



Construction of core literacy index system for early childhood physical education teachers based on hierarchical analysis method

Shirong Wu^{1,*}, Wenqi Hu² and Huijing Xiao²

¹ College of Sports Science, Changsha Normal University, Hunan, Changsha, 410100, China

² Hunan College of Foreign Studies, Changsha, Hunan, 410205, China

SUMMARY: *This study synthesized the literature analysis and experts' opinions, established the final evaluation index system after several rounds of index screening, selected the hierarchical analysis method to calculate the weights of each index, and created a gray multilevel evaluation model to evaluate the core literacy of early childhood physical education teachers. The index system was applied to evaluate the core literacy of several early childhood physical education teachers in combination with actual cases to verify the practicality of the evaluation system. Through the process of initial screening and re-screening of indicators, the study obtains that the indicator system contains 4 first-level indicators, 10 second-level indicators and 37 third-level indicators. Hierarchical analysis determined that the weights of the first-level indicators of ideological character, professional knowledge, professional ability, and innovative learning were 0.317, 0.289, 0.211, and 0.183, respectively. The average scores of the 50 early childhood physical education teachers on the above first-level indicators were 4.58, 4.34, 4.25, and 3.85, respectively, and the grayscale scores of their core qualities were in the interval of (4,5), which was in the "excellent" grade. The core literacy index system of early childhood physical education teachers based on hierarchical analysis has practical value.*

KEYWORDS: *hierarchical analysis method; gray multilevel evaluation model; evaluation index system; early childhood physical education teachers; core literacy*

1 Introduction

Currently, young children's participation in physical activity is insufficient, and the convenience of socialization and urbanization, as well as the pressure of social survival, have greatly reduced the space and time for physical activity. Obesity, overweight and chronic diseases have become important crises for preschoolers [1, 2]. Reasonable participation in physical activity by young children can effectively increase muscle size, bone density, joint stability and cardiorespiratory function, reduce body fat content, thus enhancing the body load bearing capacity and developmental ability, and help young children's awareness of sports and the formation of personality psychology [3-5]. Early childhood teachers are important guides for young children's sports development, which will have a direct impact on young children's sports cognition, habit formation, behavioral performance, interest stimulation and retention. The results of literature [6] showed that preschool children's physical activity levels were significantly higher in lessons taught by active teachers, suggesting that teachers' role modeling behaviors are a key factor in facilitating the acquisition of physical activity in young children. Literature [7] used hierarchical linear regression analysis to indicate that factors such as early

*Shirong8778@163.com

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childhood physical education teacher training and professional development explained 18% of the variance in children's motor function skills, highlighting the important value of professional development.

Under the guidance of the concept of core literacy in sports in the new era, teachers are given the same role and status as students, and while teachers become educators, they must also maintain the role of learners to promote the development of students' core literacy in sports, and the development of teachers' own core literacy in sports is also very important [8-10]. The developmental experience of sports in early childhood can lay a good foundation for the formation of individual sports core literacy, and the level of core literacy of early childhood physical education teachers will have an important impact on it. It can be seen that it is necessary for early childhood teachers to develop their own physical education core literacy, that is, it is necessary for the times, and it is also necessary for professional development. However, kindergartens at different levels around the world in the structure of physical education teachers, generally show a lack of teachers who have undergone professional physical education training, teachers with insufficient experience in organizing and teaching physical activity classes, teachers with weak basic theories and experience in physical education, and a lack of science in teaching and so on [11-15]. Thus, it seems that kindergarten teachers' core competence in physical education is relatively lacking, which is a major dilemma in the development of physical education in the preschool field, and the development and enhancement of the core qualities of early childhood physical education teachers has become an urgent and realistic problem to be solved.

Literature [16] used the Delphi method to construct an indicator system of early childhood physical education teachers' competence that contains 5 first-level, 17 second-level and 54 third-level indicators. The system has good reliability and rationality, which can provide scientific basis for improving teachers' teaching ability and developing structured early childhood physical education curriculum. Literature [17] constructed a core literacy development index system for college physical education teachers through qualitative analysis, Delphi method and hierarchical analysis method (AHP). The system contains 4 main indicators and 15 sub-indicators such as moral character, educational ability, etc. The structure is clear, scientific and reasonable, which provides an effective theoretical framework for assessing and developing the core competence of physical education teachers. Among them, AHP is a widely used decision analysis method, which helps decision makers make reasonable decisions by constructing a hierarchical structure and a comparison matrix to rank and assign weights to different factors.

In the field of physical education, the application of AHP method for curriculum design and optimization, teaching evaluation, and teacher-student evaluation has achieved remarkable results. Literature [18] proposed that the design of physical education curriculum optimized by AHP method is mainly through the empowerment of influencing factors of curriculum selection and evaluation, which effectively improves the scientificity of curriculum and the diversity of evaluation. Literature [19] created an AHP-based multi-criteria decision-making framework for optimizing physical education curricula, identifying five core dimensions and their weights, such as teaching quality, and the evaluation showed game-based learning as the optimal strategy. Literature [20] used AHP to construct a physical education teaching evaluation system containing 22 indicators based on goal management, and quantified the weights of the indicators in order to improve the quality of teaching and promote the cultivation of students' lifelong sports awareness. Literature [21] combined AHP and fuzzy comprehensive evaluation method to create a computer-assisted physical education teaching evaluation system covering the dimensions of teaching process, learning outcomes and resource availability, which provides a scientific basis for optimizing the integration of technology and the teaching practice of

professional classes for physical education teachers. Literature [22] used the improved Delphi method to design an assessment framework for Chinese young children's physical literacy that included four dimensions such as motivation confidence and physical ability, and determined the basis of indicator weights using the AHP method. Literature [23] constructed an AHP-based physical education teacher competency assessment model, which contains four key criteria and 21 sub-criteria, including teaching, professional, vocational and technical, in which teaching competency is recognized as the core element, providing a scientific framework for systematically assessing and improving teacher competency. Literature [24] established a competency model for primary physical education teachers with the help of AHP, and found that the relative importance of each teacher's competency was ranked as personal relationship, self-management, professional competency, learning and freedom, sense of challenge, and creativity, and the advantages of the AHP method in the construction of indexes and weighting of indexes provided a reference to the construction of the index system of core literacy for early childhood physical education teachers.

In this paper, several experts were invited to participate in the screening of the core literacy indicator system of early childhood physical education teachers, and the original indicators were deleted or modified according to the degree of concentration and coordination of the experts' opinions, so as to finalize the construction of the evaluation indicator system. The obtained index system is weighted by the hierarchical analysis method, and then combined with the gray multilevel evaluation model to realize the accurate evaluation of the core literacy of early childhood physical education teachers. In order to verify the validity of the evaluation system, relevant questionnaires were designed, and several randomly selected early childhood physical education teachers conducted empirical research.

2 Early Childhood Physical Education Teacher Core Literacy Indicator System

On the basis of reviewing a large amount of literature and consulting relevant experts, and following the principles of scientific comprehensiveness, systematic operability and timeliness, the study initially proposes four primary indicators, 13 secondary indicators and 42 tertiary indicators of the core literacy indicator system for early childhood physical education teachers, and the screening process of the indicators will be discussed in detail in the following section.

2.1 Indicator screening methodology

The study adopts the Delphi method, inviting experts to judge the importance of the indicators in the questionnaire in order to complete the screening of indicators, the process of screening indicators using the Delphi method is as follows:

(1) Selection of experts

Eight experts in pedagogy, school sports, teacher education, physical education, etc. were invited to serve as the panel of experts for this study. During the research process, the experts filled in the questionnaires and provided opinions with reference value, so that their credibility and validity were guaranteed and the research was carried out smoothly.

(2) Distribute questionnaires to solicit experts' opinions

According to the preliminary formulation of the indicators, the expert questionnaire was designed (two rounds in total), and eight experts were invited to judge the importance of the indicators in the questionnaire and put forward relevant opinions and suggestions. After collecting the questionnaires, the importance of each indicator in the questionnaire will be scored to establish the final indicators.

Scoring basis: This questionnaire uses a five-level Likert scale to select indicators based on the experts' scores on the importance of each indicator at each level. The importance of the experts' selection of indicators is divided into very important, important, generally important, unimportant, and very unimportant, and assigned the values of 5, 4, 3, 2, and 1 in turn, so as to facilitate the statistics and calculation of the data at a later stage.

(3) Data organization and analysis

SPSS software and EXCEL office software are used for statistical analysis to derive the values of arithmetic mean, coefficient of variation and coefficient of full marks for each indicator.

(4) Screening indicators

Screening indicators are mainly carried out through two aspects: the degree of concentration of expert opinions and the degree of coordination, in which the degree of concentration of experts is examined by the arithmetic mean (\bar{x}), the standard deviation (σ_i), and the degree of coordination of expert opinions is examined by the coefficient of variation (V_i).

a. Arithmetic mean (\bar{x}), can be distinctive amount of concentration using the arithmetic mean to reflect the degree of concentration of expert opinion. The formula is as follows:

$$\bar{x} = \frac{x_1 + x_2 + x_3 + \dots + x_n}{n} = \frac{\sum_{i=1}^n x_i}{n} \quad (1)$$

where: \bar{x} denotes the arithmetic mean, x_i denotes the i th variable value, n denotes the overall number of units, and Σ is the summation symbol. The arithmetic mean takes values between 0 and 5, with the larger \bar{x} corresponding to the higher importance of the i indicator.

b. Standard deviation (σ_i):

$$\sigma_i = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n}} \quad (2)$$

c. coefficient of variation (V_i):

$$V_i = \frac{\sigma}{\bar{x}} \quad (3)$$

The coefficient of variation is the ratio of the standard deviation to the mean and reflects the absolute value of the degree of dispersion of the data. It is an important indicator of the degree of coordination of experts, and after statistical analysis it is possible to identify the consistency of the evaluation of each indicator and remove indicators with large differences. The coefficient of variation greater than 0.25 should be removed, and the coefficient of variation V_σ of the evaluation results of each indicator indicates the degree of fluctuation and the degree of coordination of experts on the relative importance of the indicator.

In this study, the basis for selection was that an indicator with an average value greater than 3.5 and a coefficient of variation of less than 0.25 indicated that the indicator was highly credible; otherwise, it was considered for removal after seeking expert feedback.

2.2 Initial screening of indicators

In this indicator screening, the original indicator questionnaire was mailed to eight experts, mainly by e-mail. It was filled in and returned by the experts, and then statistically and analytically analyzed. The degree of concentration and coordination of the expert ratings of the first-level indicators were obtained as shown in Table 1. The arithmetic mean of the four first-level indicators of ideology and moral character (A), professional knowledge (B), professional ability (C), and innovative learning (D) are 4.63, 4.25, 4.38, and 4.50, respectively, and the standard deviation is 0.518, 0.707, 0.744, and 0.535, respectively, with corresponding coefficients of variation of 0.112, 0.166, 0.170, and 0.119, respectively. The degree of concentration and harmonization of the experts' ratings for the four level 1 indicators is high, and the level 1 indicators do not need to be revised.

Table 1: The level of concentration and coordination of primary indicator

Experts	Primary indicator			
	Ideological morality(A)	Professional knowledge(B)	Professional ability(C)	Innovative learning(D)
1	5	4	5	5
2	4	5	5	5
3	5	4	5	5
4	5	5	4	4
5	4	4	3	4
6	4	4	4	4
7	5	3	4	4
8	5	5	5	5
\bar{x}	4.63	4.25	4.38	4.50
σ_i	0.518	0.707	0.744	0.535
V_i	0.112	0.166	0.170	0.119

The degree of concentration and harmonization of expert scores for the secondary indicators is shown in Table 2. For the secondary indicators, the arithmetic mean score value of understanding empathy (C3) was 4.08, with a standard deviation of 1.090, and its coefficient of variation was $0.267 > 0.25$. After consulting with the experts, it was agreed that this indicator would be merged with the indicator of teaching ability (C2). Twelve secondary indicators, such as dedication and care for students, were eventually retained.

Table 2: The level of concentration and coordination of secondary indicator

Secondary indicator	\bar{x}	σ_i	V_i
Love is dedicated(A1)	4.59	0.685	0.149
Love student(A2)	4.25	0.632	0.149
Master watch(A3)	4.67	0.624	0.134
Theoretical knowledge(B1)	4.12	0.512	0.124
Athletic skill(B2)	4.16	0.520	0.125
Education theory(B3)	4.15	0.697	0.168
Safety knowledge(B4)	4.35	0.68	0.156
Physical quality(C1)	4.36	0.648	0.149
Teaching ability(C2)	4.66	0.671	0.144
Empathy(C3)	4.08	1.090	0.267
After-school guidance(C4)	4.42	0.565	0.128
Reform innovation(D1)	4.59	0.608	0.132
Lifelong learning(D2)	4.22	0.571	0.135

The degree of concentration and harmonization of expert ratings at the three levels of indicators is shown in Table 3. At the level of the three-level indicators, a total of four indicators had a coefficient of variation of more than 0.25, namely knowledge of sport management science (B11), scientific and healthy living habits (C12), good posture and physical function (C13), and focusing on one's own professional development (D16). Among the experts' decisions, 2 indicators were deleted, i.e. knowledge of sport management science and focus on own professional development. The two indicators of scientific and healthy living habits and good posture and physical functioning are strongly correlated, and for this reason they were combined and recorded as healthy posture and physical functioning.

Table 3: The level of concentration and coordination of tertiary indicator

Tertiary indicator	\bar{x}	σ_i	V_i
Follow the law of education(A11)	4.45	0.538	0.121
To fulfill the rights of teachers' responsibilities(A12)	4.51	0.596	0.132
Use career spirit and career ideal(A13)	4.55	0.555	0.122
Equal treatment for students(A21)	4.68	0.472	0.101
Teaching by aptitude(A22)	4.28	0.595	0.139
Caring for the student body(A23)	4.17	0.521	0.125
Trust students' attitudes and behaviors(A24)	4.50	0.463	0.103
Civilized behavior(A31)	4.10	0.463	0.113
Positive(A32)	4.64	0.627	0.135
Good character(A33)	4.22	0.519	0.123
Knowledge of sports management(B11)	4.28	1.309	0.306
Sports competition(B12)	4.15	0.444	0.107
Physical and health course content understanding(B13)	4.14	0.468	0.113
Be able to avoid risk of injury(B21)	4.62	0.642	0.139
Knowledge of injury emergency(B22)	4.65	0.548	0.118
Knowledge of education(B31)	4.38	0.587	0.134
Knowledge of education psychology(B32)	4.42	0.482	0.109
Proficient in sports skills(B41)	4.30	0.486	0.113
Mastering the core elements of skill(B42)	4.22	0.456	0.108
Strong body(C11)	4.11	0.517	0.126
Good posture and body function(C12)	4.26	1.172	0.275
Scientific and healthy living habits(C13)	4.23	1.306	0.309
Language presentation ability(C21)	4.52	0.574	0.127
Binding energy of teaching methods(C22)	4.22	0.569	0.135
Teaching group management ability(C23)	4.50	0.495	0.110
Analysis of literature data ability(C24)	4.43	0.532	0.120
Statistics and analysis(C25)	4.46	0.544	0.122
Reporting ability(C26)	4.27	0.567	0.133
Thinking ability(C31)	4.50	0.518	0.115
Communication ability(C32)	4.24	0.449	0.106
The choice of the content of extracurricular activities(C41)	4.40	0.519	0.118
The ability of sports activities in extracurricular activities(C42)	4.11	0.505	0.123
The creative ability of sports culture in extracurricular activities(C43)	4.27	0.585	0.137
The ability to manage extracurricular activities(C44)	4.23	0.466	0.110
Analyze the particularity of different specialties(D11)	4.21	0.497	0.118
Teaching and particularity focus on combining(D12)	4.35	0.548	0.126
Reform teaching concept(D13)	4.55	0.541	0.119
Innovative curriculum goals(D14)	4.17	0.509	0.122
Focus on student cohesion(D15)	4.14	0.418	0.101
Focus on our professional development(D16)	4.40	1.117	0.254
Develop a professional development plan(D21)	4.15	0.506	0.122
Actively participate in training(D22)	4.69	0.652	0.139

2.3 Indicator re-screening

The methodology of the second round of screening is the same as the first round, in which the statistics of the second round of screening for the secondary indicators are shown in Table 4. In the second round of screening, the coefficients of variation of theoretical knowledge (B1), educational theory (B3), and safety knowledge (B4) are large, and have exceeded 0.25, and the experts believe that these three indicators can be combined to promote the comprehensive development of young children.

Table 4: The second round of the secondary indicator is calculated

Secondary indicator	\bar{x}	σ_i	V_i
Love is dedicated(A1)	4.38	0.723	0.165
Love student(A2)	4.32	0.816	0.189
Master watch(A3)	4.22	0.798	0.189
Theoretical knowledge(B1)	4.26	1.218	0.286
Athletic skill(B2)	4.31	0.849	0.197
Education theory(B3)	4.11	1.143	0.278
Safety knowledge(B4)	4.12	1.096	0.266
Physical quality(C1)	4.27	0.572	0.134
Teaching ability(C2)	4.12	0.614	0.149
After-school guidance(C4)	4.2	0.802	0.191
Reform innovation(D1)	4.35	0.822	0.189
Lifelong learning(D2)	4.10	0.508	0.124

Table 5 shows the statistical results of the second round of screening for the three-level indicators. In this round of screening, the experts took into account the poor correlation between literature analysis and professional specificity and early childhood physical education teaching, and deleted the two indicators of the ability to analyze literature and information (C24) and analyzing the specificity of different professions (D11).

Table 5: The second round of the tertiary indicator is calculated

Tertiary indicator	\bar{x}	σ_i	V_i
Follow the law of education(A11)	4.32	0.886	0.205
To fulfill the rights of teachers' responsibilities(A12)	4.33	0.879	0.203
Use career spirit and career ideal(A13)	4.24	0.878	0.207
Equal treatment for students(A21)	4.26	0.822	0.193
Teaching by aptitude(A22)	4.55	0.592	0.130
Caring for the student body(A23)	4.42	0.575	0.130
Trust students' attitudes and behaviors(A24)	4.65	0.916	0.197
Civilized behavior(A31)	4.26	0.861	0.202
Positive(A32)	4.33	0.706	0.163
Good character(A33)	4.43	0.580	0.131
Sports competition(B12)	4.65	0.642	0.138
Physical and health course content understanding(B13)	4.19	0.624	0.149
Be able to avoid risk of injury(B21)	4.05	0.555	0.137
Knowledge of injury emergency(B22)	4.61	0.710	0.154
Knowledge of education(B31)	4.61	0.894	0.194
Knowledge of education psychology(B32)	4.53	0.666	0.147
Proficient in sports skills(B41)	4.24	0.827	0.195
Mastering the core elements of skill(B42)	4.29	0.613	0.143
Strong body(C11)	4.5	0.851	0.189
Healthy body and body function(C12)	4.52	0.588	0.130
Language presentation ability(C21)	4.31	0.784	0.182
Binding energy of teaching methods(C22)	4.42	0.919	0.208
Teaching group management ability(C23)	4.62	0.610	0.132
Analysis of literature data ability(C24)	4.65	1.280	0.275
Statistics and analysis(C25)	4.19	0.687	0.164
Reporting ability(C26)	4.37	0.610	0.140
Thinking ability(C31)	4.03	0.774	0.192
Communication ability(C32)	4.09	0.638	0.156
The choice of the content of extracurricular activities(C41)	4.12	0.840	0.204
The ability of sports activities in extracurricular activities(C42)	4.4	0.708	0.161
The creative ability of sports culture in extracurricular activities(C43)	4.69	0.849	0.181
The ability to manage extracurricular activities(C44)	4.23	0.795	0.188
Analyze the particularity of different specialties(D11)	4.20	1.252	0.298
Teaching and particularity focus on combining(D12)	4.49	0.831	0.185
Reform teaching concept(D13)	4.15	0.672	0.162
Innovative curriculum goals(D14)	4.13	0.640	0.155
Focus on student cohesion(D15)	4.01	0.545	0.136
Develop a professional development plan(D21)	4.46	0.584	0.131
Actively participate in training(D22)	4.41	0.675	0.153

After two rounds of screening, four primary indicators, 10 secondary indicators, and 37 tertiary indicators were finally identified, and the screened indicators were renumbered to constitute a new core literacy evaluation index system for early childhood physical education teachers as shown in Table 6.

Table 6: The evaluation index system of the core quality of children's sports teachers

Primary indicator	Secondary indicator	Tertiary indicator
Ideological morality(A)	Love is dedicated(A1)	Follow the law of education(A11)
		To fulfill the rights of teachers' responsibilities(A12)
		Use career spirit and career ideal(A13)
	Love student(A2)	Equal treatment for students(A21)
		Teaching by aptitude(A22)
		Caring for the student body(A23)
		Trust students' attitudes and behaviors(A24)
	Master watch(A3)	Civilized behavior(A31)
		Positive(A32)
Good character(A33)		
Professional knowledge(B)	Child development(B1)	Sports competition(B11)
		Physical and health course content understanding(B12)
		Be able to avoid risk of injury(B13)
		Knowledge of injury emergency(B14)
		Knowledge of education(B15)
		Knowledge of education psychology(B16)
	Athletic skill(B2)	Proficient in sports skills(B21)
		Mastering the core elements of skill(B22)
Professional ability(C)	Physical quality(C1)	Strong body(C11)
		Healthy body and body function(C12)
	Teaching ability(C2)	Language presentation ability(C21)
		Binding energy of teaching methods(C22)
		Teaching group management ability(C23)
		Statistics and analysis(C24)
		Reporting ability(C25)
		Thinking ability(C26)
	After-school guidance(C3)	Communication ability(C27)
		The choice of the content of extracurricular activities(C31)
		The ability of sports activities in extracurricular activities(C32)
		The creative ability of sports culture in extracurricular activities(C33)
		The ability to manage extracurricular activities(C34)
		Innovative learning(D)
Reform teaching concept(D12)		
Innovative curriculum goals(D13)		
Focus on student cohesion(D14)		
Lifelong learning(D2)	Develop a professional development plan(D21)	
	Actively participate in training(D22)	

3 Core literacy assessment model

The study chose the hierarchical analysis method to determine the weights of the core literacy evaluation indicators for early childhood physical education teachers constructed above, while creating a gray multilevel evaluation model to evaluate the core literacy of established early childhood physical education teachers.

3.1 Hierarchical analysis to determine weights

The process of constructing weights by hierarchical analysis is shown in Figure 1. Hierarchical analysis method is proposed by Saaty, an American operations researcher, in analyzing the mutual influence of various factors, the factors are divided into a number of levels, on the basis of which the weights of each indicator are determined. This paper uses Yaahp, an auxiliary software for hierarchical analysis method, to determine the weights, which has a simple interface, can draw hierarchical models, and can also automatically correct inconsistent interpretation matrices, weight assignments and sensitivity. The study was conducted by distributing questionnaires to 48 physical education teachers in 21 kindergartens and scoring the indicators to obtain initial data for evaluating the importance of the indicators.

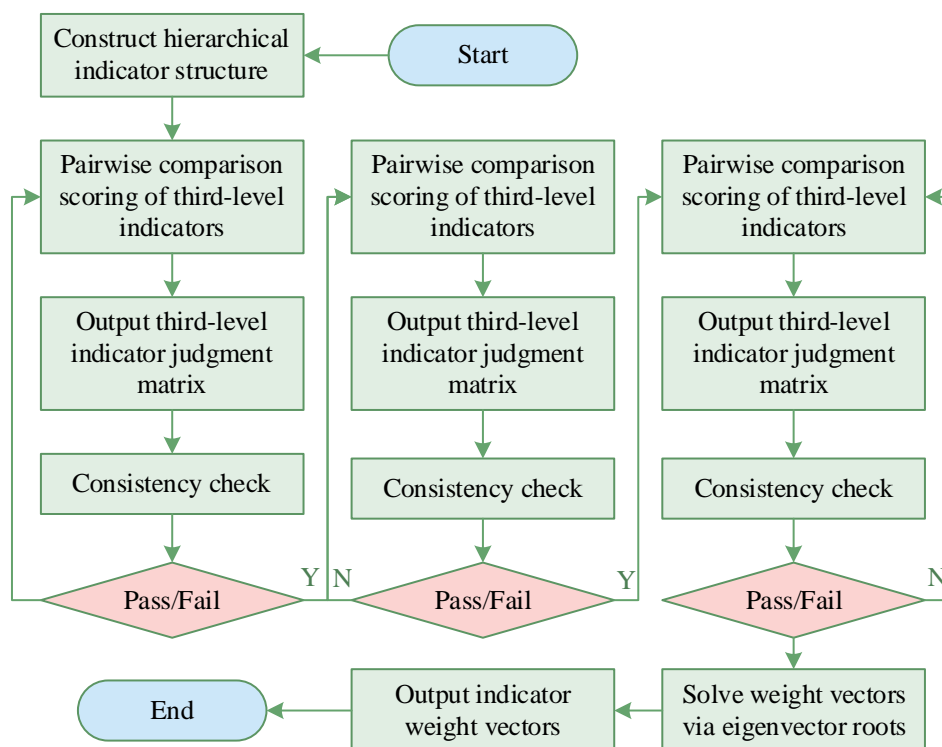


Figure 1: Hierarchical analysis builds the weighting process

The specific steps for constructing weights in hierarchical analysis are as follows:

a. Construct the hierarchical analysis structure.

b. Construct the judgment matrix: the indicators form the judgment matrix by two-by-two comparison, and the comparison of indicators needs to be quantified, i.e., the relative importance of two-by-two comparisons of the indicators is assigned artificially, so as to improve the precision of the comparison. In the process of assigning the relative importance degree, it is necessary to refer to a certain standard, which is called the scale. There are 9 importance

levels and their quantitative values for the judgment of two-by-two comparison of indicators, and the quantification of importance levels is as follows:

A_{ij} is assigned a value of 1, and both i, j elements are equally important.

A_{ij} is assigned a value of 3, and the element i is slightly more important than the element j .

A_{ij} is assigned a value of 5, and the element i is significantly more important than the element j .

A_{ij} is assigned a value of 7, and the i element is strongly more important than the j element.

A_{ij} is assigned a value of 9, and the i element is extremely important than the j element.

Assigning values of 2, 4, 6, and 8, the level of importance falls between the above scales.

The two two indicators are compared and scored, and the scoring result is a_{ij} , and the scoring value of a_{ij} and a_{ji} is the inverse of the scoring value, i.e., $a_{ij} = 1/a_{ji}$, and the indicator compares with itself as 1. Indicators at each level are compared to obtain the following matrix:

$$\begin{array}{c}
 A1 \quad A2 \quad \dots \quad An \\
 A1 \left[\begin{array}{cccc} 1 & a12 & \dots & a1n \\ A2 & a21 & 1 & \dots & a2n \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ An & an1 & an2 & \dots & 1 \end{array} \right. \\
 \end{array} \quad (1)$$

c. Principle of consistency test:

First calculate the weight value of each indicator in the matrix:

$$W_i = \left(\prod_{j=1}^n a_{ij} \right)^{\frac{1}{n}} / \sum_{i=1}^n \left(\prod_{j=1}^n a_{ij} \right)^{\frac{1}{n}} \quad (2)$$

Next calculate the maximum characteristic root of the judgment matrix:

$$\lambda_{\max} \approx \frac{1}{n} \sum_{i=1}^n \frac{(AW)_i}{W_i} = \frac{1}{n} \sum_{i=1}^n \frac{\sum_{j=1}^n a_{ij} W_j}{W_i} \quad (3)$$

The consistency indicator CI is then calculated:

$$CI = \frac{\lambda_{\max} - n}{n - 1} \quad (4)$$

Finally, the consistency ratio is calculated:

$$CR = \frac{CI}{RI} \quad (5)$$

RI is the average random consistency index, when $CR < 0.1$, the consistency of the judgment matrix is accepted, and consistency is not passed then the scoring table needs to be re-corrected until $CR < 0.1$ is satisfied. Refer to Table 7 for the values of RI .

Table 7: The conformance indicator RI standard

Number	1	2	3	4	5	6	7	8
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41

d. Weight calculation:

This paper takes the judgment matrix constructed by the four first-level indicators of ideological character (A), professional knowledge (B), professional ability (C) and innovative learning (D) as an example, and calculates its weights in detail here, and the other weight calculation process will not be repeated. The scoring value and weight calculation of Teacher 1 are shown in Table 8. According to the scoring data given by Teacher 1, the weights of ideological character (A), professional knowledge (B), professional ability (C) and innovative learning (D) are calculated as 0.329, 0.287, 0.206, 0.177, respectively, and the consistency test $CR=0.069 < 0.1$, passing the consistency test.

Table 8: Teacher 1 rating and weight calculation

	A	B	C	D	w
A	1.00	1.00	2.00	2.00	0.329
B	1.00	1.00	2.00	1.00	0.287
C	0.50	0.50	1.00	2.00	0.206
D	0.50	1.00	0.50	1.00	0.178
$\lambda_{\max}=4.19, CI=0.062, CR=0.069$					

Similarly, the weights of Teacher 1 to Teacher 48 indicators were obtained as shown in Table 9. Teachers generally agreed that ideology and morality (A) is more important than other indicators, and they believe that ideology and morality is the key to the beginning of early childhood education. Taking the arithmetic mean of the weights of the 48 teachers, the arithmetic mean weights of ideology and moral character (A), professional knowledge (B), professional competence (C), and innovative learning (D) were 0.317, 0.289, 0.211, and 0.183, respectively. The following section uses the same method to calculate the weights of the secondary and tertiary indicators under them.

Table 9: Teacher 1~ teacher 48 index weight

	A	B	C	D
Teacher 1	0.329	0.287	0.206	0.178
Teacher 2	0.305	0.278	0.226	0.191
Teacher 3	0.312	0.316	0.190	0.182
...
teacher 46	0.319	0.28	0.220	0.181
Teacher 47	0.329	0.281	0.204	0.186
Teacher 48	0.293	0.271	0.222	0.214
Average	0.317	0.289	0.211	0.183

e. Hierarchical analysis method weights summarization

According to the above calculation method, the weights of the indicators at all levels of the hierarchical analysis method for calculating the core literacy of early childhood physical education teachers are summarized, and the results of the weight summary of the hierarchical analysis method are shown in Figure 2. The weights of the three levels of indicators are assigned between 0.0109 and 0.0594, and the following can be based on the weights of the indicators, combined with the gray multilevel evaluation model, to carry out empirical analysis of the core literacy of early childhood physical education teachers.

Core literacy										
A					C					
A1		A2		A3		C1			C3	
A11 0.0325		A21 0.0318		A22 0.0304		C11 0.0205		C12 0.0141		C31 0.0194
A12 0.0311				A31 0.031		C21 0.0171		C24 0.0144	C25 0.0178	C32 0.0154
A13 0.0309		A23 0.0321		A24 0.0323		C22 0.0219				C33 0.0112
				A33 0.0335		C23 0.0167		C26 0.0169	C27 0.0109	C34 0.0147
B					D					
B1			B2		D1			D2		
B11 0.0241	B12 0.0228	B15 0.0471		B21 0.0594		D11 0.0532		D13 0.0214	D21 0.0212	
B13 0.0221	B14 0.0339	B16 0.0389		B22 0.0407		D12 0.0267		D14 0.0323	D22 0.0282	

Figure 2: The hierarchical analysis weight summary results

3.2 Gray multilevel evaluation model

The indicator system in this paper is a three-level hierarchy, with the highest level of both early childhood physical education teachers' core literacy comprehensive evaluation as the target level W , with 4 first-level indicators, 10 second-level indicators, and 37 third-level indicators. Gray multilevel evaluation steps as described in Figure 3.

a. The study is based on the developed core literacy index system and weights of early childhood physical education teachers, and the teachers are researched in detail according to each index to understand the core literacy of teachers.

b. The scoring standard of the evaluation indicators is developed, and the indicators are scored according to the scoring standard. The actual data and qualitative indicators researched are all transformed into scores of scoring criteria, forming a scoring matrix, notated as RX_i , X is how many levels of indicators, and i is the first indicator.

c. Determine the weight of the indicator, notated as SX_i , X for several levels of indicators, i for the first indicator indicator weight, the specific weight as described above.

d. Determine the evaluation scale. The evaluation scale is divided into 4 levels: "Excellent", "Good", "Average", and "Needs Improvement". The first level of the scale is "Excellent", with

a score of $\in (4,5]$. The second level is "Good", with a score of $\in (3,4]$. The third level is "Average", with a score of $\in (2,3]$. The fourth level is "Needs Improvement", with a score of $\in (1,2]$.

The research evaluation is divided into three levels:

The first level is the pre-evaluation, which conducts a pre-evaluation of the three-level indicators C_i , and is calculated according to the following formula:

$$W_{B_i} = R_{C_i} * S_{C_i} = (W_{B_1}, W_{B_2}, \dots, W_{B_i}) \tag{6}$$

The second level of evaluation is the controlling evaluation, which evaluates the secondary indicator B_i and is calculated according to the following formula:

$$W_{A_i} = R_{B_i} * S_{B_i} = (W_{A_1}, W_{A_2}, \dots, W_{A_i}) \tag{7}$$

The third level of evaluation is the final comprehensive evaluation, which concludes the full evaluation process and is calculated according to the following formula:

$$W = R_{A_i} * S_{A_i} \tag{8}$$

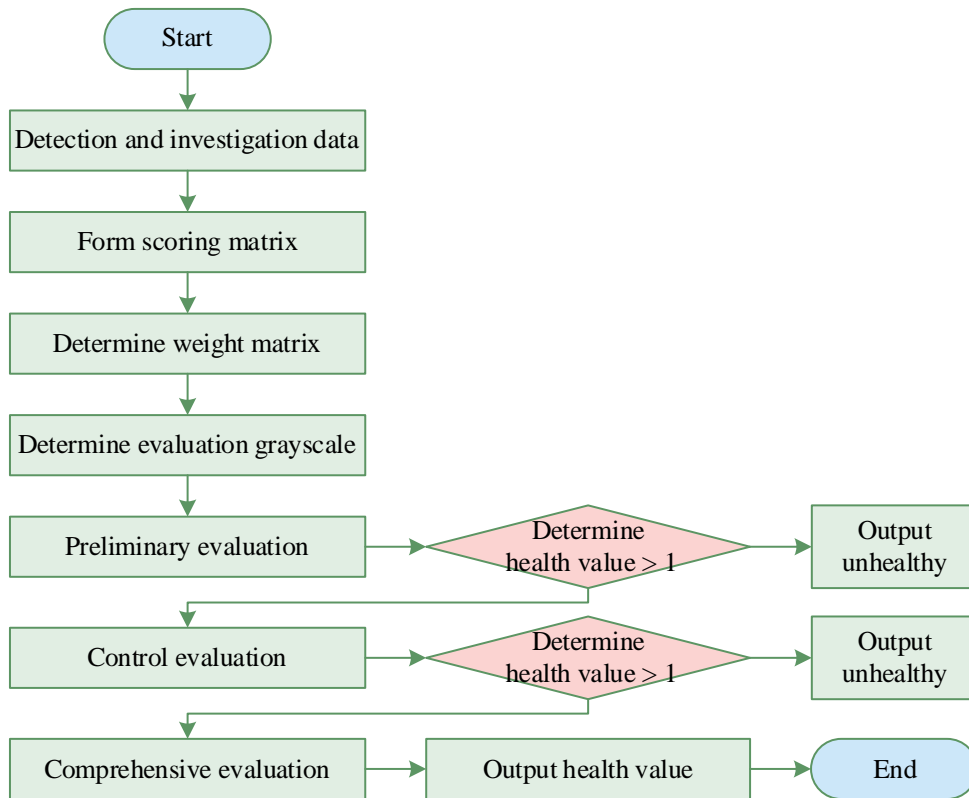


Figure 3: Gray multi-level evaluation process

4 Empirical analysis of the core literacy indicator system

4.1 Factor analysis of questionnaire scales

Drawing on previous research experience and combining the core literacy index system for early childhood teachers constructed above, the study designed a relevant questionnaire containing 37 items. The survey was started after the subjects were fully asked about their willingness to participate. The questionnaire was factor analyzed, and a total of 117 questionnaires were distributed and 115 questionnaires were recovered, with a questionnaire recovery rate of 98.29%. After eliminating the invalid questionnaires, 112 valid questionnaires were obtained, and the validity rate of the questionnaires was 95.73%, and factor analysis was applied to the collected questionnaire sample data.

The factor loading coefficients of the Early Childhood Physical Education Teachers' Core Literacy Scale question items were analyzed by principal component analysis and variance orthogonal maximum rotation, and Figure 4 shows the results of the exploratory factor analysis of the Core Literacy Scale. Each question item falls accurately on the corresponding level 1 indicator factor, and the factor loadings of each question item range from 0.78 to 0.90, with a common degree distribution from 0.70 to 0.88. The factor loading coefficients of the Early Childhood Physical Education Teachers' Core Literacy Scale items were analyzed by principal component analysis and variance orthogonal maximum rotation, and a total of four common factors were extracted, which corresponded to the first-level indexes of the evaluation system, i.e., ideology and moral integrity (A), specialized knowledge (B), professional ability (C), and innovative learning (D). The finalized Core Literacy Scale for Early Childhood Physical Education Teachers contains 37 items and four dimensions: ideological character (items 1-10), professional knowledge (items 11-18), professional competence (items 19-31), and innovative learning (items 32-37), with a cumulative interpretive rate of the scale of 73.414%, and the KMO value of the Core Literacy Scale of 0.873, which indicates that the research-developed measurement scale has good construct validity.

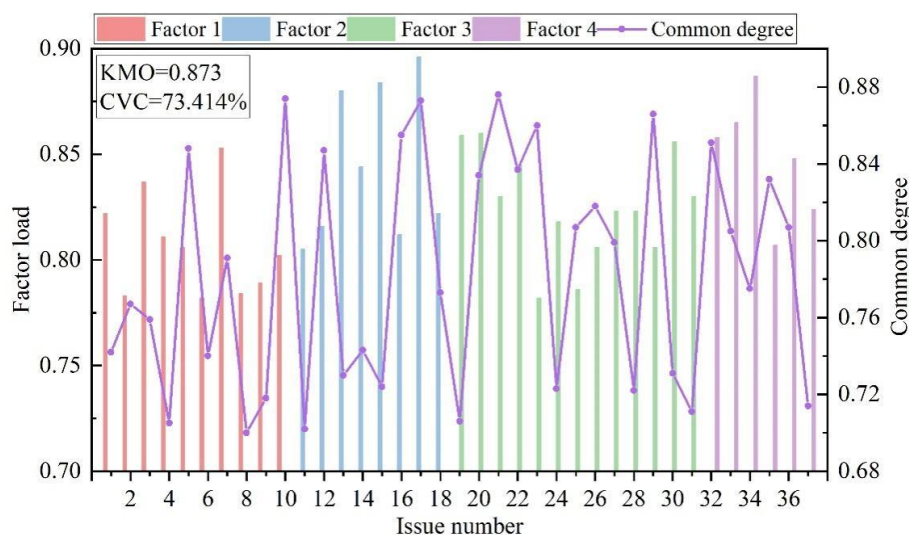


Figure 4: The analysis of the exploratory factor of the core literacy scale

4.2 Gray scale evaluation of core literacy

In order to accurately and deeply understand the current situation of core literacy of early childhood physical education teachers, this study randomly selected 50 early childhood

physical education teachers in a certain city as the research object, and explored the level of the four items of ideology and moral character, professional knowledge, professional competence, and innovative learning using the questionnaire determined above.

Figure 5 shows the results of the core literacy research of the 50 early childhood physical education teachers. The overall mean score of ideology and moral character (A) of the 50 early childhood physical education teachers was 4.58, which indicates that early childhood physical education teachers in a certain city have a high level of ideological literacy, and they have achieved a true love for their work, care for their students, and so on. In addition, the overall mean scores of the 50 early childhood teachers in terms of professional knowledge (B) and professional competence (C) are close to each other, 4.34 and 4.25 respectively, which are also at a high level. Specialized knowledge and professional ability are the guarantee for the quality of teachers' teaching. Early childhood physical education teachers can also strengthen interdisciplinary learning while mastering sports-related knowledge, and infiltrate the competence of other disciplines into physical education teaching, so as to enhance the efficiency of physical education classes. In terms of innovative learning (D), the overall mean score of the 50 early childhood physical education teachers was relatively low, only 3.85, which indicates that early childhood physical education teachers did not perform as well as the above three dimensions in this dimension. When imparting knowledge, teachers need to establish their own sense of lifelong learning, set an example for their students, and continue to improve and develop themselves through out-of-school training pathways. In addition, in the era of modernization of education and digital informatization, they need to continuously improve their own informatization ability and strengthen the learning of information very few, so as to modernize the teaching of early childhood physical education.

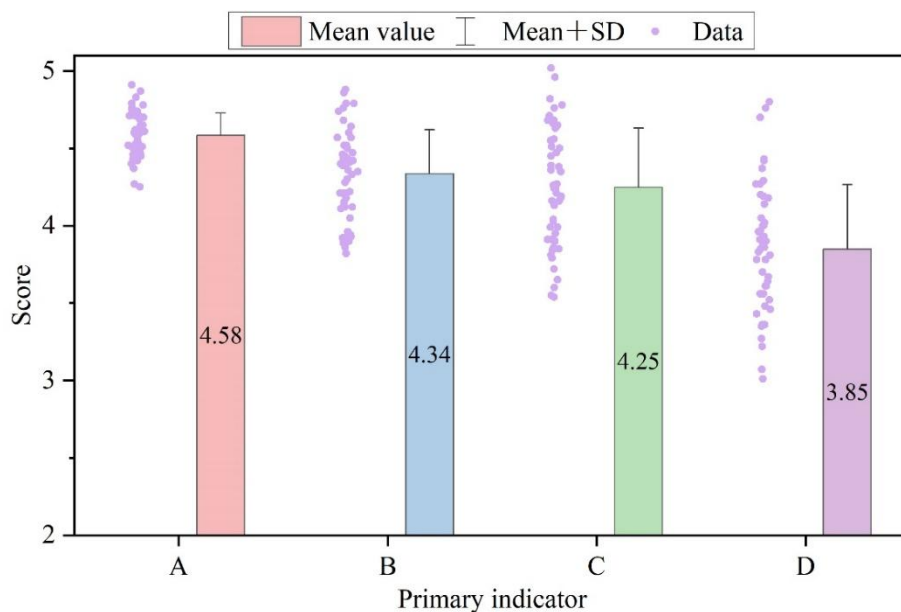


Figure 5: The research results of the core literacy of 50 children's sports teachers

Based on the above data, the study used the gray multilevel evaluation model to comprehensively evaluate the core literacy of 50 early childhood physical education teachers. The core literacy grayscale scores of 50 early childhood physical education teachers are shown in Figure 6. After inputting the survey data into the gray multilevel evaluation model, the core literacy grayscale scores of the 50 early childhood physical education teachers were obtained to be between 4.0 and 4.8, which were all in the interval of (4,5], so the core literacy of the 50 early childhood physical education teachers was at an excellent level. Early childhood

physical education teachers with good core literacy can provide a good teaching atmosphere for young children's physical education learning, which is undoubtedly the most important for young children's strong body and healthy growth. The results obtained in the validation of the core literacy index system for early childhood physical education teachers constructed in this paper do not differ much from the predicted results, which proves that the system is scientific and effective, and can more accurately reflect the actual level of core literacy of physical education teachers.

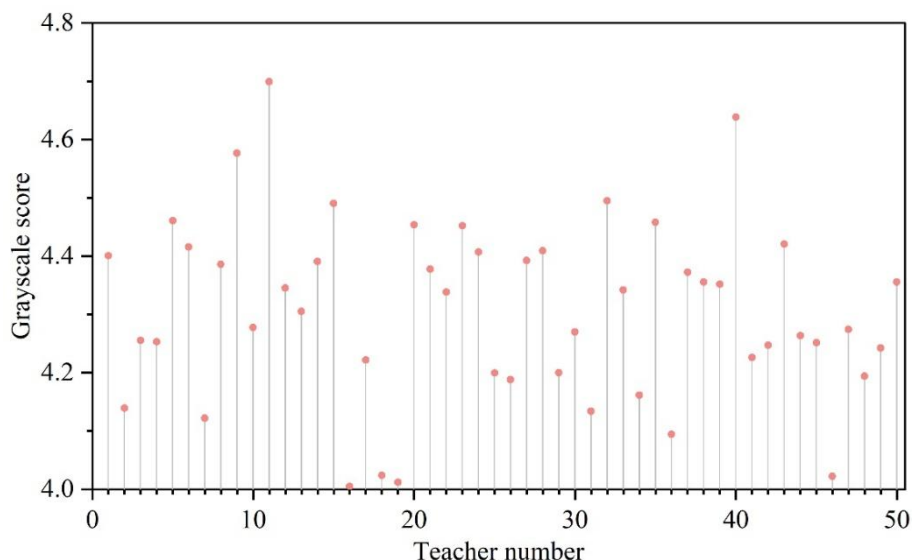


Figure 6: The core accomplishment grayscale score of 50 children's sports teachers

5 Conclusion

In order to accurately assess the core literacy of early childhood physical education teachers, the study established a relevant evaluation index system, analyzed the importance of the system's indexes through the hierarchical analysis method, and combined with the grey multilevel evaluation model to complete the evaluation of the core literacy of early childhood physical education teachers. Several early childhood physical education teachers were taken as research objects, and the way of example verification was used to explore the application value of the index system.

Through two rounds of screening of evaluation indexes, ideological character, professional knowledge, professional ability and innovative learning were identified as the first-level indexes, under which a total of 37 third-level indexes were included, and the weights of the 37 third-level indexes ranged from 0.0109 to 0.0594. The results of the questionnaire showed that the average scores of the 50 early childhood physical education teachers on ideology, professional knowledge, professional ability and innovative learning ranged from 3.85 to 4.58, and the core literacy grayscale score was calculated to be more than 4.0 according to the gray multilevel evaluation model.

The evaluation system constructed by the study has a certain degree of scientificity and validity, and it can reflect the real level of this core literacy of physical education teachers. However, because of the single experimental sample, the validity and scientificity of the indexes have not been completely verified.

About the Author

Shirong Wu was born in 1987 in Changde City, Hunan Province. She received the master's degree from Hunan Normal University, C.S. China. Her research interest include Sports humanistic sociology, information security and big data analysis.

Wenqi Hu, born in 1997 in Chenzhou City, Hunan Province, is currently pursuing her doctoral degree at School of Strength and Conditioning, ChangSha Normal University. And she is interesting in Athletic training and competitive sports.

Huijing Xiao was born in Chenzhou, Hunan Province in 1997. She studied at Changsha Normal University and obtained a bachelor's degree.

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