

A Research-Oriented Teaching Model for Public Physical Education in Colleges Based on Extenics Theory

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Lin Wang, Weifeng Deng ^(✉)
Hainan Vocational University of Science and Technology,
Haikou, China
18976257477@163.com

Abstract—This paper mainly designs a research-oriented teaching (ROT) model for public physical education (PE) in colleges based on extenics theory, which overcomes the limits and defects of the current ROT model for public PE in colleges. From the theoretical perspective, the extenics theory and method were discussed in details for implementing the ROT model for public PE in colleges. From the angle of engineering application, the authors designed an improved evaluation index system (EIS) for the implementation effect of the said ROT model, and developed the corresponding extenics superiority model, which quantifies the implementation effect. The research results further improve the ROT model for public PE in colleges.

Keywords—Research-oriented teaching (ROT), public physical education (PE), extenics theory, modern education

1 Introduction

Following the gradual improvement of the living standards and the rapid development of science and technology in modern society, high-level comprehensive talents have been increasingly needed in social development, and the role of modern education has been further highlighted. Meanwhile, quality-oriented education becomes the focus in modern education [1-4]. As an important part of modern education, physical education plays a very positive role in improving the comprehensive quality of contemporary college students. Especially for the non-PE majors, a systematic, scientific, and professional public PE curriculum is required [5-7]. For this, it is necessary to develop a ROT model of public PE suitable for modern education for cultivating college students' innovative ability. The ROT model of public PE has gradually become a hot issue of research in modern education [8-10]. Beschkova took Russian higher education as the research object and analyzed the potential educational space of comprehensive universities to develop college sports [11]. Based on the status quo and main problems during the PE discipline construction in ordinary colleges, Huang and Wang established a management model for the research-oriented public PE discipline [12]. Yang and Quan, taking the ROT model of track and field courses in colleges as the analysis object, and discussed the basic

theories and methods of implementing the ROT on this course in college PE [13]. In view of the existing problems with the current PE teaching model, Liu discussed the key content of the ROT model for PE, such as the guiding ideology, teaching process structure, and teaching method [14]. However, the public PE teaching is a systematic project involving multiple factors, and the implementation of ROT model will inevitably be affected by various conditions. In this process of developing a ROT model for public PE, it's necessary to deal with the constraints, and find ways to solve related problems. Therefore, this paper aims to design a new ROT model for public PE in colleges based on extenics theory [15-16].

This paper consists of six parts: The first part reviews the current research of the ROT for public PE in colleges; the second part discusses the limitations of the ROT model in college public PE; the third part analyzes the extenics theory and strategies for the implementation of the said model in colleges; the fourth part probes into the extenics methods to improve the implementation effect of the ROT model; the fifth part establishes the evaluation index system and evaluation model of the implementation effect; the last part gives the research conclusion of this study.

2 The Limits of Current ROT Model in College Public Physical Education

Judging from its current implementation effect for public PE in colleges, the ROT model plays a positive role in improving the theoretical support and teaching quality of college PE, and enhancing the transformation efficiency of PE research results and the integration of scientific research and practice. But with the in-depth implementation of the said model, there are still some limits in the following aspects.

2.1 Insufficient systematic planning of ROT model

The ROT model for public PE in colleges focuses more on the role of research-based factors in the PE teaching, and integrate scientific research and teaching, in order to improve the PE teaching quality, and then enhance the relevant professional teaching effects. This is an innovative teaching mode. It's the key and difficult point on how to effectively integrate scientific research and teaching in PE. As a new type of teaching model, the ROT model needs to go through a long process of exploration before the planning of research-oriented teaching and the establishment of a teaching system, not a process of accomplishing in an action. At present, the ROT model planning is still not systematic, which requires specific and in-depth discussion according to different teaching situations.

2.2 The lack of software and hardware supporting for the ROT model

The public PE in colleges is a teaching process that combines theory and practice closely. In this process, it needs not only the hardware supporting facilities such as good professional classrooms, teaching facilities, sports venues, laboratories, and

equipment, but also software supports such as sound professional teaching environment and teaching style, professional learning environment and style of study, professional teachers, and social recognition etc. As a new teaching model, the ROT requires the supports of these hardware and software facilities more urgently, to ensure its effective implementation for public PE in colleges. However, from the current implementation effect of the ROT model, there are still some deficiencies in the software and hardware supporting facilities, i.e., the configuration of hardware facilities, laboratory construction, the transformation of teaching concepts, and the construction of teaching staff. Thus, it requires to be further improved.

2.3 Weak faculty in the implementation of ROT model

The operation of the ROT model for public PE in colleges requires a certain number of high-level, high-quality and high-title professional talents in the field of sports. In the process of implementing the said model, these professional talents can research, analyze, and deal with the related problems, and propose constructive opinions and strategies, thereby providing important support for the continuous improvement and systematic development of the ROT model. At the same time, in order to improve the teaching quality of public PE, it is also necessary to have a group of high-level professional teachers. Therefore, from the perspective of disciplinary development and teaching quality improvement, it is of great significance to improve the faculty of public PE in colleges, especially for the implementation of the new teaching model. Nevertheless, the current faculty in the implementation of the ROT model for college public PE is relatively weak. First, there is a relative lack of senior talents with research-based professional levels; second, the ratio of brain drain to the introduction of professional talents is often unreasonable; third, sports professionals team building needs to be further enhanced.

2.4 Poor integration between management system and ROT model

A good management system is a key guarantee for the effective operation of the ROT model for public PE in colleges. It provides direction and guidance for the implementation of the model. However, for such a management system oriented to a new teaching model, it is often difficult to include all the various problems and unknown difficulties that may arise in the teaching process at the initial stage. Therefore, it is a process of gradual improvement. In this process, it is necessary to comprehensively consider human resource management, material resource management, and financial resource management, especially specific teacher management, teaching management, and student management, etc., and give scientific and reasonable solutions.

2.5 Inadequate teaching environment and atmosphere for the implementation of the ROT model

Different from the traditional test-oriented education model, modern education promotes quality-oriented education and pays more attention to the improvement of students' comprehensive quality. As a key component of student quality training, public PE naturally plays a very important role in modern education. But when a new or improved teaching model is introduced, there are often more obstacles in the early stages, so that the teaching concept is difficult to effectively change and the interest in learning is difficult to improve. This will inevitably affect the teaching environment and atmosphere for the implementation of the ROT model for public PE in colleges, thereby influencing the implementation effect, and making it difficult to effectively improve the teaching quality.

3 Implementation of the ROT Model for Public PE in Colleges Based on Extenics Theory

As above, there are still some problems in the implementation of the ROT model for public PE in colleges. To solve these problems, targeted analysis should be performed to determine reasonable solutions. In this paper, the extenics theory was adopted to implement the ROT model from the perspectives of four conjugate pairs.

3.1 Implementing the ROT model from the perspective of soft and hard parts

The physical things involved in the development of the ROT model for public PE in colleges are called the hard part, including human resources, financial resources, and material resources. The relationship between the physical things or the relationship between the physical things and the external objects involved in the said mode is called the soft part. It can be found that the software of the ROT model is composed of internal relations, external relations, and external connection relations between human resources, financial resources, and material resources. In the process of developing the ROT model, it can not only consider the hard or soft parts, but should be fully aware of the interaction between the two. Under the premise of improving the hard part's conditions, it's necessary to effectively dig out the relationship between the hard parts, and establish the relevant channel for the soft and hard parts. Besides, reasonable solutions should be adopted to deal with various associations, rationalize the implementation framework and execution strategies of the ROT model, and then provide support for promoting the implementation effect of the ROT model for public PE in colleges.

3.2 Implementing the ROT model from the perspective of latent and apparent parts

The explicit factors involved in the development of the ROT model for public PE in colleges are called the apparent part. From the formal point of view, the apparent part refers to the hardware facilities directly affecting the ROT model, such as stadium equipment, PE teachers, the quality of PE students, and the PE management system, which all have obvious influences on the implementation of the model. The implicit factors involved in the development of the ROT model are called the latent part. From the formal point of view, the latent part is manifested as restrictive conditions that indirectly affect the implementation of the model, such as the popularity of sports majors or disciplines, the graduate employment of PE students, the development potential of PE major, and the ability to introduce advanced talents. The latent part and the apparent part of this model are sometimes interchangeable. A good transforming relationship between the two parts will be beneficial to the development of the ROT model for public PE in colleges, and provide important support for the improvement of the PE teaching quality in colleges.

3.3 Implementing the ROT model from the perspective of material and non-material parts

The material content involved in the development of the ROT model for public PE in colleges is called the material part. From the formal point of view, the material part refers to the fund investment, infrastructure construction, discipline and professional construction, curriculum system construction, teaching staff, laboratory construction, etc. in the PE teaching process. The virtual content involved in the development of the ROT model is called the non-material part. From the formal point of view, the non-material part is manifested as the reputation and image of the school or professional, the recognition of the student training quality by the employer or social organization, the teaching environment and atmosphere of professional courses, professional scientific research or teaching ability, management ability, etc. As above, the material part is the base, while the non-material part is the means. Thus, in the process of implementing the ROT model, the attention should be paid not only to the impact of the material part on the teaching effect, which is often the most direct and important influence, but also that of the non-material part. Moreover, the two parts are mutually influenced and promoted. That is, according to the actual situation of the PE development, it can often use the advantages of the material part to solve the constraints and contradictions of the non-material part; conversely, the non-material part in the implementation of the ROT model for college public PE can also be adopted to promote the development of the material part, thereby forming a virtuous cycle of development.

3.4 Implementing the ROT model from the perspective of positive and negative parts

The positive part plays a positive role in the development of the ROT model for public PE in colleges. It includes the improvement of the basic condition investment in PE major, the improvement of teaching quality, the enhancement of teaching team building ability, laboratory construction ability, student employment rate, and curriculum system construction ability, etc. The negative part forms a negative constraint on the development of the ROT model, e.g., the over-high expenditure of sports disciplines or professional construction, loss of professional talents, and students high fail rate, and poor teaching reform ability, etc. There are sometimes inter-related or restrictive relations between the two. For example, although the high expenditure for PE discipline or professional construction is a negative influence, it can effectively promote the introduction of sports professionals, the construction of teaching teams, and laboratory construction., and greatly support the brand building of PE major, thereby attracting more social resources and funds to invest in the development of the PE major. Therefore, for both the positive and negative parts in the implementation of the ROT model for public PE in colleges, the focus should be on handling the internal promoting relationship between the two, rationally improving the positive parts, and effectively removing the negative influence and limitation of the negative parts.

4 Extenics Methods for Improving the Implementation Effect of the ROT Model for Public PE in Colleges

As above, it provides guidance for the selection of proper type of extenics-based strategies to deal with the problems existing in the implementation of the ROT model for public PE in colleges, and indicates the direction for improving the implementation effect of the said model. Besides, based on the extenics theory, for the relevant factors affecting the implementation of the ROT model, the corresponding matter-element models can be established in the form of four conjugate pairs: Soft and hard, latent and apparent, material and non-material, and positive and negative respectively.

4.1 Improving the implementation effect of the ROT model from the perspective of feature transformation

Aiming at the matter-element models of the ROT model for public PE in colleges, it's necessary to find out the matter-element features that affect the implementation effect of the models, and then analyze them from the perspectives of soft and hard, latent and apparent, material and non-material, and positive and negative parts. Then, through analysis for the relationship between the matter-element features of the same category, transformation operation such as replacement, adding, deletion, and combination was conducted, thus forming new matter-element features for the ROT

model of college public PE. According to the correlation, implication, and conductivity of the matter-element features in the ROT model, different feature transformation forms such as the single-to-single feature transformation, single-to-many feature transformation and many-to-many feature transformation can be developed on the basis of extenics theory, to improve the implementation of the ROT model in different means and ways.

4.2 Improving the implementation effect of the ROT model from the perspective of domain transformation

Generally, the ROT model for public PE in colleges is implemented mainly based on the perspective of PE major or disciplinary development. It focuses on the teaching and deepening of PE domain knowledge, including public PE teaching goal setting in colleges, teaching planning, teaching syllabus preparation, excellent textbook compilation, and professional direction deepening. However, from the development process of higher education, different majors or disciplines sometimes have strong similarities, and an effective teaching model in a certain major or discipline will provide great reference and guidance for others. Therefore, according to the established matter-element models, it is possible to analyze the domain characteristics of the ROT model for public PE in colleges based on the extenics theory, and establish the domain relationship between different majors or disciplines. Then, in response to the teaching needs during the implementation process, similar strategies in other majors or disciplines can be adopted. Similarly, various similar strategies can also be classified from the soft and hard, latent and apparent, material and non-material, and positive and negative parts, so as to provide more means and methods for the improvement of the implementation effect of the ROT model for public PE in colleges.

4.3 Improving the implementation effect of the ROT model from the perspective of value transformation

In a narrow sense, the purpose of the ROT model for public PE in colleges is to impart the teaching content of PE major and achieve the teaching objectives, so that the development of the PE professional teaching plan and the realization of the teaching objectives are completely consistent. In this process, it is often considered whether the corresponding teaching activities, teaching methods, teaching forms, teaching effects, teaching quality, and teaching atmosphere, etc. meet the preset goals and requirements. If they can achieve the teaching objectives of different PE major courses, it indicates a good implementation effect of the ROT model in colleges; otherwise, it means a poor implementation effect, and targeted measures are required. Combining with the established matter-element model, it can be found that the teaching objectives of PE courses are reflected by the corresponding matter-element feature values. If the matter-element feature values meet the extension correlation function of the ROT model, it means that the teaching goal of the PE professional course is achieved; otherwise it fails. At this time, the feature value of the matter

element or the corresponding can be transformed, to realize the divergent thinking of the teaching goal of the PE curriculum, and then achieve the teaching goal, which provides strategic support for improving the implementation effect of the ROT model for public PE in colleges.

5 Analysis for the Implementation Effect of the ROT Model for Public PE in Colleges

Extenics is a cross-discipline that studies the possibility of expanding things, and the rules and methods of innovation, and solves contradictory problems through the combination of formalization, logicalization, and mathematicalization. Extenics theory is the basic of extenics. It deals with contradictions in various fields by using formalized methods, expands engineering problems, and forms a set of effective intelligent design methods through qualitative and quantitative analysis.

5.1 Establishment of an evaluation index system

The authors believe that the ROT model for public PE in colleges is innovative, and its implementation effects need to be analysed from various aspects such as the improvement of basic teaching ability, the enhancement of teaching innovation and reform, the improvement of teaching management ability, and the teaching effect. The improvement of basic teaching ability mainly refers to the improvement of the basic professional ability and professional quality of public PE in colleges using the ROT model. It is specifically manifested in the professional level of PE teachers, the planning ability of research-based teaching tasks, and selection and teaching of research-based teaching content, the ability to formulate research-based teaching plans and outlines, the ability to introduce professional PE teachers, and the improvement of professional teacher team building. The enhancement of teaching innovation and reform ability mainly refers to the reform and innovation of public PE in colleges under the conditions of implementing the ROT model, which is reflected in the perfection of the PE curriculum system, the adaptability of the research-based teaching methods of the PE curriculum, the intelligence of the research-based teaching methods, the timeliness of the PE research-based content, the expansion of PE professional knowledge and skills, the improvement of the teaching environment, and the harmony of the PE course teaching atmosphere. The improvement of teaching management ability mainly refers to the improvement of the management efficiency related to human, material and financial resources involved in the teaching of public PE in colleges during the implementation of the ROT model, which is specifically manifested in the management system and incentive mechanism of PE teachers, software and hardware facilities management and application capabilities, PE major student management system and incentive mechanism, etc. Teaching effect refers to the teaching results achieved, which are specifically manifested in the innovation ability of PE major students, independent learning and research ability, the excellent rate and passing rate of students, the frequency of students participating in sports

competitions, the frequency of students winning sports competition awards, the number of awards for research-based teaching results, research-based teaching reform projects, high-level research-based teaching reform papers, the ability to transform PE teaching and scientific research, student learning enthusiasm and interest, and the satisfaction of social institutions with PE students, the reserve of skills and professional knowledge of sports majors, etc. Thus, the evaluation features can be extracted to construct a matter-element model based on the extenics theory and evaluate the implementation effect of the ROT model for public PE in colleges.

5.2 Division of extensional classical field and segment field

To effectively analyse the implementation effects of the ROT model for public PE in colleges, the corresponding implementation effects need to be divided into different evaluation grades. Generally, the evaluation grade of the implementation effect should be determined based on objective conditions. The improper selection of evaluation grade is not conducive to the effective judgment of the implementation effect. Assuming that there are m evaluation grades, then the extension classical field of the j -th evaluation feature at the k -th evaluation grade is given as:

$$U_{j-k} = [u_{j-k}^a, u_{j-k}^b], u_{j-k}^a \leq u_{j-k}^b, \quad 1 \leq j \leq n \quad (1)$$

In Equation (1) above, n represents the number of matter-element features, that is, the number of evaluation indicators.

The corresponding extension segment field is shown as:

$$U_j = [u_j^a, u_j^b] = \left[\min_{1 \leq k \leq m} u_{j-k}^a, \max_{1 \leq k \leq m} u_{j-k}^b \right], \quad u_j^a \leq u_j^b \quad (2)$$

5.3 The establishment of extenics superiority model

Based on the evaluation index system above, the initial evaluation data of the object P was obtained through investigation and statistical analysis etc. It's assumed that P 's initial evaluation data about the j -th evaluation feature is $V_j(P)$. If $V_j(P)$ is an accurate value, the related extenics theory can be adopted [17-18]; for the evaluation feature j , the extension distance between the object P and the extension classical field at the k -th evaluation grade is expressed as:

$$\rho_{j-k}(P) = \left| V_j(P) - \frac{u_{j-k}^a + u_{j-k}^b}{2} \right| - \frac{u_{j-k}^b - u_{j-k}^a}{2} \quad (3)$$

Similarly, for the j -th evaluation feature, the extension distance between P and the extension segment field is expressed as:

$$\rho_j(P) = \left| V_j(P) - \frac{u_j^a + u_j^b}{2} \right| - \frac{u_j^b - u_j^a}{2} \quad (4)$$

If $V_j(P)$ is a fuzzy value, that is, $V_j(P) = [v_j^a(P), v_j^b(P)]$, $v_j^a(P) \leq v_j^b(P)$, then for the j -th evaluation feature, the extension distance between P and the extension classical field at the k -th evaluation grade is expressed as:

$$\rho_{j-k}(P) = \left(\left| v_j^b(P) - \frac{u_{j-k}^a + u_{j-k}^b}{2} \right| + \left| v_j^a(P) - \frac{u_{j-k}^a + u_{j-k}^b}{2} \right| - v_j^b(P) + v_j^a(P) \right) / 2 \quad (5)$$

Similarly, for the j -th evaluation feature, the extension distance between P and the extension segment field is expressed as:

$$\rho_j(P) = \left(\left| v_j^b(P) - \frac{u_j^a + u_j^b}{2} \right| + \left| v_j^a(P) - \frac{u_j^a + u_j^b}{2} \right| - v_j^b(P) + v_j^a(P) \right) / 2 \quad (6)$$

On the basis of the extension distance, for the evaluation feature j , the extension correlation coefficient between P and the k -th evaluation grade is expressed as:

$$K_{j-k}(P) = \begin{cases} -\rho_{j-k}(P) / |U_{j-k}| & V_j(P) \in U_{j-k} \\ \rho_{j-k}(P) / (\rho_j(P) - \rho_{j-k}(P)) & V_j(P) \notin U_{j-k} \end{cases} \quad (7)$$

Different matter-element features (evaluation indicators) for the implementation effect analysis of the ROT model for public PE in colleges often have different weights. In order to obtain the comprehensive extension superiority between the object P and the k -th evaluation grade, it is necessary to obtain the weight of each matter-element feature. In this paper, AHP method [19-24] was used to analyse the weight of matter-element feature. Also, experts in the field were invited to compare and analyse the importance of n matter-element features, and to score them on the scale of 1-9. Thus, the corresponding comparison matrix was obtained, namely,

$$\mathbf{A} = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} = [a_{ij}]_{n \times n} \quad (8)$$

where, a_{ij} is the importance of the i -th matter-element feature relative to the j -th matter-element feature, $a_{ij} = 1/a_{ji}$. Table 1 lists the specific values of a_{ij} .

Table 1. Meaning of a_{ij} value

a_{ij}	Relationship between the matter-element features i and j
1	Same important
3	The former is slightly more important than the latter
5	The former is more important than the latter
7	The former is much more important than the latter
9	The former is extremely more important than the latter
2,4,6,8	Between the above-mentioned adjacent state relations
Reciprocal value	$a_{ij} = 1/a_{ji}$

It's solved to obtain the characteristic root λ_{max} corresponding to the largest eigenvector of the matrix **A**, and then there is a consistency index *CI*, namely

$$CI = (\lambda_{max} - n) / (n - 1) \tag{9}$$

Based on the number *n* f matter-element features, the random consistency index *RI* was obtained, then there is a consistency ratio *CR*, namely

$$CR = \frac{CI}{RI} = \frac{\lambda_{max} - n}{RI * (n - 1)} \tag{10}$$

If $CR < 0.1$, the weight of the *j*-th matter-element feature is given as:

$$w_j = \frac{\sum_{j=1}^n a_{ij}}{\sum_{i=1}^n \sum_{j=1}^n a_{ij}} \tag{11}$$

If not, it means that the matrix **A** does not meet the requirements of the consistency test. It is necessary to re-score the importance of matter-element features and establish a new importance comparison matrix until it meets the requirements of the consistency test.

From this, the extension superiority between the object *P* and the *k*-th evaluation grade can be derived as

$$\psi_k(P) = \sum_{j=1}^n (w_j * K_{j-k}(P)) \tag{12}$$

5.4 Model and algorithm implementation

After obtaining the extension superiority $\psi_k(P)$ between *P* and the *k*-th evaluation grade, the evaluation grade of the object *P* can be obtained by comparing the extension superiority between *P* and each evaluation grade, i.e., it satisfies:

$$\psi_s(P) = \max_{1 \leq k \leq m} \psi_k(P), \quad 1 \leq s, k \leq m \quad (13)$$

It indicates that P is at the s -th evaluation grade for implementation effect of the said model.

To sum up, the process of analysing the implementation effect of the ROT model for public PE in colleges was realized, as shown in Figure 1.

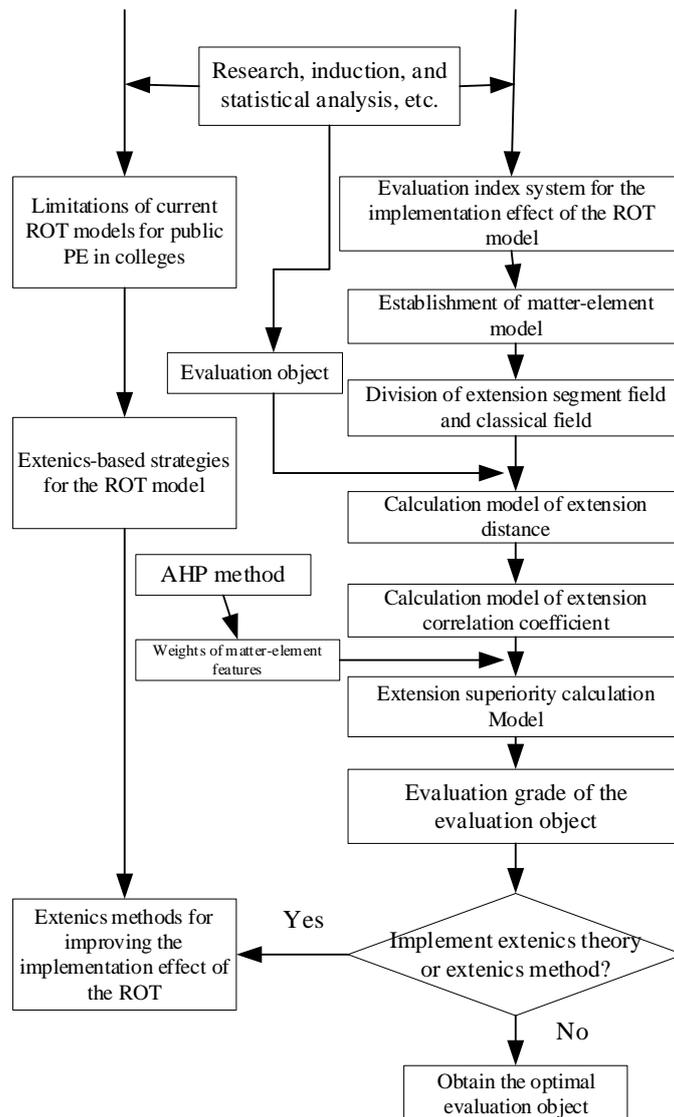


Fig. 1. Analysis for the implementation effect of the ROT model for public PE in colleges

6 Conclusion

The authors analyse the existing problems and limitations in the current ROT model of public PE in colleges, and discusses related influencing factors, which is of positive significance for understanding the current state of public PE in colleges.

The extenics theory and methods were applied in this paper to improve the implementation effect of the ROT model, which plays an important role in promoting the implementation of the ROT model for public PE in colleges.

An evaluation index system and an extension superiority model were established to analyse the implementation effect of the said ROT model based on the extenics theory, which provides support for the quantitative analysis of the implementation effect.

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8 References

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9 Authors

Lin Wang a Ph.D., and associate professor, is selected as the high-level talent in Hainan Province. He is the creator of Neutralization System, Tai Chi Yoga, Class I instructor of National Health Qigong, psychological counsellor, and senior Yoga Instructor. He has more than ten years of experience in teaching Tai Chi abroad, and is engaged in theoretical practice and research development of Tai Chi yoga, meditation and decompression, Health Qigong, physical and mental growth. He has taught hundreds of times at home and abroad. He has published several papers at home and abroad, including 7 monographs and 2 papers included in international conferences, presided over 1 provincial-level project, and won 2 national second prizes and 1 third prize for his papers. He studied for a bachelor degree of Physical Education and Training from Hebei Sport University in 1994-1998, a master degree in the School of Physical Education of Hebei Normal University in 1999-2001, and a PhD of theories and methods of physical education, sports training, health care and adaptive sports in Russian National University of Physical Education, Sports and Tourism in 2003-2007. He taught at the Department of Traditional Martial Arts, Hebei Institute of Physical Education in 1998-1999, at the School of Physical Education, Hebei Normal University in 2001-2002, and at the school of Sports Theory and Training, Russian Sports University in 2007-2015. Also, he worked as General Manager and Head Coach of Russian Tai Chi Center “Тайцзи Центр” in 2003-2016. Since 2017, he has taught in the School of Health Sciences, Hainan College of Vocation and Technique.

Weifeng Deng female, Han nationality, was born in December 1976. She graduated from English Department of Hebei Normal University with a bachelor degree in English in July 1999. In the same year, she was admitted to Hebei Normal University for a master degree in English Language and Literature. Since 2000, she was a part-time English teacher of Dingzhou Normal School for two consecutive years. In 2002, She studied in Russia for a doctoral degree. From April 2003 to November 2007, she also worked as a part-time Chinese teacher in various schools and training courses in Moscow. After returning to China in 2007, She worked as a translator for English and Russian. From September 2014 to July 2015, she was an English teacher and counsellor in Classes 1, 2 and 3 for the 2014 Simultaneous Interpretation majors in Hebei Foreign Studies University. Since July 2015, she has been a full-time English teacher in the Public Department of Hainan College of Vocation and Technique.

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