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The basic direction and realization path of teaching innovation of primary and secondary school physical education based on artificial intelligence

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Abstract

When the era of artificial intelligence comes in full swing, it is more important for primary and secondary schools to grasp the focus of teaching reform in the process of physical education reform and combine it with the actual situation to achieve teaching innovation. In this paper, we combine the characteristics of chaotic system such as randomness and ergodicity to improve the population diversity, thus forming a scheduling algorithm based on chaotic genetic algorithm. The improved genetic algorithm can standardize the physical education curriculum and complete the scheduling of it. Based on the calculation of the fitness function, conflicting lesson planning schemes can be eliminated. This ensures both the population size and the diversity of the population. Then some physical education courses in a university in Guiyang for the academic year 2021-2022 are used as experimental data, and the population size is now set to 100, and the number of iterations are 50, 100, 150, 200, 250 and 300, and the simulation experiments are analyzed. The results show that the chaotic genetic algorithm, however, reaches equilibrium at 150, converges quickly, and its fitness value is higher than that of the genetic algorithm, so the application of chaotic genetic algorithm in physical education innovation is feasible and effective. This study perfectly achieves the goal of physical education innovation by developing a reasonable curriculum plan.

Keywords: *Artificial intelligence, primary and secondary school physical education, teaching innovation, chaotic genetic algorithm, fitness function.*

Introduction

Under the background of new curriculum reform, the innovation and reform of physical education teaching mode in colleges and universities is an inevitable trend, which is also an important direction for the development of physical education in China (F, 2016; Liu M 2015). At the present stage, colleges and universities have maintained high attention to the overall development of college students, and they have taken the cultivation of innovative and high-quality talents as the key content of college education reform (G, 2018; Sun J M 2017). In this situation, physical education

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in colleges and universities needs to conform to the direction of the development of the times and reform the teaching system and teaching content in all aspects, so as to improve the quality of physical education in colleges and universities (D, 2018; Jin, 2018). The educational and teaching innovation and wide application of artificial intelligence and its facilities have greatly improved the performance of public physical education and its innovative reform in colleges and universities (Liu W 2017; Xiong Z Y 2015). Colleges and universities should keep pace with the times and pay attention to stimulating the interest and enthusiasm of college students in physical education learning and cultivating the awareness of lifelong exercise in addition to the cultivation of physical quality of contemporary college students (Jie Y U 2017; Qin M 2019).

The literature (H, 2018) suggests that with the diversified economic development and the continuous improvement of technology, it deeply roots and influences people's way of thinking and philosophy, and puts forward higher requirements for the improvement of students' physical quality.

Based on the necessity of constructing an innovative model of physical education in colleges and universities, literature (Yang S Q 2018) explores feasible ways to construct physical education courses in terms of their teaching weight, physical education concepts, and physical education course innovation system. The literature (I, 2010) proposes that in primary physical education, teachers provide innovative education and design interesting training methods according to the characteristics of physical education majors, so that students can actively participate in learning and training. Students should also be guided to engage in cooperative learning, communication and discussion to improve learning efficiency, effectively improve motor skills and overall motor skills, and achieve effective basic and physical education innovation education.

The literature (Zhao H P 2016) analyzes the significance of sports innovation talent training, and explores the path of building the innovation system of physical education and the strategy of innovation talent training. It aims to provide reference for physical education teachers to successfully accomplish the goal of training innovative talents in physical education.

The literature (J, 2015) analyzes the limitations of modern physical education from the perspective of contextual cognitive theory, deeply explores the necessity of introducing virtual reality technology into physical education, and constructs a new model of physical education teaching after applying virtual reality technology in consideration of improving teaching quality and innovative teaching methods.

In this paper, we propose to apply an improved genetic algorithm to the physical education scheduling problem by first arranging the physical education course information in a real number coding manner to form a chromosome and subsequently an initial population. Then the individual fitness F is determined and the outstanding parent individuals are selected, before chaotic crossover and chaotic mutation operations are performed.

In the process of physical education curriculum arrangement, the rules to be followed in accordance with the constraints of the physical education curriculum can be divided into two categories: one is the rules that must be implemented - hard rules, and the other is the rules that are satisfied as much as possible - soft rules, which in turn makes the physical education curriculum arrangement The work is done more efficiently. Students are divided into three different age groups: elementary, secondary (middle and high school) and higher education, each of which has significant physical and psychological differences. In physical education activities, educators should tailor their teaching to the students' needs, keep corresponding to the teaching ideology, design the teaching objectives to be achieved and choose the corresponding physical education model for each school section.

Finally, it is verified through simulation experiments that physical education based on chaotic genetic algorithm achieves more significant teaching effects and allows students to remember each action more clearly. In turn, students can cultivate good physical exercise habits and master the correct physical exercise methods, thus promoting the improvement of students' physical quality, physical and mental health, and being able to face their studies and life with ease, relaxation and pleasure.

Innovation of physical education teaching in primary and secondary schools under the background of artificial intelligence

Strengthen the application of artificial intelligence in physical education

Figure 1 shows the flow chart of the application of artificial intelligence in physical education. Primary and secondary school physical education teachers should use artificial intelligence to reform physical education, and the teaching advantages brought by artificial intelligence cannot be ignored. Teachers should use AI to design teaching programs that are tailored to students' individual situations and perfectly match their future growth and development, taking into account students' actual conditions.

The design process should take into account the students' limits, their desire to learn, and the matching teaching methods to ensure that students can play sports and learn about physical education in a fun and relaxed way within their limits. The teaching program relying on artificial intelligence should be different from person to person, which increases the teaching content and the teaching burden of physical education teachers to a certain extent, but brings students a more intuitive teaching effect, allowing them to accumulate more practical experience in sports and physical education, so that their practical ability can be significantly improved.

It can be said that the technical support of artificial intelligence has largely met the different physical education learning needs of students. It is a modern teaching innovation based on modern technology, integrating students' actual needs and personality characteristics.

To a large extent, AI optimizes the teaching mode of teachers, combining theory and practice, with

more emphasis on perfectly matching effective physical exercise programs to individual students, so that students' physical skills and physical fitness can be improved at the same time. This is an important step in the transformation of physical education in primary and secondary school physical education in the context of artificial intelligence, and is an efficient means to improve the current status of physical education.

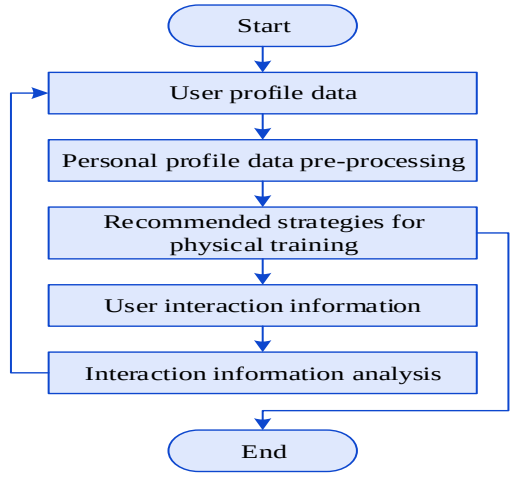

Figure 1. Application flow chart of artificial intelligence in physical education

Chaotic Genetic Algorithm in Physical Education Application

Figure 2 shows the flow chart of chaotic genetic algorithm. The improved genetic algorithm was applied to the study of physical education scheduling problem, firstly, the physical education course information was arranged in a real number coding way to form chromosomes, then the initial population, then the individual fitness F was determined, and the outstanding parent individuals were selected, before chaotic crossover and chaotic mutation operations were performed, and finally, the end conditions were judged.

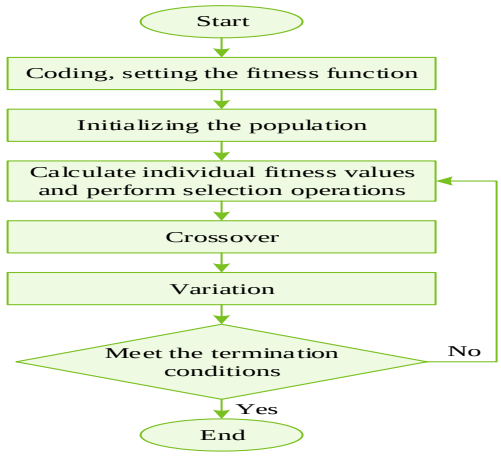

Figure 2. Flow chart of chaotic genetic algorithm

Coding

The essence of coding is to convert the scheduling problem into a problem that can be solved by a computer. The coding method determines not only the chromosomal arrangement of individuals, but also the method of their decoding. Thus the coding method is highly decisive for the efficiency of the genetic evolutionary operations of the population.

Figure 3 shows the two-dimensional table of time periods. In this paper, we use the real number coding method to code the physical education course information, assuming that there are five teaching days per week in the school, and each teaching day can be divided into five class periods, then there are 25 class periods in a week. Each day can be divided into five periods, so there are 25 periods in a week, which are denoted by $D_1, D_2, \mathrm{L}\ D_{25}$. Assuming that there are n classrooms in the school, the PE schedule for a week is represented by a two-dimensional table. According to the lesson plan, the teacher, the classes taught by the teacher, and the class to which the teacher belongs are determined and are represented as an element by A. By placing A in one of the cells of the two-dimensional table, this forms our physical education schedule for the week. Where the course includes the course name, the gender of the class (male, female, mixed), and the classroom includes the campus and the specific classroom number, whose value definition can be expressed by equation (1).

$$X_i Y_j = \begin{cases} XY, X_i \text{classroom}, Y_j \text{Time and class} \\ 0, X_i \text{classroom}, Y_j \text{No class on time} \end{cases} \quad (1)$$

We can therefore represent the weekly class schedule as a two-dimensional matrix. The rows represent the class locations and the columns represent the class times. The two-dimensional

matrix is shown in equation (2).

$$\begin{bmatrix} 0 & L & XY & L & XY \\ M & & M & & M \\ XY & & 1 & L & 1 \\ M & & M & & M \\ 0 & & 0 & & XY \\ M & & M & & M \end{bmatrix} \quad (2)$$

Assuming that the object of PE scheduling is XY, we know from equation (2) that if XY is scheduled in a classroom at a certain time, then we need to fill in XY in the corresponding position of the two-dimensional matrix of the class schedule; otherwise, we need to fill in 0 in the corresponding position, and 1 means that there is a class, but not a PE public class, but other types of classes, such as college English, Civics and other public classes.

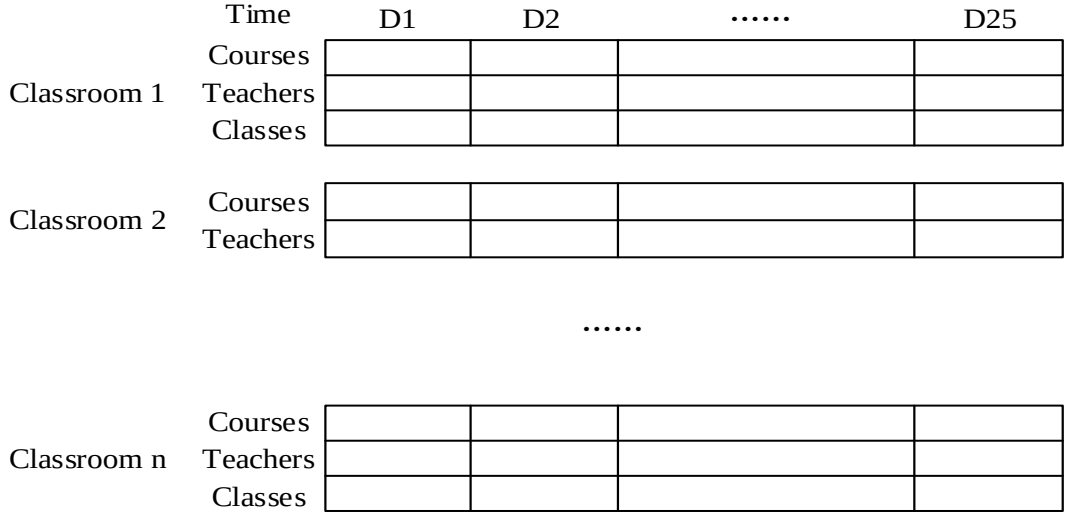

Figure 3. Time period two-dimensional table

Population initialization

Initialize each indicator to generate the population. Because the initial population, if chosen to be generated randomly, will make many individuals far away from the optimal solution, which limits the efficiency of the algorithm. Therefore, its convergence problem is related to its initialized population. In this paper, chaos algorithm is combined in the global search process to improve the computational speed, reduce the computational time, and improve the quality of the initial population. The initialized population is the chaotic mapping generated by n point denoted as:

$$X_{n+1} = \mu X_n \left(1 - X_n\right), n = 1, 2, 3, \mathrm{L}\ , n \tag{3}$$

where: μ denotes the control parameter.

When $\mu = 4$, enter the fully chaotic mapping. Therefore, we take $\mu = 4$ and initialize the initial value of X_n in the $Logistic$ mapping to get the initial population. In addition to this, since the hard constraints must be completed, we will check the hard constraints and reinitialize them if they are not satisfied.

Selection of the fitness function

Because the fitness function not only has a direct connection to the convergence speed of the algorithm, but also has a direct impact on whether the best solution can be found at the end. Therefore, we can select the fitness function from these two aspects. According to the objective constraint analysis described above, the following fitness function is used in this paper:

$$g\left(x\right) = \sum_{i=1}^{3} w_i \times f_i \times \frac{\theta}{3} \tag{4}$$

Where: f_1, f_2, f_3 denote the time interval function, the uniform course distribution function, and the teacher class distribution function, respectively, and w_1, w_2, w_3 denote the weights of a constraint. f_1, f_2, f_3 and w_1, w_2, w_3 can be set according to the customization of teaching management experience. θ indicates whether there is a conflict in the current course schedule, if there is a conflict, it is 0 and the scheduling scheme is eliminated, otherwise it is 1.

According to the calculation of the fitness function, it is possible to eliminate conflicting lesson plan solutions, but if only conflicting individuals are eliminated, the variety of the population decreases rapidly.

To solve the problem, the population initialization process is used again to generate many new individuals during the elimination process, in which conflicting individuals need to be replenished. This ensures both the population size and the diversity of the population.

Selection

The selection operation mainly simulates the evolutionary process of organisms in which organisms suitable for that environment survive and those unsuitable for that environment are eliminated. And to prepare for crossover operation.

The basic principle is that the larger the fitness value, the easier it is to be selected for crossover

operation, and vice versa, it is eliminated. In this paper, we use the roulette selection method, and this method is briefly explained below.

Let the population size be N and the fitness of individual i be $g(i)$, then the probability of individual i being selected is P_i.

$$P_i = \frac{g(i)}{\sum_{i=1}^{N} g(i)}, i = 1, 2, \mathrm{K}, N \quad (5)$$

From equation (5), the likelihood of being selected is proportional to P_i. The greater it is, the more likely it is to be selected. On the contrary, the probability of selected individuals is almost none, and they may even be eliminated. The probability of being selected is calculated by equation (5), and then it is possible to decide which individuals are selected as the initial individuals of the parent.

Chaotic crossover

Selective chaotic crossover, i.e., the exchange of genes by selecting a row or a column of a two-dimensional matrix in the crossover operation. In this paper, the rows of the two-dimensional matrix (course schedule information) represent the class locations and the columns represent the class times. If the columns (classrooms) are crossed, only the class location of a course is changed each time, and the rest is not changed, so the crossover effect is not obvious.

(1) Determine the initial conditions. That is, assume a crossover probability p_c and let it take the value range p_c.

(2) Determine the chaotic sequence x_n, i.e., randomly select a number x_0 as the initial value and generate a chaotic sequence according to Equation (1), if x_n is less than the set value of p_c, map the sequence x_n into a two-dimensional matrix, otherwise, continue to select a random number x_0 to generate a chaotic sequence, and then make a judgment.

(3) Determine which row is to be crossed. That is, when $x_n \in [0,1]$, the row labeled for the crossover operation is:

$$i = [D \times x_n] \quad (6)$$

Where: D denotes a class period, there are five weekdays in a week and five class periods in a weekday, i.e., the value of D is 25. $[*]$ denotes rounding.

(4) Perform crossover operation. First, we should specify the specific number of rows for the crossover operation, and then compare all the values of the two parents in this row. If the parent individuals have 0 or 1 at a certain determined position, we keep them unchanged and do not perform the crossover operation. Otherwise, the values corresponding to the two parent individuals are swapped.

Chaotic variation

Figure 4 shows the structure of chaotic mutation. The mutation operation is to swap a specific element of a two-dimensional matrix with another specific element to form a new individual. For genetic algorithms, the mutation operation is used because it prevents the number of species in the population from becoming smaller, as well as to speed it up and reduce the search time when searching locally for the entire population. The mutation will be performed by chaotic mutation, first determining the mutation probability, then selecting a random number to generate a chaotic sequence according to equation (1), followed by determining the specific location of the mutation (including row coordinates and column coordinates), and finally performing the mutation.

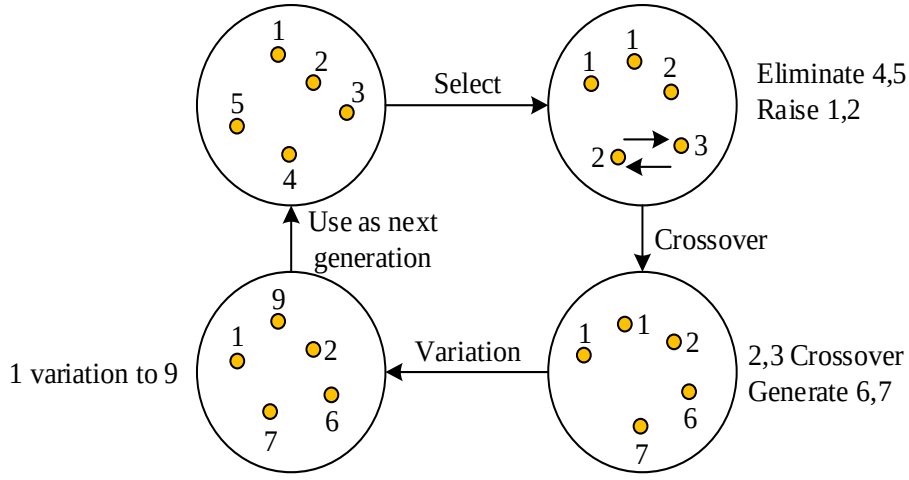

Figure 4. Chaotic variation structure diagram

When $x_n \in [0,1]$, the first row is labeled:

$$i_1 = [D \times x_n] \tag{7}$$

When $x_{2n} \in [0,1]$, the second row is labeled:

$$i_2 = [D \times x_{2n}] \tag{8}$$

When $x_{3n} \in [0,1]$, the second column is labeled:

$$c_1 = [R \times x_{3n}] \tag{9}$$

When $x_{4n} \in [0,1]$, the second column is labeled:

$$c_2 = [R \times x_{4n}] \tag{10}$$

Where: D denotes a class period, there are five weekdays in a week and five class periods in a weekday, i.e., the value of D is 25. R denotes the total number of classrooms, and $[*]$ denotes rounding.

Rules of scheduling and optimization model

The essence of the scheduling problem is to solve the problem of conflicting resources under multiple constraints. That is, when scheduling, conflicts cannot arise between teachers, courses, classrooms, times and classes. In the process of scheduling physical education courses, the rules to be followed according to the constraints of physical education courses can be divided into two categories (one is the rule that must be implemented - hard rules, and the other is the rule that is satisfied as much as possible --soft rules), which in turn makes the scheduling of physical education courses more efficient.

Denote by θ_{2h} the effectiveness factor of a course with a class time spacing of h:

$$f_2 = \sum_{w=1}^{W} R_w \theta_{2h} \tag{11}$$

The efficiency of the class was different for different time periods, and for each time period the efficiency of the class was expressed by the efficiency value, which also indicated the willingness of some students to attend the class during this time period, or the efficiency of the class during this time period, while certain time periods were not suitable for scheduling physical education classes. We set the efficiency values for each time period of the day as shown in Table 1.

Table 1. The efficiency value of physical education classes in different time periods of the day

time slot	Monday	Tuesday	Wednesday	Thursday	Friday
1-2 am	0	0	0	0	0
3-4 am	0.86	0.88	0.86	0.83	0.81
5-6 p.m	0.34	0.38	0.56	0.52	0.51

7-8 p.m	0.64	0.68	0.66	0.62	0.63
9-10 pm	0	0	0	0	0

The efficiency of physical education classes in that period, because physical education classes are not suitable to be scheduled in the morning one or two periods and in the evening ninety periods, so that the efficiency of classes in the morning one or two periods and in the evening ninety periods is zero, then the efficiency of classes in each period is expressed as shown in equation (12) below.

$$f_1 = \sum_{w=1}^{W} R_w \theta_{1d} \tag{12}$$

Where θ_{1d} is used to denote the teaching effectiveness factor of the d nd session.

If the teacher's aerobics class is too concentrated, the teacher will be fatigued, which will affect the effectiveness of teaching. However, if the classes are too spread out, the teacher will be running around, thus wasting time. The coefficient of θ_{3j} is the coefficient of meeting the requirements of the course, as shown in equation (13):

$$f_3 = \sum_{w=1}^{W} R_w \theta_{3j} \tag{13}$$

Thus, it appears that the scheduling problem is an optimization decision problem with multiple constraints and multiple objectives. Therefore, in the optimization process, each soft rule is specified as the objective function and each hard rule as its constraints, thus establishing its mathematical model, see equation (14):

$$\begin{cases} \max, f(x) = (f_1, f_2, f_3) \\ s.t, R \in \begin{cases} R_1 \\ R_2 \\ R_3 \end{cases} \end{cases} \tag{14}$$

Analysis of the results of physical education innovation

Statistical Analysis of Physical Education Teaching Mode

Table 2 shows the statistical table of physical education teaching mode classification. As far as the students are concerned, we can divide them into three stages according to their different ages: elementary school, middle school (junior high school and high school) and college. There are obvious differences in the physiological and psychological aspects of students in each stage, so in teaching activities, we have to teach according to their abilities, keep corresponding to the teaching

ideas, design the teaching objectives to be achieved and choose the corresponding physical education teaching modes for each stage. From this data, we can know that for the elementary school level physical education is mainly interest-based and focuses more on the emotional experience type of teaching model. The secondary level is the best time to learn skills, and the teaching mode is more focused on skill learning. For the college level, the teaching mode focuses on skill learning and physical improvement at the same time.

Table 2. Statistical Table of Classification of Physical Education Teaching Modes

name	Focus on skill learning	Focus on emotional experience	Focus on improving physical fitness	Are important	total
primary school	7	17	12	16	52
	13%	34%	22%	31%	100%
middle school	20	2	18	12	52
	40%	4%	34%	23%	100%
colleges and universities	13	1	9	29	52
	25%	2%	15%	58%	100%

Comparison and analysis of students' aerobics technique scores after the experiment

Figure 5 shows the analysis of students' movement completion scores after the experiment. The students' aerobics technique scores were mainly evaluated by the students' completion of the third set of the first level movements of mass aerobics, and the assessment teachers started to evaluate five dimensions: accuracy of movements, proficiency of movements, amplitude of movements, strength of movements and accuracy of music rhythm. The average score given by the three teachers was used as the basis for analysis, and the results showed that only 40% of the control group was in excellent condition, and only 64% of the students in the experimental group maintained excellent condition.

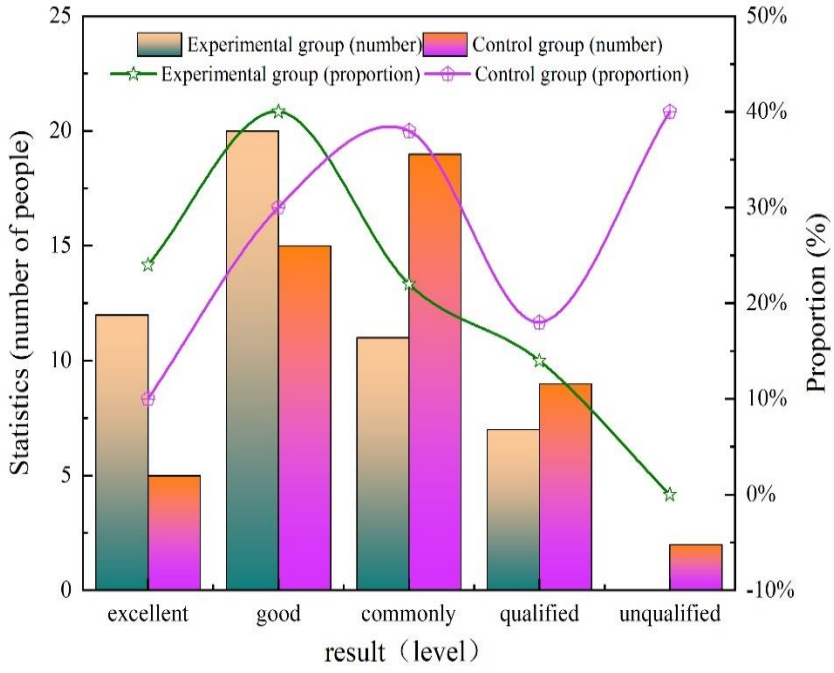

Figure 5. Analysis of students' performance after the experiment

Table 3 shows the statistical analysis of students' movement completion scores after the experiment. The same comparative analysis in Table 3 leads to the conclusion that compared to the control group, the students in the experimental group performed better, with the mean scores of 79.38 and 85.43, respectively, and the difference between the two groups is very significant as shown by P=0.00 <0.01.

It can be inferred that the teaching effect achieved by chaotic genetic algorithm based physical education is more significant, which can make students remember each movement more clearly and really learn aerobics well. Therefore, this new teaching method deserves to be widely promoted in future teaching.

Table 3. Statistical analysis of students' performance after the experiment

group	$X \pm s$	T	P
experimental group	85.44 ± 8.31	5.88	0.00<0.05
control group	79.39 ± 8.74		

Simulation experimental analysis of physical education scheduling based on chaotic genetic algorithm

In this paper, some physical education courses in a university in Guiyang for the academic year 2021-2022 are used as experimental data to complete the scheduling work of physical education

courses. The population size is set to 100 and the number of iterations are 50, 100, 150, 200, 250, 300. According to the scheduling requirements, two scheduling schemes based on genetic algorithm and chaotic genetic algorithm are used, and then a test program is designed for testing according to the algorithmic ideas in Chapter 2.

Figure 6 shows the number of iterations and the number of occurrences of the better eigenvalues. In terms of the number of eigenvalues, when the population size is constant, the number of times the better eigenvalue (denoted by eigenvalue later) appears for both algorithms is proportional to the number of iterations, i.e., as the number of algorithm runs increases, the eigenvalue increases. For the genetic algorithm, the eigenvalues do not fluctuate up and down after 150 runs. In the case of the chaotic genetic algorithm, the eigenvalues do not fluctuate up and down until after 200 iterations. It can be seen that the use of chaotic genetic algorithm in the scheduling system is more effective.

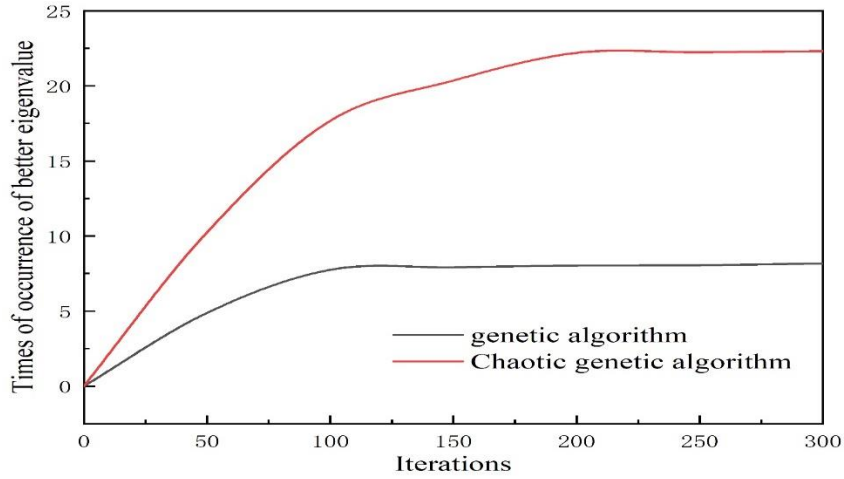

Figure 6. Iteration times and occurrence times of better eigenvalue

Figure 7 shows the fitness function versus the number of iterations. The genetic algorithm reaches equilibrium at about 200, but the chaotic genetic algorithm reaches equilibrium at 150, with a fast convergence rate, and its fitness value is higher than that of the genetic algorithm, so the chaotic genetic algorithm works better than the genetic algorithm. In summary, compared with genetic algorithm, chaos genetic algorithm consumes less time and has better scheduling effect in the process of scheduling physical education courses, thus it can improve computer efficiency, speed up the calculation speed and reduce the calculation time. Therefore, the application of chaos genetic algorithm in physical education innovation is feasible and effective. In the process of physical education curriculum scheduling based on chaotic genetic algorithm, the problem of physical education resource allocation is well solved. Teachers can use systematic artificial intelligence analysis to understand students' sports tendencies, and then allocate educational resources in a reasonable way. For example, for sports such as basketball and soccer, which students choose a lot

and are highly motivated, because they are easy to start, subject to many, as well as the overall teaching is relatively simple, it is necessary to increase teaching resources in the teaching process to meet the needs of many students. And teachers should be trained to teach in a timely manner to improve their professionalism so that the whole teaching can be carried out effectively. For some sports with gender differences in selection, such as aerobics and cheerleading, teachers need to have the ability to teach the sport, develop teaching plans for individual students, explore potential student groups, and form relevant teams so that this group of students has the opportunity to participate in higher level competitions and move to higher stages.

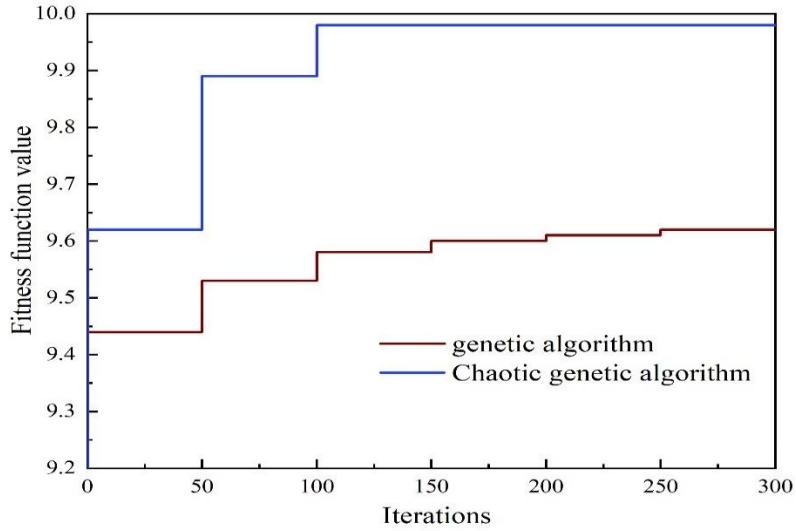

Figure 7. Fitness function and iteration number

Conclusion

Based on the development of artificial intelligence technology, this paper proposes a chaotic genetic algorithm-based physical education curriculum scheduling study applicable to primary and secondary schools nationwide through the study of automatic scheduling algorithms to achieve innovation in physical education teaching in primary and secondary schools. The following conclusions can be drawn:

(1) In the statistics of physical education mode classification, it is found that physical education at the elementary school level focuses on the teaching mode of emotional experience category, physical education at the secondary school level focuses on the teaching mode of skill learning category, and physical education at the university level focuses on both skill and physical quality. The physical education teaching modes suitable for popularization at the school level include fun teaching mode and game teaching method. At the secondary school level, physical education teaching modes suitable for popularization include group teaching mode and integrated teaching mode inside and outside the classroom. The physical education teaching modes suitable for

popularization at the university level include "three autonomous" teaching mode and exercise prescription teaching mode.

(2) The data of students' aerobics skill scores before and after the experiment were compared between the experimental class and the control class. It was found that the effect of physical education based on chaotic genetic algorithm was more significant. The students' independent initiative played more thoroughly, which promoted the students' learning status of aerobics course and also promoted the teacher-student interaction and student-student interaction in aerobics physical education class.

(3) In the simulation experimental analysis of physical education scheduling based on chaotic genetic algorithm, in the chaotic genetic algorithm, the eigenvalues did not fluctuate up and down until after it was run 200 times, and compared with the traditional genetic algorithm, the improved chaotic genetic algorithm has been greatly improved in physical education scheduling. In the process of physical education scheduling based on Chaos Genetic Algorithm, the problem of physical education resource allocation is well solved, and teachers can understand students' sports tendencies through systematic artificial intelligence analysis, and then reasonably allocate educational resources.

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