Research on the Construction of an Effectiveness Evaluation Index System for Middle School Physical Education Homework

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Abstract: This study adopts methods including the literature review method, Delphi method, Analytic Hierarchy Process (AHP), and mathematical statistics method. Based on the collation of relevant literature and results of expert interviews, preliminary effectiveness evaluation indicators for middle school physical education homework are formulated. These preliminary indicators are further screened, eliminated, and revised, and finally an effectiveness evaluation index system for middle school physical education homework is established, consisting of 4 first-level indicators, 18 second-level indicators, and 42 third-level indicators. After completing the reliability and validity tests of the system, AHP is used to calculate the weight values of the first-level, second-level, and third-level indicators of the middle school physical education homework effectiveness evaluation, all of which pass the consistency test. The construction of an effectiveness index system for physical education homework is an exploratory project. In subsequent studies, the scope of investigation should be further expanded, and the results should be promptly fed back into the existing index system.

Keywords: Physical Education Homework, Effectiveness, Evaluation Index System

1. Introduction

As an important way to improve the physical fitness of adolescents, physical education homework has attracted much attention. It can not only meet the sports needs of adolescents, enhance their enthusiasm for exercise, and implement the "Sunshine Sports - One Hour of Exercise Every Day" initiative, but also promote the goals of physical education teaching, boost students' physical and mental health, and help them develop lifelong physical activity habits. Middle school is a critical period of adolescence for teenagers. The *Compulsory Education Physical Education and Health Curriculum Standards (2022 Edition)* puts forward requirements for sports participation, motor skills, and physical health, making it imperative to urge students to engage in physical exercise [1]. Research on the effectiveness of physical education homework is an indispensable part of effective physical education teaching research. With the implementation of physical education homework systems in primary and secondary schools across various regions, analyzing the effectiveness of physical education homework holds significant practical significance. How to construct an effective and scientific index system for evaluating the effectiveness of middle school physical education homework is the main problem this paper aims to solve.

2. Research Status of the Effectiveness Evaluation Index System for Middle School Physical Education Homework

Through reviewing relevant domestic and foreign literature, it is found that foreign research on physical education homework is mainly quantitative, generally integrated into teaching process research, and mostly conducted through practice and case analysis [2]. In terms of domestic research, most existing literature focuses on analyzing the current implementation status of homework, existing problems, and corresponding countermeasures based on teachers' teaching experience summaries. These studies mainly explore the significance of homework, lacking substantive progress in uncovering the root causes of problems. Domestic research on homework effectiveness has yielded a certain scale of achievements; however, research specifically on the effectiveness of physical education homework is scarce. There is a lack of in-depth research on how to design efficient and reasonable physical education homework based on students' academic performance and individual differences, making further investigation necessary.

3. Research Methods

3.1 Delphi Method

The Delphi method is adopted in this study for the initially established middle school physical education homework evaluation index system. To ensure the expert validity of this study, experts with profound professional backgrounds and rich relevant teaching experience are selected. After three rounds of expert consultation, the final effectiveness evaluation index system for middle school physical education homework and its indicator weights are obtained [3]. Calculations show that the authority coefficients of the expert group in both rounds are greater than 0.8, indicating that experts' evaluation scores of the indicators are relatively high, which meets the criteria for indicator screening. According to the expert consultation results, the coordination coefficient of the first round of experts is 0.2883 ($\lambda^2 = 60.543$, P = 0.0361), and that of the second round is 0.4117 ($\lambda^2 = 43.928$, P = 0.0259). These results demonstrate good overall coordination of opinions among the expert group and high credibility of the evaluation indicators.

3.2 Analytic Hierarchy Process (AHP)

This study uses AHP to analyze the weights of each level of indicators in the physical education homework effectiveness evaluation index system. The main steps are as follows: first, construct the hierarchical structure of effectiveness evaluation indicators; second, invite experts to conduct pairwise comparisons of the importance of each factor in the hierarchical structure of the evaluation index system, thereby establishing a weight judgment matrix for effectiveness evaluation indicators with subordinate relationships; finally, calculate the weight values after passing the consistency test of the judgment matrix.

3.3 Mathematical Statistics Method

The collected expert consultation forms and relevant questionnaires are organized into data, which are input into Excel software to establish a database for calculating the expert activity coefficient, authority coefficient, and coordination degree of expert opinions. The questionnaire data are imported into SPSS 22.0 software for factor analysis to verify the reliability and validity of the index system. The weight values of the expert questionnaire data are sorted and calculated to obtain the weights of the effectiveness evaluation index system.

4. Construction of the Effectiveness Evaluation Index System for Middle School Physical Education Homework

4.1 Screening and Determination of Effectiveness Evaluation Indicators

The selection of indicators for the evaluation system is a process that requires scientificity, practicality, thinking, and analysis. Therefore, it is necessary to establish a scientific, reasonable, and practical evaluation index system for the effectiveness of physical education homework. The preliminary screening of indicators is the initial stage in constructing the effectiveness evaluation index system for middle school physical education homework. The preliminary indicator screening process is based on reading a large number of literature materials and, after communicating with experts, summarizes and organizes the general scope of indicators included in the effectiveness evaluation system for middle school physical education homework. The complete process of physical education homework should include four links: homework design, homework assignment, homework evaluation, and homework feedback, forming a complete closed-loop system. These four links cover all activities of physical education homework under the guidance of effective teaching concepts in chronological order. After determining the four first-level indicators, in-depth analysis is conducted on the second-level indicators included in each first-level indicator and the third-level indicators under the second-level indicators. An initial evaluation index system consisting of 4 first-level indicators, 17 second-level indicators, and 44 third-level indicators is established.

4.2 Optimization and Improvement of the Effectiveness Evaluation Index System

The quality of an evaluation index system depends on whether the indicator selection method is reasonable and whether the number and content of indicators are appropriate[4]. Therefore, adopting

appropriate methods and screening reasonable content is crucial for the construction of the index system. On the basis of the initially established evaluation indicators, expert opinions are consulted to screen, adjust, and revise the original indicators, further refining and improving the effectiveness evaluation index system for middle school physical education homework. Through descriptive statistical analysis of the data and two rounds of expert verification, the indicators are modified and eliminated. The average score of all indicators for evaluating the effectiveness of middle school physical education homework is above 4, the coefficient of variation of each indicator is less than 0.25, and the corresponding P-values are all less than 0.05. This indicates that experts have a high degree of recognition of the evaluation indicators and that the finally obtained effectiveness evaluation index system for middle school physical education homework has gained unanimous approval from experts.

4.3 Verification of the Effectiveness of the Evaluation Index System

To verify the scientificity and rationality of the index system, it is necessary to conduct reliability and validity tests on the index system. Currently, there is no available scale for constructing the effectiveness evaluation index system for middle school physical education homework. Drawing on the research experience of Hu Qingshan (2019) [5], a questionnaire for evaluating the effectiveness of middle school physical education homework is compiled based on the established index system, with a total of 42 questions. After collecting the questionnaires, the data are input into SPSS 22.0 software for factor analysis to conduct reliability and validity tests.

4.3.1 Reliability Test

The scale developed in this paper has 4 dimensions: Homework Concept, Homework Assignment, Homework Evaluation, and Homework Feedback. Among them, the Homework Concept dimension (B1) includes 15 measurement variables, the Homework Assignment dimension (B2) includes 11 measurement variables, the Homework Evaluation dimension (B3) includes 9 measurement variables, and the Homework Feedback dimension (B4) includes 7 measurement variables. SPSS 22.0 software is used to test the consistency coefficient of the number of items. The overall Cronbach's α coefficient of the survey scale is 0.791, indicating that the 42 items in the survey scale of the middle school physical education homework effectiveness evaluation index system meet the statistical reliability requirements, and the overall reliability of the questionnaire is very good, so it can be adopted.

4.3.2 Validity Test

The validity test in this paper includes construct validity test and content validity test. Through multiple rounds of screening, elimination, and revision of indicators using the Delphi method, the final effectiveness evaluation index system for middle school physical education homework is formed. Moreover, the expert authority coefficient and coordination coefficient are relatively high, so it can be considered that this evaluation index system has good content validity (see Table 1).

Table 1. Summary of Expert Authority Coefficients and Coordination Coefficients for Expert Consultation Indicators

Survey Round	Familiarity Coefficient (Ca)	Judgment Coefficient (Cs)	Coordination Coefficient (W)	Chi-Square Value (λ^2)	Significance (P)	Authority Coefficient (Cr)
First Round	0.83	0.81	0.2883	60.546	0.0361	0.82
Second Round	0.84	0.86	0.4117	43.928	0.0259	0.85

Exploratory factor analysis is used to test the construct validity, with principal component analysis as the analytical method. SPSS 22.0 software is used to conduct the KMO test and Bartlett's spherical test to determine whether factor analysis is feasible[6]. The KMO test and Bartlett's spherical test are conducted on the measurement items and overall validity of the questionnaire, resulting in a KMO value of 0.827 and a Bartlett's spherical test result of 3990.758 (Sig. is significant) (see Table 2). This indicates that principal component analysis can be conducted on this questionnaire survey. Principal component analysis is performed on the questionnaire data using SPSS 22.0 statistical analysis software. The results show that four factors can be extracted from the questionnaire data, and the grouping of each factor is consistent with the grouping of the questionnaire's preset dimensions. Varimax rotation is performed on the 4 main factors, and the component loadings of all 42 items after rotation are greater than 0.5, indicating that the construct validity of this questionnaire is acceptable. In summary, the survey sample data of this study have statistical significance, and the overall reliability and validity of the questionnaire are good. The Cronbach's α coefficients of the four measurement dimensions in the table below are all

greater than 0.7, indicating a high degree of reliability. The overall Cronbach's α coefficient of the survey scale is 0.791, indicating that the 42 items in the survey scale of the middle school physical education homework effectiveness evaluation index system meet the statistical reliability requirements, and the overall reliability of the questionnaire is very good, so it can be adopted (see Table 3).

Table 2. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.827
Bartlett's Test of Sphericity	Approx. Chi-Square	3990.758
	df	861
	Sig.	0.000***

Table 3. Variable Reliability Test Table

Dimension	Number of Items	Cronbach's α Coefficient
Homework Concept	15	0.723
Homework Assignment	11	0.846
Homework Evaluation	9	0.814
Homework Feedback	7	0.782
Overall Questionnaire	42	0.791

After expert screening via the Delphi method and reliability and validity tests, the final evaluation index system is constructed, including four first-level indicators ("Homework Concept", "Homework Assignment", "Homework Evaluation", and "Homework Feedback"), 18 second-level indicators under the first-level indicators, and 42 third-level indicators.

4.4 Weight Analysis of the Effectiveness Evaluation Indicators for Middle School Physical Education Homework

4.4.1 Construction of the Hierarchical Structure for Effectiveness Evaluation Indicators

In this study, a hierarchical structure is constructed to input the results of experts' pairwise comparisons into the analysis software. Based on the previously constructed effectiveness evaluation index system for middle school physical education homework, a questionnaire on experts' weight opinions is designed. Experts are invited to assign values to the importance of evaluation indicators at all levels. Referring to the judgment matrix evaluation scale for indicators at the same level, experts use scale values to measure the importance of two indicators when comparing them. After collecting the expert questionnaires, the experts' scoring results are entered into Yaahp 12.0 software, and calculations are conducted by constructing a judgment matrix for hierarchical indicators.

4.4.2 Weight Results of the Effectiveness Evaluation Indicators

After calculation, the CR values of all judgment matrices do not exceed 0.1, indicating that all judgment matrices have passed the consistency test and their consistency is within an acceptable range. Subsequently, the weight values of indicators at all levels are obtained. The comprehensive weights of indicators at each level are derived using the Analytic Hierarchy Process (AHP), and the final weight table of the effectiveness evaluation index system for middle school physical education homework is summarized (see Table 4).

Table 4. Effectiveness Evaluation Index System and Indicator Weights for Middle School Physical Education Homework

First-level Indicators	Weight	Second-level Indicators	Weight	Third-level Indicators	Weight
Homework Concept	0.2614	Diverse Values	0.0599	Physical Fitness	0.0262
				Stress Relief	0.0082
				Mood Regulation	0.0155
				Social Competence	0.0101
		Common	0.0284	Mental Health	0.0098

		Characteristics		Physical Development Features	0.0068
				Psychological Development Features	0.0046
				Thinking Ability	0.0072
		Individual Characteristics	0.0220	Interests and Hobbies	0.0045
				Physical Conditions	0.0109
				Emotional Personality	0.0066
		Homework Subjects	0.0399	Teacher Leadership	0.0210
				Student Autonomy	0.0189
		Teaching Relevance	0.1113	Appropriate Connection	0.0534
				High Adaptability	0.0579
Homework Assignment	0.3031	Homework Type	0.0177	Combination of Demonstration and Competition	0.0059
				Combination of Online and Offline	0.0118
		Homework Content	0.1514	Safety and Reliability	0.0560
				Laws of Physical and Mental Development	0.0383
				Physical and Intellectual Participation	0.0312
				Social Practice Participation	0.0259
		Homework Load	0.0436	Heart Rate Range	0.0436
		Completion Time	0.0429	Time Range	0.0429
		Completion Form	0.0178	Independent and Cooperative Homework	0.0059
				Specialized and Comprehensive Homework	0.0119
		Openness Degree	0.0297	Multi-party Participation	0.0297
Homework Evaluation	0.2313	Evaluation Time	0.0497	Evaluation Time	0.0497
		Evaluation Participation	0.0244	Teacher Participation	0.0042
				Student Participation	0.0058
				Joint Participation	0.0144
		Evaluation Dimensions	0.1146	Motor Skill Mastery	0.0232
				Homework Completion Attitude	0.0434
				Health Knowledge Mastery	0.0479
		Evaluation Type	0.0427	Process-oriented Evaluation	0.0165
				Summative Evaluation	0.0262
Homework Feedback	0.2042	Feedback Content	0.1067	Content Appropriateness	0.0520
				Content Diversity	0.0249
				Content Targetedness	0.0298
		Feedback Time	0.0293	Feedback Time Range	0.0293
		Feedback Form	0.0682	Descriptive Feedback	0.0384
				Formative Feedback	0.0195
				Critical Feedback	0.0104

According to the weight statistics, the first-level indicators in descending order of weight are: Homework Assignment (0.3031), Homework Concept (0.2614), Homework Evaluation (0.2313), and Homework Feedback (0.2042). It can be seen that in the evaluation process of physical education homework, Homework Assignment is more important than other links, and the weight distribution of the four first-level indicators is relatively balanced overall. Among the second-level indicators under "Homework Concept", "Teaching Relevance" (0.1113) accounts for a significant weight, indicating that the design concept of physical education homework should be guided by relevance to physical education teaching content. In the "Homework Assignment" dimension, "Homework Content" has the highest weight. Therefore, in the homework assignment process, the focus should be on "Homework Content" (0.1514): grasping the physical and mental development characteristics of junior high school students and assigning targeted physical education homework. Secondly, the "Homework Load" indicator (0.0436)

should be given priority consideration: insufficient physical education homework load cannot achieve the exercise effect, while excessive load may have adverse effects on physical development. Similarly, "Completion Time" (0.0429) should not be ignored; physical education homework should be controlled within a reasonable time range to ensure that it does not affect the completion of homework for major subjects while allowing students to exercise moderately and achieve a balance between study and rest.

Under the "Homework Evaluation" dimension, "Evaluation Dimensions" (0.1146) have an absolutely important weight, and comprehensive consideration should be given to the mastery of motor skills, attitude towards homework completion, and mastery of health care knowledge. At the same time, "Evaluation Time" (0.0497) and "Evaluation Type" (0.0427) should be considered—whether the evaluation time is timely and the choice of evaluation type are also key factors in the evaluation dimension of physical education homework.

In the "Homework Feedback" dimension, experts believe that the "Feedback Content" indicator (0.1067) is the most important. Physical education teachers should provide students with homework feedback at an appropriate time (0.0293), and the main form of feedback should be descriptive feedback (0.0384).

5. Conclusions

This paper constructs an effectiveness evaluation index system for middle school physical education homework in China, including 4 first-level indicators (Homework Concept, Homework Assignment, Homework Evaluation, and Homework Feedback), 18 second-level indicators, and 42 third-level indicators. The weights of the first-level, second-level, and third-level indicators are calculated using the Analytic Hierarchy Process (AHP), and all pass the consistency test. This indicates that the construction of the evaluation index system is scientific and reasonable. Efforts should be made to strengthen the organic integration of the physical education homework evaluation index system with teaching practice, continue to improve and refine the effectiveness evaluation index system for middle school physical education homework [7], and promptly identify deficiencies in the evaluation index system. Future research should cover a wider range of regions, further expand the scope of investigation, and promptly feed back the results into the existing index system.

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