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Improvement of Children's Negative Psychology Based on Cooperative Learning

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Abstract

This paper introduces structural equation model (SEM) to study the improvement of children's negative psychology through cooperative teaching of PE, and analyzes the interaction effect, regulation effect, and mediating effect involved in the problem. Next, the proposed SEM was reconstructed into a self-organizing path constrained neural network (SOPCNN), and the results of latent variables and observable indices were aggregated. Experimental results show that the application of cooperative teaching in PE can effectively improve the negative psychology of children. The research results provide a good reference and facilitate the practical research of improving children's negative psychology through cooperative learning.

Keywords: cooperative learning; physical education (PE); improvement of children's negative psychology

Introduction

The psychological health level directly affects the growth and development of children, and indirectly impacts the quality of talent cultivation for our society (Hasan et al., 2021; Huang et al., 2021; Othman et al., 2021; Pinna et al., 2018; Sekine et al., 2021;). Currently, China attaches great importance to the psychological health education in physical education (PE) learning (Chen et al., 2021; Eoh and Park, 2021). Children education workers are faced with the important task to study the functional attributes and features of physical education (PE) teaching model in improving children's negative psychological symptoms, and to explore and implement scientific, creative, and practical cooperative PE teaching model.

To identify the causes of the psychological problems of rural left-behind children, Su et al. (2020) tested the intervention of physical exercise in the psychological problems of these children and discovered that fixed exercise time and fixed exercise frequency help rural left-behind children improving their negative psychological symptoms.

On the research of children's psychological intervention, the common approaches include questionnaire survey, interview, experiment, and mathematical statistics (Kazakova et al., 2019; Sun et al., 2019; Straten et al., 2020; Zainuddin and Ihsan, 2013). Through multi-stage stratified cluster random sampling, Brassell et al. (2016) surveyed and evaluated the psychological health of newly admitted children, and analyzed the effects of multiple factors (e.g., admission features, age, rearing environment) on children's psychological health, using online survey and logistic regression model. Hankala et al. (2017) learned that the development of children's psychological health is greatly affected by parent-child relationship, and family parenting style. In addition, they examined the influence of children's socialization level and peer relationship under different parent occupations, and different parent-child interaction situations, drawing on Bronfenbrenner's ecological systems theory.

The teaching model of cooperative learning has been widely used in PE scenes (Artishcheva, 2018; Carpenter et al., 2014; Hser et al., 2015; Minatoya et al., 2016; Peyton et al., 2019; Russo et al., 2021; Wang, 2020; Yas et al., 2021). Walczak et al. (2018) optimized the existing children's tennis teaching model, and developed classroom teaching strategies and cooperative learning methods, which are in line with children's development features of personality, physics, and psychology. Introducing cooperative learning into children's learning process can effectively improve their insight and cognitive ability, enabling them to produce more effective behaviors, get more confident, and acquire better social skills and implicit thinking (Beeber et al., 2008; Fergeus et al., 2017; Larriba et al., 2016; Larriba et al., 2015; Turner et al., 2021). The existing studies mainly monitor children's psychological health through questionnaire survey, which cannot bring highly accurate evaluation results. The research into the relationship between PE teaching and psychological health emphasizes on quantitative analysis, and the implementation paths of relevant teaching modes (Palit et al., 2006; Zhang et al., 2020).

To draw convincing conclusions, this paper introduces structural equation model (SEM) (Zhang et al., 2020) to study the improvement of children's negative psychology through cooperative teaching of PE. Section 2 constructs an SEM for the influence of cooperative PE teaching model on children's negative psychology, and analyzes the interaction effect, regulation effect, and mediating effect involved in the problem. Section 3 reconstructs the proposed SEM into a self-organizing path constrained neural network (SOPCNN) and aggregates the results of latent variables and observable indices. Finally, experiments were carried out to prove that the application of cooperative teaching in PE can effectively improve the negative psychology of children. Through experiments and comparative analysis, it is learned from the relevant data

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that cooperative learning-based PE teaching promotes children's psychological health and provides a good reference and facilitate the practical research of improving children's negative psychology through cooperative learning.

SEM Construction and Effect Analysis

Model construction

Because our research problem is not constrained by the number of endogenous variables, measurement error of variables, or residual term, this paper applies the SEM, which overcomes the defect of traditional factor analysis (i.e., the inability to estimate factor structure and factor relationship at the same time), to analyze the factors affecting children's negative psychology. The model can estimate factor structure and factor relationship simultaneously and can be reconstructed into a self-organizing path constrained neural network. In this way, it is possible to analyze the interactive effect, regulation effect, and mediating effect of the research problem at the same time.

Figure 1 shows the flow of SEM effect analysis.

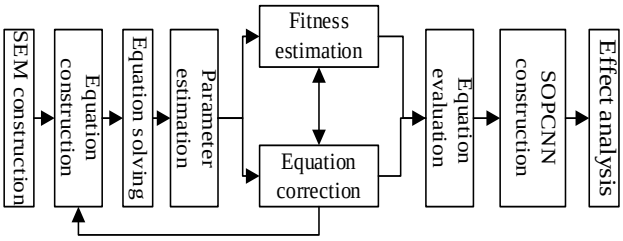


Figure 1. Flow of SEM effect analysis

To examine the influence of cooperative PE teaching model on children's negative psychology, the SEM mainly consists of two models: a measurement model and a structural model. Among them, the equations of the measurement model describe the relationship between the latent variables and observable variables of the problem, while those of the structural model describes the relationship between the latent variables.

Based on common scales of children's negative psychological response, it is assumed that the exogenous observable variables of children's negative psychology form a vector a, and the endogenous observable variables form a vector b. The relationship between a and exogenous latent variables can be described as a factor loadings matrix Ω_a, and that between b and endogenous latent variables can be described as a factor loadings matrix Ω_b. The exogenous latent variables form a vector Φ, and the endogenous latent variables form a vector γ. The error terms of a and b can be respectively described as Ψ and σ. Then, the equations of the measurement model can be established as:

$$a = \Omega_a \Phi + \Psi \quad (1)$$

$$b = \Omega_b \gamma + \sigma \quad (2)$$

Let ξ be the relationship between endogenous latent variables; δ be the influence of exogenous latent variables on endogenous latent variables; η be the residual term about the unexplained part of γ in the structural equation. Then, the equations of the structural model can be established as:

$$\eta = B\eta + \Gamma\xi + \zeta\gamma = \xi\gamma + \delta\Phi + \eta \quad (3)$$

Let φ, Γ_Ψ, Γ_σ, and Θ be the covariance matrices between exogenous latent variables. Then, the mean AV($\Phi\Phi'$) of $\Phi\Phi'$ equals φ. Let Γ_Ψ, Γ_σ, and Θ be the covariance matrices of error vector δ, σ, and residual term η. Then, AV($\Psi\Psi'$) $=\Gamma_\Psi$, AV ($\sigma\sigma'$) $=\Gamma_\sigma$, and AV ($\eta\eta'$) $=\Theta$. Finding the covariance on both sides on formula (1):

$$\begin{aligned} COV &= AV\left((\Omega_a\Phi + \Psi)(\Omega_a\Phi + \Psi)'\right) \\ &= AV\left((\Omega_a\Phi + \Psi)(\Phi'\Omega'_a + \Psi')\right) \\ &= \Omega_a AV(\Phi\Phi')\Omega'_a + AV(\Psi\Psi') \\ &= \Omega_a\phi\Omega'_a + \Gamma_\Psi \end{aligned} \quad (4)$$

The covariance matrices of a and b can be respectively expressed as:

$$\sum_{aa}(\omega) = \Omega_a\phi\Omega'_a + \Gamma_a \quad (5)$$

$$\sum_{bb}(\omega) = \Omega_b E(\gamma\gamma')\Omega'_b + \Gamma_\sigma \quad (6)$$

Let ψ be a unit matrix. Then, formula (3) can be transformed under the condition that ψ-ξ is an invertible matrix:

$$\gamma = (\psi - \xi)^{-1}(\delta\Phi + \eta) = \xi^*(\delta\Phi + \eta) \quad (7)$$

By formula (7), the following mean value can be solved:

$$\begin{aligned} &AV(\gamma\gamma') = AV\left[\left(\xi^*(\delta\Phi + \eta)\right)\left(\xi^*(\delta\Phi + \eta)\right)'\right] = \\ &AV[\xi^*(\delta\Phi + \eta)(\Phi'\delta' + \eta')\xi^{*\prime}] = \xi^*[\delta AV(\Phi\Phi')\delta' + \\ &AV(\eta\eta')]\xi^{*\prime} = \xi^*(\delta\phi\delta' + \Theta)\xi^{*\prime} \end{aligned} \quad (8)$$

Combining formulas (8) and (6):

$$\sum_{bb}(\omega) = \Omega_b\xi^*(\delta\phi\delta' + \Theta)\xi^{*\prime}\wedge{}'_b + \Gamma_\sigma \quad (9)$$

In addition, the covariance matrix between a and b can be expressed as:

$$\begin{aligned} &\sum_{ba}(\omega) = AV(ba') = AV[(\Omega_b\gamma + \sigma)(\Omega_a\Phi + \Psi)'] = \\ &AV[(\Omega_b\gamma + \sigma)(\Phi'\Omega_a{}' + \Psi')] = \Omega_b AV(\gamma\Phi')\Omega_a{}' + \\ &AV(\sigma\Psi') = \Omega_b AV(\gamma\Phi')\Omega_a{}' = \Omega_y\xi^*\delta AV(\Phi\Phi')\Omega_x{}' = \\ &\Omega_y\xi^*\delta\phi\Omega_x{}' \end{aligned} \quad (10)$$

Similarly, $\sum_{ab}(\omega)$=AV (ab') $=\Omega_a\varphi\delta\xi^{*\prime}\Omega_b'$. The covariance matrix of (b', a')' can be expressed as:

$$\begin{aligned} &\Sigma(\theta) = \begin{pmatrix} \sum_{bb}(\omega) & \sum_{ba}(\omega) \\ \sum_{ab}(\omega) & \sum_{aa}(\omega) \end{pmatrix} = \\ &\begin{pmatrix} \Omega_b\xi^*(\delta\phi\delta' + \Theta)\xi^{*\prime}\Omega_b{}' + \Gamma_\sigma & \Omega_b\xi^*\delta\phi\Omega_a{}' \\ \Omega_a\phi\delta'\xi^{*\prime}\Omega_b{}' & \Omega_a\phi\Omega_a{}' + \Gamma_\sigma \end{pmatrix} \end{aligned} \quad (11)$$

Formula (11) shows that the SEM of our problem contains eight parameter matrices: Ω_a, Ω_b, ξ, δ, φ, Θ, Γ_Ψ, and Γ_σ. These matrices must be estimated to solve the SEM.

Our SEM was set up in the light of the theories on cooperative PE teaching model and the empirical evidence on the intervention in children's negative psychology. For simplicity, the covariance matrix (5) of observable variables is denoted as R. During model solving, function fitting was adopted to import the fixed parameter values, the free parameter estimates, and R into the structural equation, and to update covariance matrix $\Sigma(\omega)$, with the aim to minimize its difference. This paper chooses the maximum likelihood estimation (MLE), i.e., the estimation that minimizes the value of fitting function G_{NK}. Let $tr(R\Sigma^{-1}(\omega))$ be the trace of matrix $R\Sigma^{-1}(\omega)$; $\log|\Sigma(\omega)|$ be the log of the determinant of $\Sigma(\omega)$; $\log|R|$ be the log of the determinant

$$G_{NK} = log|\sum(\omega)| - log|R| + tr\left(R\sum^{-1}(\omega)\right) - (e+s) \quad (12)$$

of R. Then, G_{NK} can be expressed as:

Effect analysis

Table 1

Features of cooperative PE teaching model

	Cooperation	Competition	Independence
Cooperation goals	Unified goals	Focusing on win or lose	Achieving respective goals
Teaching activities	Designed for the cooperative completion of complex, abstract works	Stressing the mastery of skills, abilities, and basic knowledge	Mastery of skills and knowledge
Teacher-student interactions	Supervision, participation, guidance, and coordination	Emphasizing on teachers' clarification of rules and disputes, and judgment of correct answers	Correcting and optimizing behaviors
Student interactions	Intra-group mutual encouragement, mutual assistance, and sharing	Inter-group fair competition	Sense of group honor, and enthusiasm for group activities
Learning space	Intra-group learning, and mutual learning	Inter-group fair competition	Independent learning space
Evaluation criteria	Using multiple criteria in the light of intra-group performance	Using multiple criteria in the light of inter-group performance	Focusing on comprehensive evaluation

From the features of cooperative PE teaching model (Table 1), the relationship between cooperation, competition, and independence reflects the superiority of cooperative learning to common learning models. Cooperative learning facilitates the formation of positive mutual assistance between children and their peers, improves their academic performance, and promotes the emotional exchanges and active behaviors between children.

According to statistics about the influence of cooperative PE teaching models on children's negative psychology, some promotes children's negative psychology from the aspects of cognition, emotions, and behaviors; some promotes children's negative psychology from psychological factors; some promotes children's negative psychology from self-efficacy; some exerts positive effects in multiple aspects. Therefore, the influencing factors interact with each other, and the interaction needs to be analyzed in detail.

Suppose the exogenous variable γ of children's negative psychology has two observable indices b_1 and b_2; the two endogenous latent variables Φ_1 and Φ_2 respectively correspond to two pairs of observable indices a_1 and a_2, and a_3 and a_4, respectively. The main effects and the interaction effect are denoted as β_1 and β_2, and β_3, respectively. Then, the interaction effect of Φ_1 and Φ_2 on γ can be described by the following SEM:

$$\gamma = \xi\gamma + \beta_1\Phi_1 + \beta_2\Phi_2 + \beta_3\Phi_1\Phi_2 + \eta \quad (13)$$

To prevent multicollinearity between indices, the two observable indices Φ_1 and Φ_2 were paired and multiplied to produce four product indices a_1a_2, a_1a_4, a_3a_2, and a_4a_2, serving as the observable indices of Φ_1 and Φ_2. Figure 2 shows the SEM of the interaction effect on children's negative psychology.

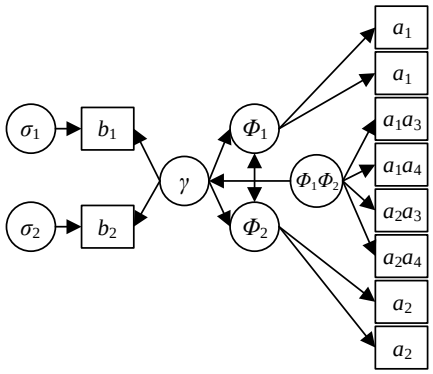


Figure 2. SEM of the interaction effect on children's negative psychology

Concerning children's negative psychology, the influence of explanatory variable a on explained variable b was analyzed. If a affects b via a mediator variable MV, the total effect of a on b can be denoted as r; the mediating effect of MV can be denoted as g, h; the direct effect can be denoted as r'. Then, the equations about the mediator variable can be established as:

$$B = rA + w_1 \quad (14)$$

$$MV = gA + w_2 \quad (15)$$

$$B = r'A + g \cdot MV + w_3 \quad (16)$$

If there is only one mediator variable, formulas (15) and (16) can be combined:

$$B = r'A + h(gA + w_2) + w_3 = (r' + gh)A + hw_2 + w_3 \quad (17)$$

Since the mediating effect must satisfy r=r'+gh, the magnitude of the effect can be measured by r-r'=gh. In the SEM of our problem, the latent variables are correlated and mutually interactive, under the mediating and regulation effects of mediator and regulation variables. Unlike the mediator variable, the regulation variable is not affected by

the explained and explanatory variables of children's negative psychology.

SOPCNN Construction

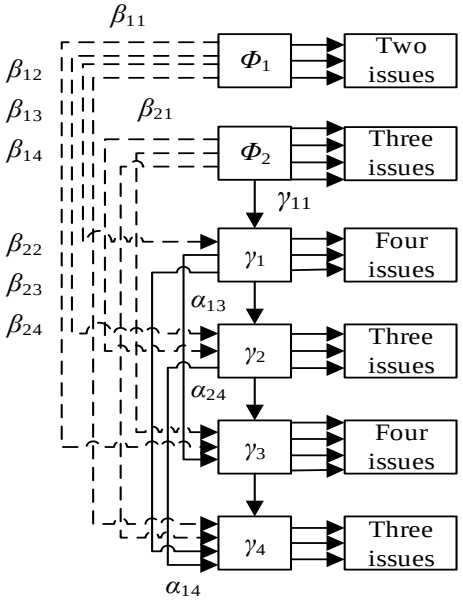


Figure 3. Children's negative psychology model

As shown in Figure 3, the proposed SEM of children's negative psychology involves six latent variables, including two explanatory variables (negative psychological symptoms Φ_1 and somatization Φ_2) and four explained variables (subjective PE intervention γ_1, stimulation of cooperative learning motivation γ_2, peer cognition and selection γ_3, and teamwork guidance γ_4). Let β_m denote the path coefficients from Φ_1 and Φ_2 to γ_1, γ_2, γ_3 and γ_4; α_{ij} denote the path coefficients among γ_1~γ_4. Then, the structural equation about the relationships between latent variables can be given by:

$$\begin{pmatrix}\gamma_1\\ \gamma_2\\ \gamma_3\\ \gamma_4\end{pmatrix}=\begin{pmatrix}0 & 0 & 0 & 0\\ \alpha_{21} & 0 & 0 & 0\\ \alpha_{31} & \alpha_{32} & 0 & 0\\ \alpha_{41} & \alpha_{42} & \alpha_{43} & 0\end{pmatrix}\begin{pmatrix}\gamma_1\\ \gamma_2\\ \gamma_3\\ \gamma_4\end{pmatrix}+\begin{pmatrix}\beta_{11} & \beta_{11}\\ \beta_{21} & \beta_{21}\\ \beta_{31} & \beta_{31}\\ \beta_{41} & \beta_{41}\end{pmatrix}\begin{pmatrix}\Phi_1\\ \Phi_2\end{pmatrix}+\begin{pmatrix}\sigma_1\\ \sigma_2\\ \sigma_3\\ \sigma_4\end{pmatrix} \quad (18)$$

Suppose $\Phi'=(\Phi'_1, \ldots, \Phi'_l)$, and $\gamma'=(\gamma'_1, \ldots, \gamma'_n)$. The coefficients of γ form an n×n matrix ξ, and those of Φ form an n×l matrix δ. The remaining vectors can be expressed as $\sigma_\gamma'=(\sigma'_1, \ldots, \sigma'_n)$. Then, the structural equation can be expanded into:

$$\gamma=\xi\gamma+\delta\Phi+\sigma_m \quad (19)$$

Every latent variable of children's negative psychology has N observable variables, each of which has M observations. Hence, all observations can be summarized as an M×N data matrix. Suppose the latent variables contain l explanatory variables and n explained variables. Let $L(\tau)$ be the number of observable variables corresponding to explanatory variable Φ_τ; $a_{\tau i}$ be the observable variables of Φ_τ (τ=1, …, l, i=1, …, $L(\tau)$); K(j) be the number of explanatory variables γ_j; b_{ij} be the corresponding observable variables (j=1, …, n, i=1, …, K(i)); Θ_{ij} and χ_{ij} be the aggregation coefficients; σ be the subscript of random error. Then, the observation equations can be established as:

$$\Phi_\tau=\sum_{i=1}^{L(\tau)}\theta_{\tau i}a_{\tau i}+\sigma_{a\tau},\tau=1,\ldots,l \quad (20)$$

$$\gamma_j=\sum_{i=1}^{K(j)}\chi_{ij}b_{ij}+\sigma_{bj},j=1,\ldots,n \quad (21)$$

The proposed SEM can be reconstructed into an SOPCNN topology. In the network, the input variables correspond to the observable variables of the problem, and the output variables correspond to latent variables Φ_τ (τ=1, …, l and γ_j, j=1, …, n). The relationship between output variables can be described by $\alpha_{\tau o}$ and $\beta_{\tau o}$ (o=1, …, n). Let u_{ij} and μ_{ij} be the loading coefficients. Following the idea of factor analysis, the relationship from latent variables to observable variables can be described by the following observation equations:

$$a_{\tau i}=u_{\tau i}\Phi_\tau+\sigma_{a\tau i},\tau=1,\ldots,l,i=1,\ldots,L(\tau) \quad (22)$$

$$b_{ij}=\mu_{ij}\gamma_i+\sigma_{bij},j=1,\ldots,n,i=1,\ldots,K(i) \quad (23)$$

Removing the random error, i.e., $\varepsilon\sigma$ with a subscript, in formula (21), a simplified expression can be obtained:

$$(a_{\tau 1},\ldots,a_{\tau L(1)})\approx(u_{\tau 1}\Phi_\tau,\ldots,u_{\tau K(1)}\Phi_\tau),\tau=1,\ldots,l \quad (24)$$

Transposing the above matrix and multiplying it with the original matrix:

$$\begin{pmatrix}a_{\tau 1}\\ \vdots\\ a_{\tau L(1)}\end{pmatrix}(a_{\tau 1},\ldots,a_{\tau L(1)})\approx \begin{pmatrix}u_{\tau 1}\Phi_t\\ \vdots\\ u_{\tau L(1)}\Phi_\tau\end{pmatrix}(u_{\tau 1}\Phi_\tau,\ldots,u_{\tau L(1)}\Phi_\tau) \quad (25)$$

The diagonal elements of the transposed and original matrices can be given by:

$$a_{\tau j}{}'a_{\tau j}\approx u_{ij}^2\Phi_\tau{}'\Phi_\tau,j=1,\ldots,L(\tau) \quad (26)$$

If Φ_τ is the unit vector, then $\Phi'_\tau\Phi_\tau=1$. In this case, u_{ij} can be calculated by:

$$\tilde{u}_{\tau j}{}'=\sqrt{a_{ij}^2a_{ij}},j=1,\ldots,L(\tau) \quad (27)$$

To complete the calculation of formula (27), the left side of formula (24) was scalar-multiplied with $(u_{i1}, \ldots, u_{iL(\tau)})'$, yielding that $u_{i1}a_{i1}+\ldots+u_{iL(\tau)}a_{iL(\tau)}\approx(u_{i1}{}^2+\ldots+u_{iL(\tau)}{}^2)\ \Phi\tau$. Assuming that $g=u_{i1}{}^2+\ldots+u_{iL(\tau)}{}^2$, we have:

$$\Phi_\tau{}^*=\frac{\tilde{u}_{\tau 1}}{g}a_{\tau 1}+\ldots+\frac{\tilde{u}_{\tau L(1)}}{g}a_{\tau L(1)} \quad (28)$$

Comparing formulas (28) and (20), it can be inferred that $\Theta_{ij}{}^*=(\Theta_{i1}{}^*\ldots\Theta_{iL(\tau)}{}^*)=(\tilde{u}_{i1}/g, \ldots, \tilde{u}_{iL(\tau)}/g)$. Since formula (20) is an indefinite equation and Φ_τ is not necessarily a unit vector, it is necessary to normalize Θ^*, i.e., to satisfy two conditions: the sum of all elements in Θ^* is $h=\tilde{u}_{i1}/g+\ldots+\tilde{u}_{iL(\tau)}/g$, and the estimation $\Theta=(\Theta_{i1}\ldots\Theta_{iL(\tau)})=(u_{i1}/gh, \ldots, u_{iL(\tau)}/gh)$. In Θ^*, all elements are nonnegative, and added up to 1. The latent variable Φ_τ can be estimated by:

$$\Phi''_\tau=\frac{\tilde{u}_{\tau 1}}{gh}a_{\tau 1}+\ldots+\frac{\tilde{u}_{\tau L(1)}}{gh}a_{\tau L(1)},\tau=1,\ldots,l \quad (29)$$

Similarly, χ_{ij} can be estimated based on formula (20).

Decision Tree (DT)-Based Evaluation of Children's Negative Psychology

This paper relies on DT algorithm to evaluate children's negative psychology under the intervention of cooperative PE teaching model. The evaluation rule is to select metrics as per the attributes of each explanatory variable and explained variable and divide the data samples to the given variable nodes. Let TS be the training sample set with class labels, which cover X different attributes (e.g., age, grade, type of school, and degree of PE intervention). Thus, there are X different classes $LU_i\{i=1, 2, 3, \ldots, X\}$. Let $LU_{i,\varepsilon}$ be the set of type LU_i samples in TS; $|s|$ and $|s_{i,TS}|$ be the number of samples in TS and $TS_{i,\varepsilon}$, respectively; EN(TS) be the entropy of the TS, which measures the chaos of mediating and regulation effects. Then, the expectation needed for classifying the samples in TS can be calculated by:

$$EN(s) = -\sum_{i=1}^{X} \frac{|s_{i,TS}|}{|s|} log2\left(\frac{|s_{i,TS}|}{|s|}\right) \quad (30)$$

If attributes SE= $\{e_1, e_2, e_3, \ldots, e_Y\}$ are discrete, TS can be divided into Y subsets $\{s_1, s_2, s_3, \ldots, s_Y\}$ accordingly. The samples in s_j (j =1, 2, 3…, Y) are valued c_j on attributes SE. The subsets correspond to the branches of TS. Then, we have:

$$EN[SE(s)] = \sum_{j=1}^{Y} \left|\frac{s_j}{s}\right| \times EN(s_j) \quad (31)$$

The variable entropy decrement induced by attributes SE can be calculated by:

$$\Delta EN(SE) = EN(s) - EN[SE(s)] \quad (32)$$

The variation in the gain rate of attributes SE can be defined as:

$$VG(SE) = \frac{\Delta EN(SE)}{PC(SE)} \quad (33)$$

where, PC(SE) is the information produced by dividing TS into Y outputs corresponding to SE:

$$PC[SE(s)] = -\sum_{j=1}^{Y} \frac{|s_j|}{|s|} \log_2\left(\frac{|s_i|}{|s|}\right) \quad (34)$$

Experiments and Results Analysis

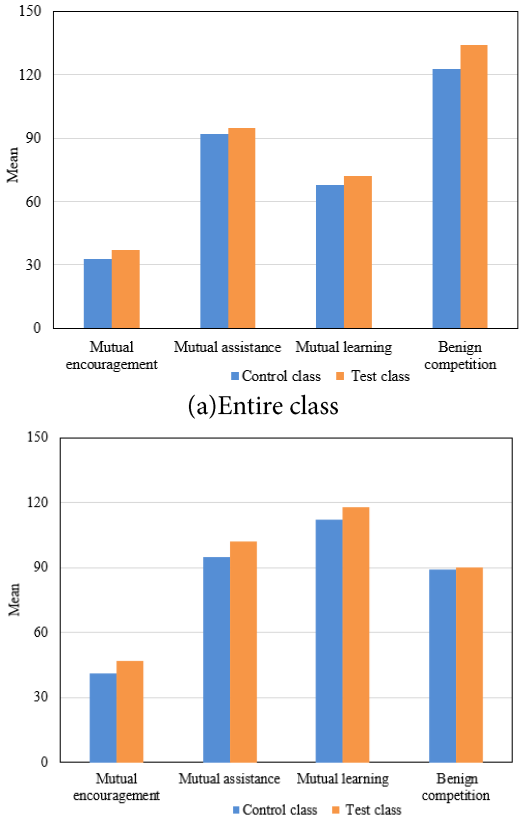
Before experiments, the feasibility of our research was demonstrated based on previous research:

(1) Web development and data mining are mature techniques. Thus, our model is technically feasible.

(2) Kindergartens and primary schools pay a high attention to psychological problems, attracting the interest of much researchers. Considering the low cost of data acquisition and project implementation, our research boasts favorable implementation conditions. Therefore, our research is financially feasible.

(3) Concerning specific operations, our simulation experiments are mainly about data collection and storage. The existing management and control of scientific data storage system are robust and accurate, making the research results more objective.

Experimental results show that the children in the test class, who learned under the cooperative PE teaching model, witnessed significant improvement of negative psychology through the experiment, especially in terms of interpersonal communication, inferiority, conceit, and anxiety. This further demonstrates our theoretical hypothesis: the application of cooperative learning in PE teaching can improve children's negative psychology, and the improving effect is closely correlated with the application elements of cooperative teaching model.



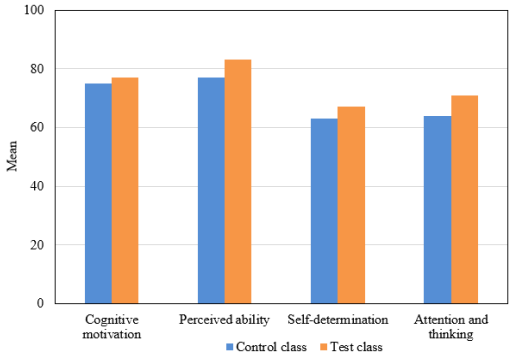
(a)Entire class

(b)Low-level group

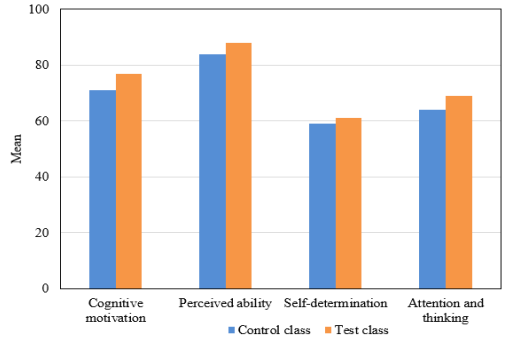
Figure 4. Learning attitudes of children before and after experiment

Figure 4 compares the children's learning attitudes before and after experiment. The overall situation of the entire class and the situation of the group with a low psychological health level are displayed in subgraphs (a) and (b), respectively. The control class was educated by the traditional teaching model, while the test class was educated by the cooperative PE teaching model, which following the principle of minimizing inter-group difference and maximizing intra-group difference. It can be inferred that the children in the test class were more active and enthusiastic in learning. This is because cooperative PE teaching model creates a relaxed learning atmosphere. Under the premise of enhancing physical exercise and physical fitness, the model stimulates the mutual encouragement, mutual assistance, mutual learning, and benign competition between children, relieves the intense learning pressure, and brings positive psychological states (i.e., confidence, and optimism) and feelings to children, thereby eliminating children's negative psychology. Compared with the entire class, the group with a low

psychological health level performed well in mutual learning and mutual assistance.



(a)Entire class



(b)Low-level group

Figure 5. Cognition, abilities, and self-efficacies of children before and after experiment

From the classroom records and observations of cooperative PE teaching, it is learned that cooperative PE teaching model can improve children's sports skill cognitive motivation, learning emotions, sports spirits, perceived sports ability, self-determination, as well as attention and thinking.

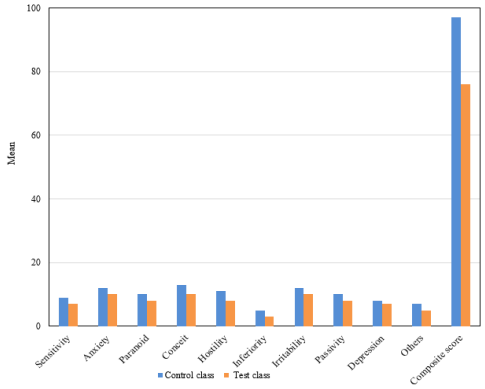
Figure 5 compares the cognition, abilities, and self-efficacies of children before and after experiment. The overall situation of the entire class and the situation of the group with a low psychological health level are displayed in subgraphs (a) and (b), respectively. In terms of sports skill cognitive motivation, the children learned to put their personal goals under group or class goals and had a stronger teamwork spirit and sense of group honor. Through cooperative PE teaching, the children perceived their own sports ability more clearly, and knew how to effectively improve team competitiveness by division of labor, cooperation, and giving full play to the strength of each teammate. Cooperative PE teaching made the children more attentive in class and think better and more actively. Compared with the entire class, the group with a low psychological health level performed well in perceived ability and cognitive motivation.

Table 2 lists the t-test results on children's psychological health level in test class and control class before experiment. Before the experiment, the authors sorted out the grouping, peer relations, and psychological health levels of the children in both test class and control class. According to the independent sample t-test, the P value was greater than 0.05 in all dimensions. That is, there is no significance difference between negative psychological factors. Hence, the two groups are homogenous in grouping, peer relations, and psychological health levels before the experiment.

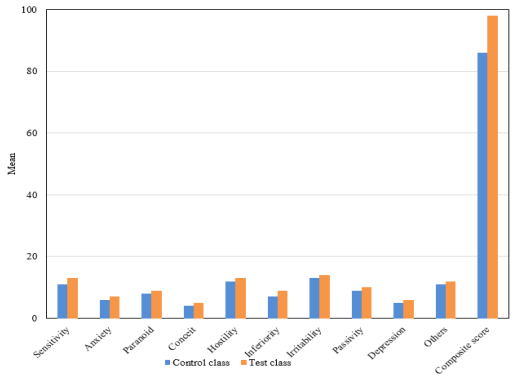
Table 2

T-test results on children's psychological health level in test class and control class before experiment

Negative psychological factors	Control class	Test class	t	p
Sensitivity	51.03±5.42	52.63±6.03	-1.323	0.192
Anxiety	19.36±3.07	19.42±3.82	-0.124	0.903
Paranoid	32.47±5.28	32.43±4.71	-1.008	0.319
Conceit	0.61±0.45	0.53±0.44	0.726	0.473
Hostility	1.18±0.53	1.12±0.57	0.769	0.442
Inferiority	1.05±0.59	0.92±0.56	1.254	0.209
Irritability	0.86±0.58	0.73±0.62	1.121	0.267
Passivity	0.84±0.62	0.78±0.57	0.457	0.643
Depression	0.79±0.53	0.76±0.63	0.002	0.997
Others	0.65±0.52	0.62±0.59	0.287	0.775
Composite score	0.86±0.41	0.75±0.43	1.045	0.293



(a)Before experiment



(b)After experiment

Figure 6. Children's negative psychological factors before and after experiment

Figure 6 compares the children's negative psychological factors before and after experiment. It can be observed that the students in the test class, who learned under the cooperative PE teaching model, had much better

psychological factors (e.g., sensitivity, anxiety, paranoid, conceit, hostility, inferiority, irritability, passivity, and depression) than those in the control class. The possible reasons are as follows:

Cooperative learning aims to enable the children to complete common tasks through division of labor and cooperation. The sensitivity, hostility and passivity can be effectively alleviated through the exchange and communication with others. The sense of group honor and good cooperation atmosphere can mitigate symptoms like paranoid, irritability, and anxiety. Once a child is accepted and recognized by others, he/she will feel less inferior and depressed. In addition, the all-round evaluation and timely feedbacks by teachers can correct the disagreement and disunity among the children. The complements from teachers can boost the sense of achievement of the children, making them more active about physical exercise.

Next, the relevant index data were processed through data analysis and statistical computation. The correlation matrix between cooperative PE teaching model and children's negative psychological factors are presented in Table 3.

Table 3

Correlation matrix between cooperative PE teaching model and children's negative psychological factors

	Negative emotions	Negative cognition	Negative behaviors	Somatization	Cooperative teaching utilization	Composite score of cooperative teaching
Negative emotions	1.000					
Negative cognition	-0.108	1.000				
Negative behaviors	0.157	-0.105	1.000			
Somatization	0.082	-0.009	0.067	1.000		
Cooperative teaching utilization	0.073	-0.043	0.085	0.268	1.000	
Composite score of cooperative teaching	0.259	-0.088	0.682	0.631	0.638	1.000
Mean	16.274	5.072	10.361	7.176	7.425	23.853
Standard deviation	7.456	4.098	3.276	2.507	2.473	5.312

The mediator should not be strongly correlated with explanatory or explained variables. This requirement does not apply to the regulation variable. Thus, the cooperative PE teaching model meets the test requirements on regulation variable test. As shown in Table 3, the cooperative PE teaching model is not significantly correlated with children's negative psychological factors. Therefore, cooperative PE teaching model has a high probability of serving as a regulation variable.

This paper takes subjective PE intervention, stimulation of cooperative learning motivation, peer cognition and selection, and teamwork guidance as explained variables, and treats negative psychological symptoms and somatization as explanatory variables. All these variables are continuous. Table 4 shows the regulation effect analysis results of each variable in cooperative PE teaching model. The results, which were obtained through centralization and hierarchy regression analysis, verify the importance of teachers to the implementation of cooperative teaching model.

Table 4

Regulation effect of each variable in cooperative PE teaching model

	Step 1	Regression equation	R^2
Subjective PE intervention	Step 1	Y=2.076+0.061X+0.083M	0.015
	Step 2	Y=2.087+0.062X+0.082M+0.451XM	0.016(0.002)
Stimulation of cooperative learning motivation	Step 1	Y=0.106+0.107X+0.108M	0.029
	Step 2	Y=0.107+0.108X+0.107M+0.112XM	0.030(0.002)
Peer cognition and selection	Step 1	Y=0.107+0.108X+0.109M	0.004
	Step 2	Y=0.108+0.109X+0.110M+0.105XM	0.006(0.002)
Teamwork guidance	Step 1	Y=0.103+0.104X+0.104M	0.089
	Step 2	Y=0.103+0.103X+0.103M+0.103XM	0.103(0.017)

Table 5

T-test results on children's learning attitudes before and after experiment

	Before experiment	After experiment	t	p
Mutual encouragement	51.07±5.39	52.31±7.65	-0.782	0.435
Mutual assistance	19.36±3.07	19.42±3.82	-1.978	0.057
Mutual learning	32.47±5.28	32.43±4.71	0.284	0.774
Benign competition	24.13±5.11	25.32±5.24	0.214	0.984

Table 6

T-test results on children's cognition, abilities, and self-efficacies before and after experiment

	Before experiment	After experiment	t	p
Cognitive motivation	51.07±5.39	52.31±7.65	-0.782	0.435
Perceived ability	19.36±3.07	19.42±3.82	-1.978	0.057
Self-determination	32.47±5.28	32.43±4.71	0.284	0.774
Attention and thinking	42.15±5.21	40.11±4.12	-0.656	0.921

Table 7

T-test results on children's negative psychological factors in control class and test class

Negative psychological factors	Control class	Test class	t	p
Sensitivity	0.62±0.47	0.83±0.54	-2.068	0.043
Anxiety	1.21±0.59	1.27±0.71	-0.475	0.628
Paranoid	1.05±0.58	1.02±0.66	0.336	0.742
Conceit	0.86±0.55	0.83±0.75	-0.107	0.925
Hostility	0.86±0.62	0.84±0.76	0.242	0.823
Inferiority	0.76±0.57	0.75±0.54	0.295	0.767
Irritability	0.68±0.53	0.72±0.68	-0.343	0.749
Passivity	0.81±0.51	0.67±0.53	1.198	0.234
Depression	0.66±0.49	0.59±0.41	1.203	0.231
Others	0.63±0.56	0.66±0.62	-0.051	0.953
Composite score	0.85±0.47	0.84±0.54	0.035	0.964

As shown in Tables 5-7, the learning attitudes of the children in control class did not change significantly in any dimension through the experiment, while their attention and thinking, and perceived ability improved significantly through the experiment; the factors like sensitivity, anxiety, passivity, and depression improved to different degrees through the experiment. The results further confirm the experimental conclusions above.

Conclusions

This paper introduces SEM to study the improvement of children's negative psychology through cooperative PE teaching. Firstly, an SEM was set up to examine how cooperative PE teaching model influences children's negative psychology, and the interaction effect, regulation effect, and mediating effect involved in the problem were analyzed in detail. After that, the proposed SEM was renovated into an SOPCNN, and the results of latent variables and observable indices were aggregated. Next, experiments were carried out to compare the children's learning attitudes, cognition, abilities, and self-efficacies before and after the intervention of cooperative PE teaching. The learning attitudes of the children before and after the experiment were subjected to t-test. Besides, the negative psychological factors of the children in control class and test class before and after the experiment also received t-test. The test results confirm that the children in the test class, who learned under cooperative PE teaching model, witnessed significant improvement to their negative psychology through the experiment.

Our research needs to be improved in the following aspects: the tracking method of children's negative psychology should be further developed; the children with psychological disorder should be tracked by setting up a psychological intervention file, thereby solving their negative psychology in time.

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