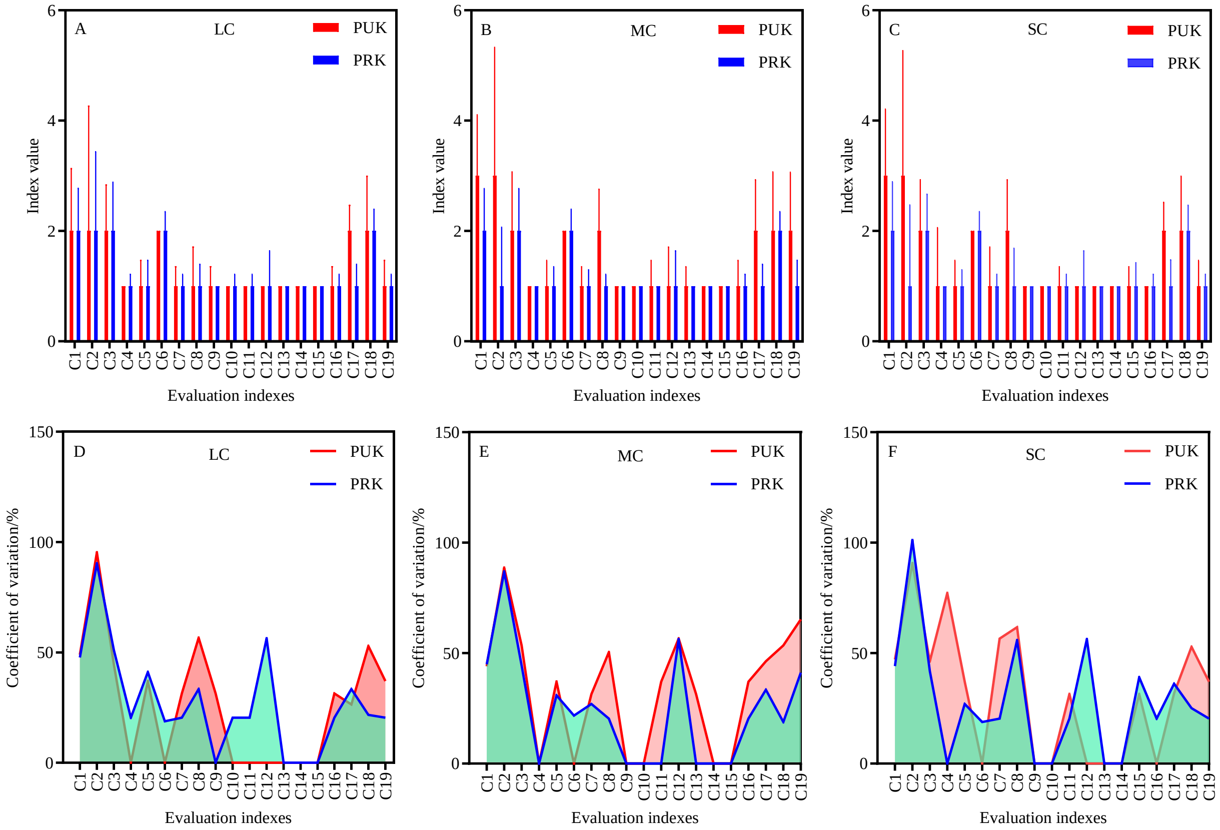

Figure 1: Observed values of each indicator of indoor environment creation evaluation (A, B, C) and their coefficients of variation (D, E, F). The positive deviation error lines in Figure A, Figure B and Figure C indicate the standard deviation, and the indicator codes are detailed in Table 1. LC: large class; MC: middle class; SC: small class; PUK: public kindergarten; PRK: private kindergarten

In order to explore the correlation among the evaluation indicators, 19 evaluation indicators were subjected to correlation analysis, and the results are shown in Figure 2. There are highly significant positive correlations between C2 and C3, C5, C8, C11 and C19 ($R>0.5$; $P<0.01$); while there are highly significant positive correlations between C4 and C10 ($R=0.695$; $P<0.01$); C5 has highly significant positive correlations with C8, C12 and C19 ($R>0.5$; $P<0.01$); C8 has highly significant positive correlations with C11 and There was a highly significant positive correlation between C8 and C11 and C19 ($R>0.5$; $P<0.01$); a highly significant positive correlation between C11 and C12 and C19 ($R>0.5$; $P<0.01$), and a highly significant positive correlation between C12 and C19; and a highly significant positive correlation between C14 and C15 ($R=0.711$; $P<0.01$).

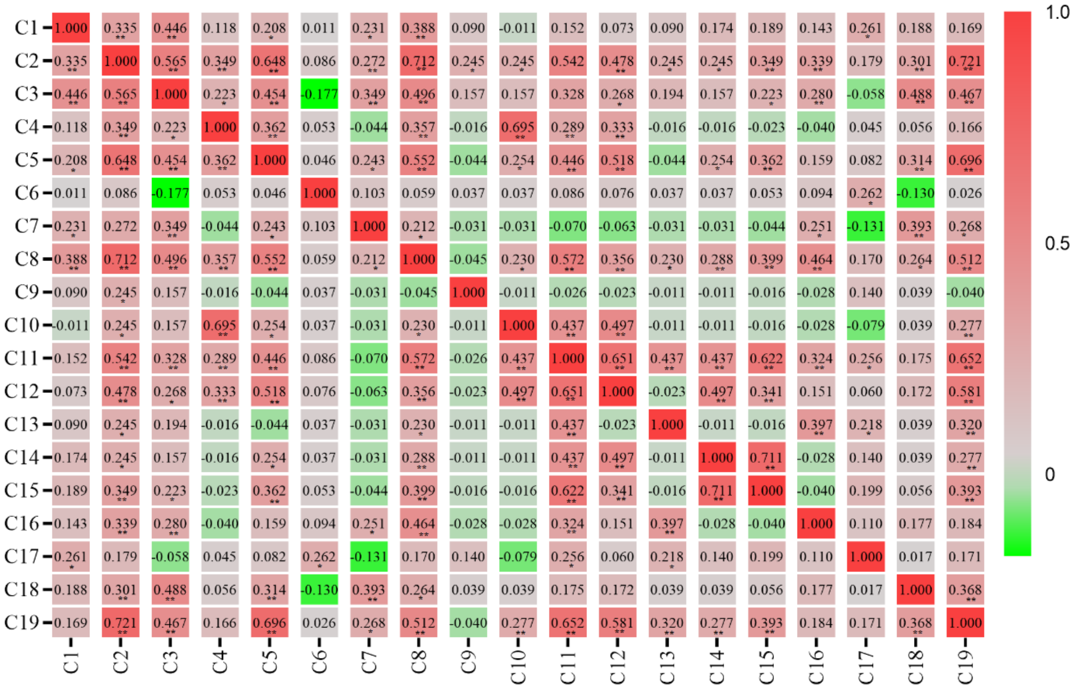

Figure 2: Correlation coefficient matrix among evaluation indicators. Asterisks denote significant differences (*P < 0.05; **P < 0.01), and the correlation coefficient are detailed in Table 1

3.4. AHP-Grey Correlation Analysis Method to Comprehensively Evaluate the Quality of Indoor Environment Creation in Kindergartens

Data from the evaluation scale of indoor environment creation in 30 public and 32 private kindergartens in rural kindergartens in northeast Yunnan were counted and used as a comparison series. Because the selected indicators are all positive indicators, the best value of each indicator is selected to construct the reference species as the reference series, and the normalized indicator values are obtained by dimensionless processing of the series. The gray correlation coefficients between the evaluation data of each indicator and the reference series for the creation of indoor environment in rural kindergartens were calculated (Figure 3). The gray correlation coefficients of each evaluation index of indoor environment creation in different kindergarten classes were analyzed. Within the guideline tier of basic conditions for indoor environment creation, the mean value of the correlation coefficient of the large class in the private kindergarten was significantly higher than that of the large class in the public kindergarten in the evaluation of environmental friendliness; there was no significant difference between the mean values of the correlation coefficients of the remaining evaluation indicators.

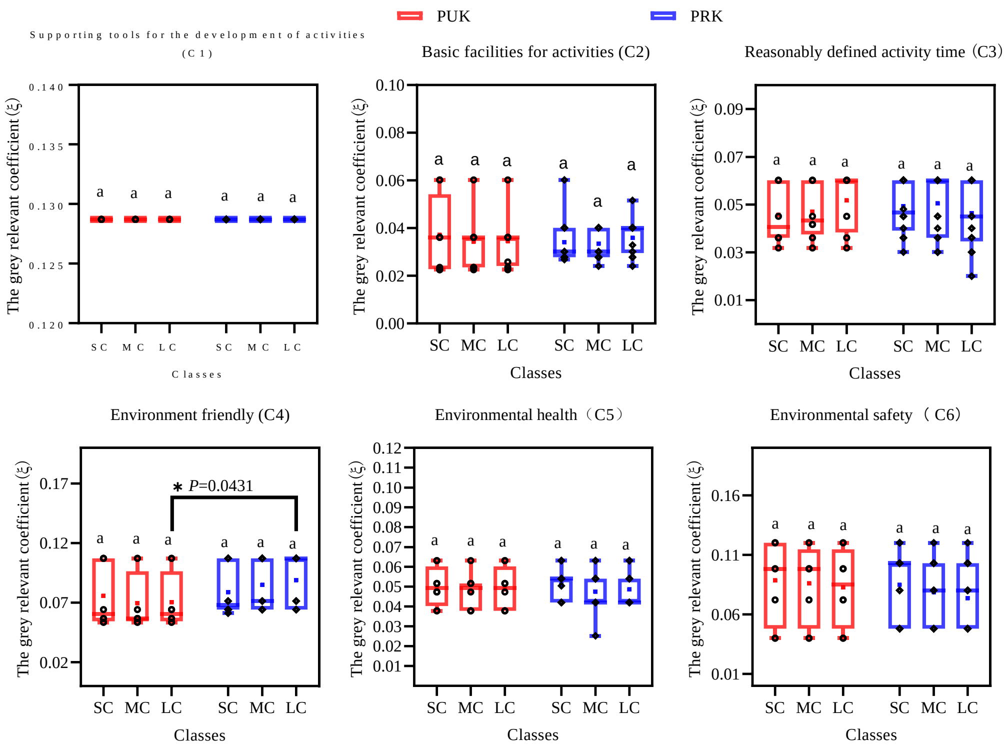

Figure 3: Gray correlation coefficients of six evaluation indicators in the basic conditions of indoor environment creation guidelines layer. The lowercase letters above the box denote the significance of the comparison of different classes in kindergartens of the same nature, the same lowercase letter means the difference is not significant, different lowercase letters means the difference is significant (Tukey test, $P < 0.05$); the asterisk above the box represents the significance of the comparison of the same classes in different kindergartens, Asterisks denotes the significant difference (Student's t test, $P < 0.05$), here only the significant difference is marked. LC: large class; MC: middle class; SC: small class; PUK: public kindergarten; PRK: private kindergarten

At the level of environmental support criteria for the creation of indoor environments, the mean values of correlations for each class in private kindergartens were significantly higher than those in public kindergartens in the evaluation of indoor wall environments; the mean values of correlations for each class in private kindergartens were significantly higher than those in public kindergartens in the evaluation of constructed areas; there was no significant difference between the mean values of correlations for the remaining evaluation indicators (Figure 4).

There was no significant difference between the mean values of the correlation coefficients of the classes in the private kindergartens and the corresponding mean values of the correlation coefficients in the public kindergartens at the spatial layout guideline level of indoor environment creation (Figure 5).

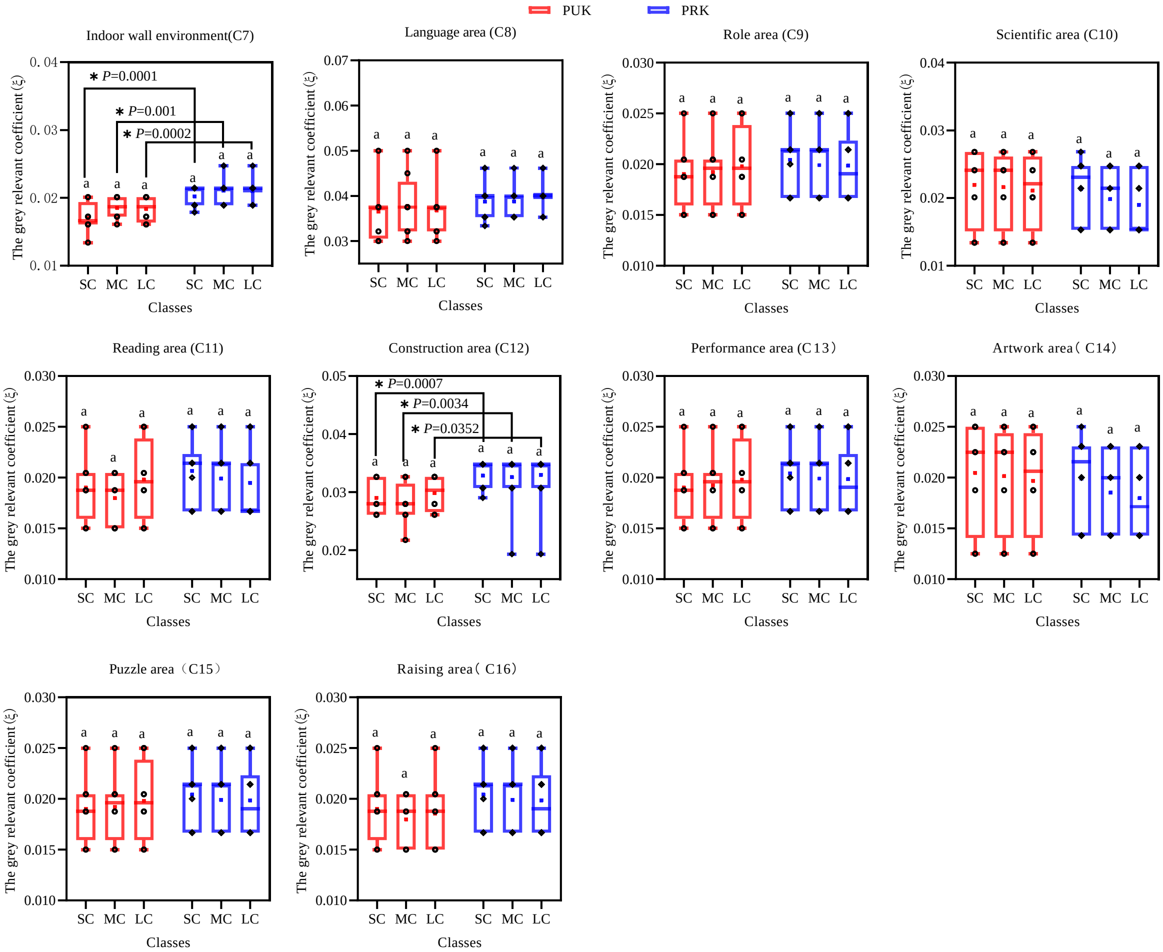

Figure 4: Gray correlation coefficients of 10 evaluation indicators in the environmental support criteria layer of indoor environment creation. The box diagram is marked with the same content as Figure 3

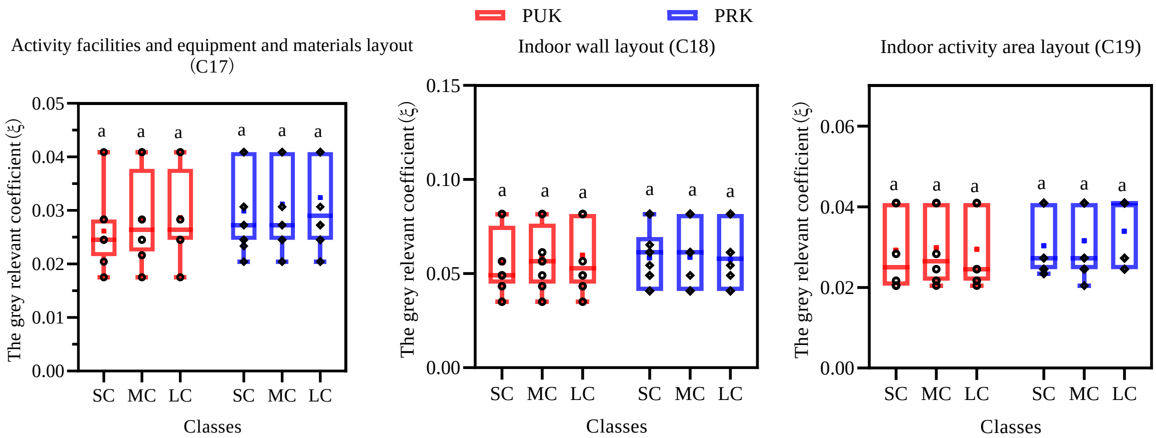

Figure 5: Gray correlation coefficients of 3 evaluation indicators of the spatial layout guideline layer of indoor environment creation. The box diagram is marked with the same content as Figure 3

Combined with the group decision weights Wi obtained from AHP, the gray correlations of indoor environment creation in large and small kindergarten classes with different schooling properties were calculated (Figure 6, Table 5). The larger the correlation degree, the closer the object is to the relative optimal index. The results of the gray correlation analysis (Figure 6) showed that the highest weighted mean value of the gray correlation of the indoor environment creation of the small, medium, and large kindergarten classes in rural kindergartens was the private small class (0.7814), representing the optimal level of indoor environment creation in the kindergartens there, followed by the private medium class, private large class, and public large class, whose weighted mean values of the correlation were 0.7761, 0.7759, and 0.7584, respectively (Table 5). The weighted mean values of the correlations were 0.7761, 0.7759, and 0.7584, respectively (Table 5), but the differences between the weighted mean values of the gray correlations of the indoor environment creation in large, medium, and small classes of kindergartens with different nature were not significant (Figure 6).

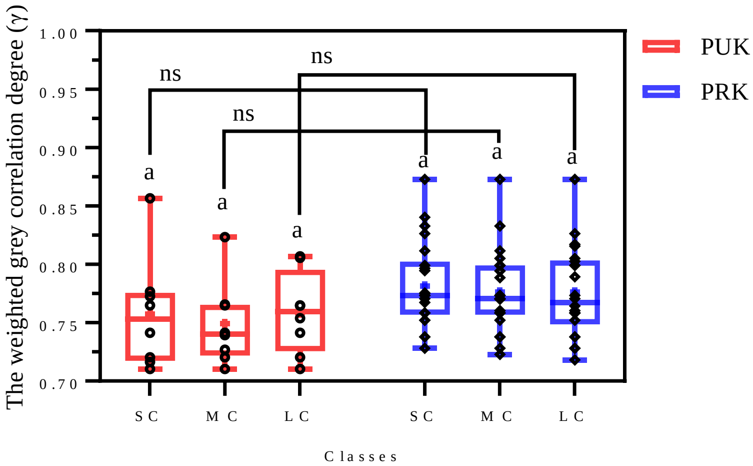

Figure 6: Gray correlation of indoor environment creation in kindergartens of different school properties for small, medium and large classes. The ns indicates that the difference is not significant, and the rest of the box plots are labeled as in Figure 3

3.5. A Comprehensive Evaluation of the Quality of Indoor Environment Creation in Kindergartens by Principal Component Analysis and Cluster Analysis

To verify the evaluation results of the weighted gray correlation method, the quality of indoor environment creation in rural kindergartens was evaluated comprehensively using principal component analysis. The KOM test and Bartlett's spherical test were conducted after standardizing the data for the 19 evaluation indicators, and the KOM value = 0.534 > 0.5 and the Bartlett's spherical test P = 0, indicating that there is a correlation between the indicators and it is suitable for principal component analysis. The principle of extracting the number of principal components is based on the principle that the eigenvalue is greater than 1. 7 principal components were extracted, and the cumulative contribution of these 7 principal components reached 77.815%, indicating that the extracted 7 principal components represent most of the information of the evaluation indexes of indoor environment creation of different kindergarten classes (Table 4). We can select the relatively independent 7 principal components as the comprehensive evaluation indexes of indoor environment creation of kindergarten classes, and achieve the purpose of dimensionality reduction.

The loading matrix of principal components reflects the magnitude and direction of the role of each evaluation indicator on the loadings of principal components, and the loadings of each indicator variable in different principal components in this study are detailed in Table 4, and the selection criteria of indicator loading values with absolute values greater than 0.5 are developed based on data characteristics. As can be seen from Table 4, principal component 1 mainly explains the information of C2 (0.859), C8 (0.824), C11 (0.804) and C19 (0.761), and its indicators can be used as representative evaluation indicators in the first principal component. The two indicators C14 (-0.641) and C15 (-0.621) in principal component 2 have large negative coefficient values. The indicators with higher loadings in principal component 3 are C17 (0.658), C13 (0.662), and C7 (-0.513). Principal component 4 mainly reflects the information of C10 (0.755).C4 has a positive and large loading value on principal component 5 with a loading value of 0.567.Principal component 6 mainly reflects the information of C6 (0.804). And the indicator with a higher loading on principal component 7 is C9 with a loading value of 0.804.

Table 4: Principal component loading matrix of indicators

Evaluation Indicators	Principal Components						
	1	2	3	4	5	6	7
C1	0.419	0.156	-0.101	-0.346	0.469	-0.074	-0.199
C2	0.859	0.113	-0.061	0.102	0.238	-0.046	0.129
C3	0.674	0.337	-0.253	-0.091	0.069	-0.293	-0.025
C4	0.286	-0.027	-0.241	0.418	0.567	0.084	-0.358
C5	0.677	0.001	-0.384	0.088	0.009	0.155	-0.066
C6	0.109	0.003	0.217	0.045	0.231	0.804	0.388
C7	0.210	0.476	-0.513	-0.309	-0.188	0.282	0.139
C8	0.824	-0.130	-0.083	-0.165	0.214	0.079	-0.235
C9	0.059	0.110	0.026	-0.062	0.456	-0.415	0.740
C10	0.325	-0.181	-0.197	0.755	-0.048	-0.025	0.114
C11	0.804	-0.167	0.279	0.189	-0.223	-0.036	0.026
C12	0.661	-0.426	-0.108	0.304	-0.242	-0.002	0.194
C13	0.371	0.464	0.662	0.090	-0.150	-0.146	-0.130
C14	0.523	-0.641	0.078	-0.429	-0.093	-0.005	0.033
C15	0.595	-0.621	0.097	-0.428	-0.069	-0.006	0.010
C16	0.390	0.481	0.180	-0.033	-0.158	0.182	-0.071
C17	0.370	0.199	0.658	-0.078	0.280	0.105	0.000
C18	0.382	0.406	-0.438	-0.176	-0.296	-0.002	0.134
C19	0.761	0.274	0.217	0.126	-0.306	-0.078	0.039
Eigenvalue	5.615	2.171	1.888	1.577	1.376	1.103	1.055
Contribution rate /%	29.555	11.424	9.935	8.298	7.242	5.807	5.554
Cumulative contribution rate /%	29.555	40.979	50.914	59.212	66.454	72.261	77.815

According to the eigenvector is the square root of the initial factor loading moment divided by the eigenvalue, the eigenvector corresponding to each indicator is derived, and the expression of the function of 7 principal components with 19 evaluation indicators can be obtained as follows.

The first principal component:

F1=0.177C1+0.363C2+0.284C3+0.121C4+0.286C5+0.046C6+0.089C7+0.348C8+0.025C9+0.137C10+0.339C11+0.279C12+0.157C13+0.221C14+0.251C154+0.165C16+0.156C17+0.161C18+0.321C19

The second principal component:

F2=0.106C1+0.077C2+0.229C3-0.018C4+0.001C5+0.002C6+0.323C7-0.088C8+0.075C9- -0.123C10-0.113C11 -0.289C12+0.315C13-0.435C14-0.421C15+0.326C16+0.135C17+0.276C18+0.186C19

The third principal component:

F3=-0.074C1-0.044C2-0.184C3-0.175C4-0.279C5+0.158C6-0.373C7-0.060C8+0.019C9 -0.143C10+0.203C11-0.079C12+0.482C13+0.057C14+0.071C15+0.131C16+0.479C17-0.319C18+0.158C19

The fourth principal component:

F4=-0.276C1+0.081C2-0.072C3+0.333C4+0.070C5+0.036C6-0.246C7-0.131C8-0.049C9 +0.601C10+0.151C11+0.242C12+0.072C13-0.342C14-0.341C15-0.026C16-0.062C17-0.140C18+0.100C19

The fifthth principal componen:

F5=0.400C1+0.203C2+0.059C3+0.483C4+0.008C5+0.197C6-0.160C7+0.182C8+0.389C9 -0.041C10-0.190C11-0.206C12-0.128C13-0.079C14-0.059C15-0.135C16+0.239C17-0.252C18-0.261C19

The sixth principal component:

F6=-0.063C1-0.039C2-0.250C3+0.072C4+0.132C5+0.685C6+0.240C7+0.067C8-0.354C9-0.021C10-0.031C11-0.002C12-0.124C13-0.004C14-0.005C15+0.155C16+0.090C17-0.002C18-0.066C19

The seventh principal component:

F7=-0.194C1+0.126C2-0.024C3-0.349C4-0.064C5+0.378C6+0.135C7-0.229C8+0.720C9 +0.111C10+0.025C11+0.189C12-0.127C13+0.032C14+0.010C15-0.069C16+0.000C17+0.130C18+0.038C19

Finally, the comprehensive score value is calculated, the weighted average of the seven principal components is calculated by taking the corresponding variance contribution rate of the seven principal components as the weights, and the comprehensive score model of the components can be constructed: according to the proportional weight of the eigenvalues of each principal component to the total eigenvalues of the extracted principal components, the comprehensive evaluation model of the indoor environment creation of kindergartens of different nature is thus constructed, and the formula of the comprehensive evaluation model.

F=(0.296F1+0.114F2+0.099F3+0.083F4+0.072 F5+0.058 F6+0.056F7)/0.7782, where F is the sample composite score.

According to the comprehensive evaluation model, the comprehensive principal component values of indoor environment creation in all kindergartens can be calculated and ranked according to the comprehensive principal component values, and the results are shown in Table 5. From the above analysis results, it can be seen that the calculation results of the weighted gray correlation method and the principal component analysis method are consistent, which indicates the authenticity of the results, and the joint use of the two methods can make a quantitative, comprehensive and accurate comprehensive evaluation of the quality of indoor environment creation in kindergarten classes of different school properties. The above results also indicate that the evaluation system established in this study is feasible and scientific.

Based on the different performance of 19 evaluation indicators in large, medium and small classes of kindergartens with different schooling nature, a cluster analysis was conducted to simplify the evaluation indicators of indoor environment creation in rural kindergartens by combining the results of principal component analysis, with the aim of screening out representative indicators for quick evaluation and increasing the feasibility and validity of practical operation. The results of the clustering analysis are shown in Figure 7. As can be seen from Figure 7, the 19 indicators are divided into four clusters. Based on the results of correlation coefficients and principal component analysis, the original variable information was retained as much as possible and the indicators with higher correlation were combined, and the 19 indicators were finally simplified to 5. These 5 indicators were: reading area (C11, taxon I), role area (C9, taxon I), layout of indoor activity area (C19, taxon II), language area (C8, taxon III), and basic facilities for activity development (C2, taxon IV). As shown in Figures 3, 4, and 5, the gray correlation coefficients of the above five indicators are also larger in the private small classes, and the quality of environmental creation is closest to the optimal state in the region. These five indicators can be used as representative indicators for the evaluation of indoor environment creation in rural kindergartens.

Table 5: Comprehensive quality, weighted correlation degree and ranking

Kindergarten Classes	Principal component analysis method		Weighted grey correlation analysis	
	Composite principal component value F	ranking	Weighted correlation	ranking
Large classes (Public kindergartens)	2.190	4	0.758	4
Middle class (Public kindergartens)	2.181	5	0.749	6
Small Classes (Public kindergartens)	2.113	6	0.757	5
Large Classes (Private kindergartens)	2.577	3	0.776	3
Middle Classes (Private kindergartens)	2.625	2	0.7761	2
Small Classes (Private kindergartens)	2.816	1	0.7814	1

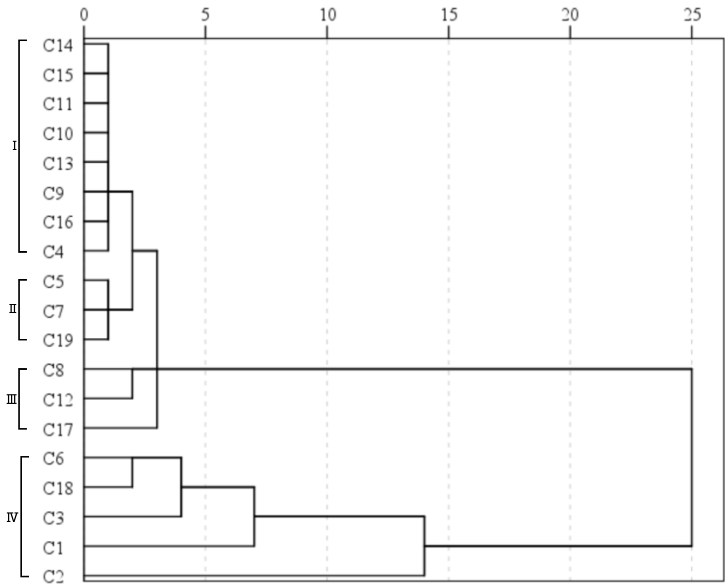

Figure 7: The cluster analysis of 19 evaluation indicators. The indicator codes are detailed in Table 1

4. Discussion

4.1. Evaluation Index System Weight Allocation

The environment is an important educational resource in the cognitive, social and emotional development of young children. Providing a healthy, safe, harmonious and caring environment for young children to grow up in can promote their all-round development [17, 18]. In addition, children's activities and learning require specific material materials that enable activities to proceed smoothly, meet children's learning needs, and promote their development [19]. The basic conditions for the creation of the indoor environment cover auxiliary tools for activities, basic facilities, environmental health, safety and friendliness, and other indicators are the material materials necessary for kindergartens to carry out the corresponding activities, and are the basic materials that children must rely on for learning and development. Therefore, the largest weight coefficient in this study was 0.5396 for the basic condition criterion layer of indoor environment creation (Table 2), while the three indicators with the greatest weight within the basic condition criterion layer of indoor environment creation were auxiliary tools for activity development (weight coefficient: 0.1287), environmental safety (weight coefficient: 0.1203), and environmental friendliness (weight coefficient: 0.1072).

The environmental support weight of indoor environment creation was 0.2970 and the spatial layout weight was 0.1634, and the weight of these two indicator layers was relatively low. The creation of environmental support and spatial layout needs to be adapted to the local conditions of the kindergarten, combined with the actual situation of the kindergarten and the design of the curriculum, to create a kindergarten indoor environment in line with the specific kindergarten, environmental support and spatial layout with a high degree of flexibility [20]. Therefore, compared to the basic conditions for the creation of indoor environments, the weights assigned to environmental support and spatial layout are low. A reasonable distribution of weights for each criterion level in the process of environment creation by ECE practitioners will help give full play to the nurturing value of the environment.

4.2. Variation of the Observed Values of Each Index and Correlation Coefficient Analysis

The basic facilities for activities are the most basic material conditions required for kindergarten educational activities, and the main time of children's daily life is in the activity room. The basic facilities (C2) for activities in rural kindergartens of different nature vary greatly, which reflects the objective reality of insufficient investment in basic facilities and equipment and uneven allocation of resources, and the overall potential for improving the basic facilities and equipment of the indoor environment of rural kindergartens. The coefficient of variation of the observed values of the indicators of the art area (C14) in the large, medium and small classes of rural kindergartens with different schooling nature was 0. The quality of the environment creation in the art area was consistent, and the environment creation was homogeneous, ignoring the individual needs of teachers' teaching and children's activities.

The quality of indoor environment creation varies widely among public kindergartens for the small class environment-friendly indicator (C4), the middle class indoor activity area layout indicator (C19), and the small class language area indicator (C8). The value orientation of kindergarten determines the direction of kindergarten operation [21], hence there are inevitable differences in the quality of indoor environment creation; secondly, when creating indoor environments between different schools, there are large differences in the indicators of environment friendliness for small and medium-sized children stages, and the schools take into account the physical and mental development characteristics of small and medium-sized children at this age, and provide some soft facilities and soft toys for children to promote their emotional and emotional better development, especially for small children, certain soft facilities and friendly equipment can make them integrate into kindergarten faster and relieve anxiety in school. However, some of them also ignore the creation of indoor friendly environment, which may be caused by the lack of attention to the philosophy of running the garden and education. As the main place to provide children with reading materials and create a good reading atmosphere, the language area should have paid much attention to the development of children's early reading habits and abilities. The teachers' uneven educational concepts in creating this environment led to large differences in the quality of the layout of the language area in the small classes; the same is true for the layout of the indoor activity area in the middle classes. In addition, there is a large variation in the quality of the built-up area (C12) in private kindergartens, which is due to a large variation in the physical support and provision.

The analysis of the correlation among the evaluation indicators shows that indicator C2 has a highly significant positive correlation with C3, C5, C8, C11 and C19, and the reasonable arrangement of children's daily life is necessary for the orderly implementation of kindergarten activities, while the basic facilities for activities (C2), as a fundamental element that must be provided for the creation of indoor environment, has a significant positive correlation with the reasonably specified activity time (C3). The more abundant and sufficient basic facilities for activities provided in the creation of kindergarten indoor environment, the more conducive to the reasonable arrangement of kindergarten's daily life, thus significantly improving the quality of kindergarten education [22]; Basic facilities (C2) and environmental hygiene (C5) were also significantly and positively correlated, pointing to the establishment of a clear hygiene and health care system, regular and effective disinfection measures, and the development of strict hygiene and behavioral habits for children in childcare [23]. There is also a significant positive correlation between the basic facilities (C2) and the language area (C8), the reading area (C11), and the layout of the indoor activity area (C19), which indicates that the division and layout of the two dimensions of environmental support and spatial layout are closely related to each other under the premise that the basic conditions are provided to meet the standards, and the richer the facilities and equipment provided in the basic conditions, the more appropriate and reasonable the layout planning and creation of the indoor activity area is, the more effectively it can support children's learning and development [24], thus improving the quality of the environment for human development. The two dimensions of environmental support and spatial layout of the indoor environment were correlated with each other. The language materials available to children, the hierarchy of materials, the richness and attractiveness of the reading materials in the language area, and the frequency of updating were all positively correlated with the persistence of children's interest in reading, and the layout of the two areas should be adjacent to each other and away from noisy areas, thus there was also a highly significant positive correlation between the language area (C8) and the reading area (C11) and the layout of the indoor activity area (C19). The environmental friendliness of the kindergarten indoor environment is beneficial to the transition and extension of the environmental nurturing value of the science zone area, and is more conducive to children's bold exploration and creativity in the science zone, so the correlation analysis found a highly significant positive correlation between environmental friendliness (C4) and science zone (C10). There was a highly significant positive relationship between environmental hygiene (C5) and language area (C8), constructive area (C12) and indoor activity area layout (C19), which indicates that it is necessary to continuously follow up the sanitation and disinfection system and continuously improve the teachers' ability and effectiveness in performing their duties of care when creating the indoor environment in kindergartens, and the quality and level of performance of these functions will directly affect the quality of the language area and constructive area environment creation [25], which in turn will affect the rationality and scientificity of the activity area layout. The correlation between the reading area (C11), the construction area (C12) and the layout of the indoor activity area (C19) is highly significant, and there is also a highly significant positive correlation between C12 and C19. The reading area and the construction area are almost the regular themes of the kindergarten indoor environment, the correlation between the three suggests that adequate indoor space and space is a sufficient condition for the effective planning and utilization of the construction area, while the reading materials provided to children can be used as a preparation for children's experience in building blocks and construction games in the construction area. There is also a highly significant positive correlation between the art area (C14) and the puzzle area (C15), with the low structure and plasticity of the art area giving children the opportunity and possibility to fully express themselves, the artwork area gives children the space for free play and imagination, and the puzzle area allows children to develop hands-on skills, imagination, creativity and collaborative skills through active exploration and experimentation [26], the quality of the two environments is interrelated, and they both contribute to children's cognition and development, fully revealing the potential value of the environment as a curriculum resource.

4.3. Evaluation of Basic Conditions for the Creation of Indoor Environment in Kindergartens

Evaluation of the basic conditions for the creation of indoor environments in rural kindergartens. Environmentally friendly is mainly reflected in the availability of soft facilities for children and clean soft toys for children to take and play with. In the field study, the gray correlation coefficients of environmental friendliness indicators in the basic conditions of private kindergartens were higher than those of public kindergartens, and the weighted correlation coefficients of environmental friendliness indicators in private kindergarten large classes were significantly higher than those of public kindergartens, and private kindergartens were more environmentally friendly than public kindergartens. The private kindergartens in the region create their environments more from the perspective of children's emotional needs being met.

The evaluation of other indicators within the guideline layer of basic conditions of indoor environment creation revealed no significant differences in the gray correlation coefficients of each indicator between public and private kindergartens. The region's current rural kindergarten environment creation, the basic conditions of the creation of the environment is relatively similar, lacking a certain degree of variability, flexibility and innovation. In terms of schedule structure, television or computer, activity apparatus and materials, sanitation, tables and chairs, and safety, the environment of rural kindergartens in this region was only created to meet the basic needs for the implementation of daily life activities. In the future, kindergartens need to pay attention to the creation of basic conditions: (1) to create activities and materials that meet the needs of children's age according to local conditions, and to provide ergonomic tables and chairs for children; (2) to reasonably arrange the schedule structure of children's daily life according to the physiological characteristics of children of different ages; (3) to provide a friendly and safe indoor secluded space, taking into account the needs of children's emotional relaxation; (4) to provide TV or computer equipment that can be easily operated to meet the basic teaching and learning conditions of teachers and children.

4.4. Comprehensive Evaluation of Environmental Support

The overall problem of creating indoor wall environment in rural kindergartens is that teachers do not know enough about the value of creating environment, parents do not participate, and openness and education are lacking [27, 28]. This study found that the gray correlation coefficients of indoor wall environment indicators were significantly higher in private kindergartens than in public kindergartens. In the field research, private kindergartens in the creation of indoor wall environment, indoor wall arrangement has a certain aesthetic, such as not cluttered, no excessive hanging ribbons and other decorations; at the same time both some thematic division, such as can see the theme wall about a teaching activity theme design. Only one new kindergarten in the county has a certain theme wall in the creation of the indoor wall environment, and a theme wall design such as "me and my family" is presented in individual classes, while other public kindergartens have no plan for indoor wall decoration or the walls are covered by various colors of stickers unrelated to the theme. The quality of the kindergarten environment is closely related to the strength of teachers, children's perceptions, funding sources, government supervision, parental requirements and teacher recognition [29]. In the future, we can improve the overall quality of kindergarten environment creation by strengthening the professional capacity training of post-service teachers, reaching the environmental creation concept of wall environment creation and curriculum integration, conducting seminars on kindergarten theme wall design and teaching activities, and offering courses related to wall environment creation for preschool education students.

As an important form of educational organization, the activity area plays an irreplaceable role in children's development. Teachers can divide the activity area space into functional areas according to children's own characteristics and hobbies, and let children freely choose various areas to show the educational characteristics of "teaching according to each individual" [30]. The construction area is an important part of kindergarten regional activities. By providing rich construction materials, children can enrich their life experience and continue to develop physically and mentally while building and playing freely [31]. The results of this study showed that the number of gray off links in the construction area of private kindergartens was significantly higher than that of public kindergartens, and it was found that the construction area of many private kindergartens had enough blocks and other auxiliary construction materials for children to build, and there was space on the floor for construction games, while most of the construction areas in public kindergartens were not obviously set up and divided, and the materials put in were only some scattered blocks, and the area occupied by the area was small. However, the placement and arrangement of materials in the indoor construction area were similar for all age groups in the same school. It is suggested that in the future, attention should be paid to the following in the creation of the indoor construction zone environment: (1) children's age differences lead to differences in their ability to build materials, and attention should be paid to the needs of children of different ages; (2) as the main place for children's independent activities, the construction zone should be reasonably set up in the division of space in relation to the class size; (3) the level of kindergarten's understanding of the planning and material placement of the construction zone should be raised to better serve (3) to raise the level of kindergarten's understanding of the planning and material placement of the construction area, so as to better serve the physical and mental development of children.

There was no significant difference between the gray correlation coefficients of the other evaluation indicators in environmental support. Currently, the indoor environment in rural kindergartens has a high level of homogeneity, and the indoor areas in different age groups are uniformly set up, and the materials are mostly similar. However, the unity of indoor environment creation with the curriculum, the interaction with children's activities, and the correlation with teachers' teaching are still not enough. It is suggested that in the future creation of kindergarten environment, we should strengthen the consideration of the value of what the environment is to nurture people, clarify the educational value and function of the environment, and support the quality improvement of kindergarten education and teaching activities from the material level.

4.5. Comprehensive Evaluation Analysis of Spatial Layout

Whether the "spatial education" function of kindergarten indoor environment is effective or not is closely related to the planning and layout of indoor activity space. Through the weighted gray correlation analysis of the three indicator layers of activity facilities and materials layout, indoor wall layout and indoor activity area layout, there was no significant difference between the gray correlation coefficient values of each class in the private kindergarten and the corresponding correlation coefficient values in the public kindergarten. The results show that there is little difference in the indoor space planning and layout of rural kindergartens, and the overall situation is as follows: (1) indoor facilities and equipment or activity materials are placed arbitrarily, and the relevant teaching activity facilities and equipment are not organized according to their functions; (2) although there are wall designs for display in the interior, the designs are more disorganized and the themes are not prominent; (3) the division of indoor activity areas is not obvious, and the sight lines are blocked during space planning situation. (4) There is not enough space to divide the activity areas, resulting in crowded ground space for playing with blocks, insufficient space for operating activities in the art area, and the art activity easels cannot be placed. Therefore, the current indoor environment in rural kindergartens is not aesthetically pleasing, educational, living, or scientific.

4.6. Analysis of the Overall Correlation Of Kindergartens with Different Nature of Operation

The educational function of kindergarten environment has been widely recognized. The largest weighted gray correlation in this study is for private small classes (0.7814), followed by private middle classes, private large classes, and public large classes, which indicates that private education has developed rapidly in recent years with the support of national guidelines and policies, and private kindergartens have been able to achieve sustainable development by improving their own advantages in school operation under strong competition in the market.

Based on the comprehensive evaluation of indoor environment creation in rural kindergartens in this study, the following recommendations are made: (1) ensure that there is enough space for activities and that the size of indoor space meets the minimum useable area per student; (2) update our ideological understanding of the value of kindergarten environment education and re-establish the positioning of kindergarten environment as a "hidden curriculum"; (3) strengthen the construction of regional kindergarten environment creation communities, learn from each other the concept of quality environment creation, and apply and promote it according to local conditions.

As children grow older, their physical and mental development gradually changes from passive acceptance to active transformation in their interaction with the environment. When evaluating the creation of indoor environments in kindergartens of different ages, the evaluation of environmental creation at the material level alone may no longer be a comprehensive assessment of the quality of kindergarten environments.

5. Conclusion

1) In the evaluation system for the creation of indoor environment in rural kindergartens, the basic conditions have the greatest weight (weighting factor 0.5396), and having good basic material conditions in the process of creating indoor environment in kindergartens is the primary prerequisite for carrying out educational and teaching activities.

2) Based on the evaluation system established in this study, the results of the weighted gray correlation analysis and the principal component analysis were consistent, and the level of indoor environment creation in private small kindergartens in this region was optimal.

3) Reading area (C11), role area (C9), layout of indoor activity area (C19), language area (C8), and basic facilities for conducting activities (C2), these five indicators can be used as representative indicators for the evaluation of indoor environment creation in rural kindergartens.

4) The evaluation system of rural kindergarten indoor environment creation constructed by this study based on hierarchical analysis and gray correlation analysis has certain feasibility and scientificity, and the evaluation system constructed by this study can provide reference and direction

for improving the existing evaluation system and formulating evaluation standards.

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