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Mathematical model construction for time-optimized path planning and curriculum efficiency enhancement in study tours

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ABSTRACT

As the most popular mode of out-of-school education in recent years, study tour plays an important role in the comprehensive ability improvement and overall development of students. Based on the path planning problem of study tour, this paper proposes a travel route optimization model with time optimization as the goal orientation, aiming to plan the time-optimal path for students in the study tour process. The particle swarm algorithm is used to improve the genetic algorithm for solving the travel route optimization model. The effectiveness of the optimization model and the hybrid algorithm is verified through the analysis of an actual case of a study tour, and the experimental results are substantially optimized compared with the traditional planning path, reducing the time spent by 2.2 days. Then we use qualitative comparative analysis method to explore the efficiency improvement of the curriculum of study tours, and obtain four grouping paths, which can cover more than 85% of the cases. The research in this paper not only helps to enrich the academic research of cross disciplines in the form of "travel + education", but also provides theoretical basis and practical reference for the development of study tours to a certain extent.

Keywords: tourism route optimization; particle swarm algorithm; genetic algorithm; qualitative comparative analysis; study trip

1. Introduction

Study tour is an important part of the comprehensive practice program of school society. It aims to let students feel the beautiful natural scenery and understand the long history and culture of the motherland during the trip, cultivate good scientific literacy, humanistic literacy and international vision, and develop good civic literacy and social responsibility consciousness [1-4]. Enhance class cohesion, strengthen communication and exchange among students, and cultivate students' sense of solidarity and cooperation. Through study tours, students can develop in all aspects such as physical,

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mental, emotional, moral and so on. And proper path planning and curriculum setting are needed in the study trip [5-8].

Before planning the route, it is necessary to research and evaluate the learning resources in the target area. You can use the Internet, libraries, research institutions and other channels to find out what local attractions, museums, scientific research institutions, etc. are suitable for study tours. Factors such as security, accessibility and operability should also be considered [9-12]. According to the learning resources and the needs of the target group, make a detailed itinerary. Consideration should be given to the rational use of time, so that students can get as many learning and experiential opportunities as possible in a limited time. The itinerary should include daily activities, time schedule and transportation [13-16]. Study tour route design is not only concerned about the depth of learning, but also focus on the integration of subject knowledge. The knowledge of different disciplines can be integrated into the various attractions and activities, so that students can get more interdisciplinary learning opportunities in the process of visiting and learning. When visiting history museums, it can be combined with language, literature, geography and other disciplines for in-depth study [17-20].

In this paper, considering the influence of travel time uncertainty, defining the tourism experience utility function composed of tourism travel utility and tourism activity utility, and taking this as the goal, establishing the random chance constraint planning model of study tour route. On the basis of particle swarm algorithm, the mutation idea of genetic algorithm is introduced, and through inertia weight adjustment, elimination mechanism design, and mutation rate control, the PSO-GA algorithm is designed for solving the tourism route optimization model. A study trip plan is analyzed as an example to compare and analyze the time of traditional path planning and the model path planning in this paper to verify the actual utility of the tourism route optimization model. Select the antecedent variables and outcome variables of the efficiency improvement of the study tours program, through the case collection of a rural study and learning base, use the fuzzy set qualitative comparative analysis method to group analysis, and obtain the group path of the efficiency improvement of the study tours program. Finally, the analysis of the article is synthesized to propose strategies and suggestions for the development of study tour.

2. Time-optimized path planning in study tours

Study tours is a kind of educational tourism activity that takes primary and secondary school students as the main object, takes collective travel life as the carrier, takes the improvement of students' quality as the teaching purpose, relies on social resources such as tourist attractions, and carries out experiential education and research learning [21]. As a new key direction of development in the tourism market today and in the future, study tours has received more and more attention from academics. In this chapter, time-optimized path planning in study tours is studied to construct a study tours route optimization model.

2.1. Tourism route optimization model

In the transportation network of tourist cities, there are several attractions that can be used for study tour activities distributed between the starting point and the end point of tourists' trips, and there are different transportation modes available between the nodes, and students need to spend a certain amount of time and cost to carry out study tour activities at the tourist attractions. Due to the constraints of study tours time $T_{\max}$ and cost C and the uncertainty of the transportation system, how to optimize the study tours routes to enhance the study tours experience of the tourists is a problem worth exploring. The problem can be defined as an effective network $G=(V,E)$, where V is the set of nodes consisting of the starting point (v_1), the ending point (v_n) and the attraction $v_i(i=2,3,\cdots,n-1)$ from which the tourist departs, the opening and closing moments of the attraction are $t_{open,i}$ and $t_{close,i}$, respectively, and the required travel activity time and cost of the attraction v_i are $T^0_{divation,i}$ and $C_{\alpha etivity,i}$. E is the set of road segments connecting the nodes. For any one road section $(i,j)\in E$, tourists can choose the transportation mode k travel, which $k\in\{Walk,Bus,Subway,Taxi\}$. Each road section has time and cost weights, the travel time and cost of the transportation mode k between nodes are $T^k_{travel,ij}$, $C^k_{travel,ij}$, and the travel time is a non-deterministic value that obeys a certain distribution law.

2.1.1. Tourism experience utility function. The concepts of tourism activity utility and tourism trip utility are used to describe the study tour experience utility. The tourism experience utility of a study tour route is the sum of the tourism activity utility and tourism trip utility of the route.

1) Tourism travel utility. Assuming that the travel time of different transportation modes between nodes $T^k_{travel,ij}$ serves a normal distribution, the traveler needs to weigh the travel time and cost to choose the transportation mode during the trip. Define the generalized travel cost for a tourist to reach node j from node i using transportation mode k as:

$$GC^k_{travel,ij}=\alpha_1T^k_{travel,ij}+\alpha_2\varphi C^k_{travel,ij} \tag{1}$$

Where: φ is the cost a time conversion factor, take $\varphi=1/VOT$, that is, the higher the value of travel time (VOT), φ the smaller, and vice versa, φ the larger. α_1, α_2 reflect the traveler's choice of transportation mode criteria when traveling, which can reflect the traveler's preferred attitude towards travel time and cost.

Then the mean and variance of the traveler's generalized travel cost are:

$$E\left(GC^k_{travel,ij}\right)=\alpha_1E\left(T^k_{travel,ij}\right)+\alpha_2\varphi C^k_{travel,ij} \tag{2}$$

$$Var\left(GC^k_{travel,ij}\right)=\alpha_1^2Var\left(T^k_{travel,ij}\right) \tag{3}$$

The travel utility then implies the loss of time and money, and since the travel cost is uncertain, it can be assumed that the traveler will consider the mean and variance of the travel cost when making the choice of transportation modes, and then the travel utility of various transportation modes is defined as:

$$U^k_{travel,ij}=-E\left(GC^k_{travel,ij}\right)-\omega\sqrt{Var\left(GC^k_{travel,ij}\right)} \tag{4}$$

Where: ω is the risk aversion coefficient.

2) Tourism activity utility. Tourism activity experience is to obtain a sense of satisfaction from receiving services and tourism experience, and it can be considered that tourism activity utility is related to the attributes of the tourist attraction, the duration of the tourism activity, and the cost of carrying out the tourism activity. Typically, if a tourist arrives before the opening of the attraction or arrives at the attraction without any guarantee that he or she will complete the tourist activity within the required duration of the tourist activity at the attraction, this will result in waiting or delay losses. Therefore, the utility of the tourism activity also includes the negative utility generated by the delay or waiting time.

During the outing, waiting time $T_{unit,i}=t_{open,i}-t_{wrive,i}$ is generated when the arrival moment at the tourist attraction is $t_{wrive,i}<t_{open,i}$. When $t_{open,i}\le t_{wrize,i}\le t_{close,i}$, the waiting time is 0. If $t_{close,i}-T^0_{duration,i}<t_{arrive,i}\le t_{dose,i}$, the delay time generated $T_{delay,i}=t_{arrive,i}-t_{dose,i}+T^0_{duration,i}$, and the actual tourist activity time at the attraction is $T_{duration,i}=t_{dose,i}-t_{arrive,i}$. When $t_{arrrive,i}\le t_{dose,i}-T^0_{duration,i}$, the delay time generated is 0 and $T_{duration,i}=T^0_{duration,i}$. A certain negative utility is assigned to the additional waiting time or delay time, and thus the tourist's time at the attraction due to the waiting time or delay time is generated of negative utility can be expressed as:

$$U_{SD,i} = -\theta\Big(\max\left[t_{open,i} - t_{arrive,i}, 0\right] + \max\left[t_{arrive,i} - t_{dose,i} + T^{0}_{drration,i}, 0\right]\Big) \tag{5}$$

Where: θ is the unit time penalty coefficient.

The tourism activity utility function is expressed as:

$$U_{activity,i} = \frac{\beta_1 A_i + \beta_2 \ln\left(T_{duration,i}\right)}{\exp\left(\beta_3 C_{activity,i}\right)} + U_{SD,i}\left(t_{arrarrive,iive,i}\right) \tag{6}$$

Where: A_i is the attractiveness of the attraction i, β_1 is the coefficient of tourist preference for the attractiveness of the attraction. β_2 is the preference coefficient of tourists for the duration of tourist activities. β_3 is the preference coefficient of tourists for the cost of attraction activities.

2.1.2. Optimization modeling. The constraints considered when performing tourism route optimization are study tours time, cost budget and attraction service time constraints. The stochastic planning problem arises due to the study tours time uncertainty factor in the transportation network of tourist cities. And the stochastic planning problem can be described by an opportunity constrained planning model. The tourism route optimization model is as follows:

$$\max U = \max\left(\sum_{k=1}^{m}\sum_{i=1}^{n-1}\sum_{j=2}^{n} x_{ij}^{k} U_{traved,ij}^{k} + \sum_{i=2}^{n-1} y_i U_{adisity,i}\right) \tag{7}$$

Constraints:

$$\sum_{k=1}^{m}\sum_{j=2}^{n} x_{1j}^{k} = 1 \tag{8}$$

$$\sum_{k=1}^{m}\sum_{i=1}^{n-1} x_{in}^{k} = 1 \tag{9}$$

$$\sum_{k=1}^{m}\sum_{i=1}^{n}\sum_{j=1}^{n} x_{ij}^{k} = 1 \tag{10}$$

$$t_{arrvie,1} = t_{start} \tag{11}$$

$$\sum_{k=1}^{m}\sum_{j=2}^{n}\left(t_{arrive,i} + T_{unit,i} + T_{drration,i} + T_{travel,ij}\right) x_{ij}^{k} = t_{arrive,j} \tag{12}$$

$$P\left(t_{open,i} < t_{arrive,i} < t_{dose,i}\right) \geq \alpha_0 \tag{13}$$

$$T_{unit,i} = \max\left[\left(t_{oper,i} - t_{arrive,i}\right), 0\right] \tag{14}$$

$$T_{delay,i} = \max\left[t_{arrive,i} - t_{dose,i} + T_{derotion,i}, 0\right] \tag{15}$$

$$P\left(\sum_{k=1}^{n}\sum_{i=1}^{n-1}\sum_{j=2}^{n} x_{ij}^{k} T_{trwd,ij}^{k} + \sum_{i=2}^{n-1} y_i\left(T_{uuit,i} + T_{dcration,i}\right) \leq T_{\max}\right) \geq \beta_0 \tag{16}$$

$$\sum_{k=1}^{m}\sum_{i=1}^{n-1}\sum_{j=2}^{n} x_{ij}^{k} C_{travel,ij}^{k} + \sum_{i=2}^{n-1} y_i C_{activity,i} \leq C \tag{17}$$

$$x_{ij}^{k} = \begin{cases} 1 & \text{Choose transportation mode } k \text{ to travel from node } i \text{ to } j \\ 0 & \text{Otherwise} \end{cases} \tag{18}$$

$$y_i = \begin{cases} 1 & \text{Node } i \text{ is selected} \\ 0 & \text{Otherwise} \end{cases} \tag{19}$$

Eq. (7), i.e., maximizing the tourist's utility of the tourism experience as the objective function. Eqs. (8) to (9) ensure that the tourist's starting point is the residence and returns to the residence at the end of the tourist trip. Equation (10) requires the tourist to choose only one mode of transportation to travel on each path. Equations (11) to (12) are the departure moment of the tourist and the arrival moment of the computational node j. Eq. (13) is the attraction service time constraint. Eq. (14) ~ Eq. (15) calculates the waiting time and delay time of the tourist at attraction i. Eq. (16) ~ Eq. (17) are time and cost budget constraints. Eq. (18) ~ Eq. (19) are 0-1 decision variables.

2.2. Solution Algorithm

In this paper, when designing the optimization algorithm, we adhere to the principle of not being too complex to avoid increasing too much computational volume. Particle swarm algorithm is a more concise algorithm in many optimization algorithms with more concise computational rules, in order to find the optimal solution of the time optimization problem of the study tour route, this paper introduces the mutation idea of genetic algorithm on the basis of particle swarm algorithm to form PSO-GA algorithm.

2.2.1. Particle Swarm Algorithm. Particle swarm algorithms utilize a randomly generated swarm of particles to find an optimal solution by iterating over a search range. Each particle carries two pieces of information, position $X(i)_k = (x_1, x_2, \cdots, x_n)_k$ and velocity $V(i)_k = (v_l, v_2, \cdots, v_n)_k$, with velocity equal to the distance that this position steps to the next position. k is the number of evolutionary generations the population is in.

$P(i)_{Best}$ is the historical optimum of the i nd particle, G_{Best} is the historical optimum of the population, and the "optimum" described above is calculated by the fitness function $F(X)$, which calculates the fitness value of each particle $(x_1, x_2, \cdots, x_n)_k$

$$\begin{aligned} V(i)_{k+1} &= \omega(i)_k + c_1 r_1 \left(P(i)_{Best} - X(i)_k\right) \\ &\quad + c_2 r_2 \left(G_{Best} - X(i)_k\right) \\ X(i)_{k+1} &= X(i)_k + V(i)_{k+1} \end{aligned} \tag{20}$$

Where, ω - inertia factor, $c_1 c_2$ - learning factor, $r_1 r_2$ - random number within $[0,1]$.

2.2.2. Genetic algorithms. Genetic Algorithm is also an evolutionary process that involves the formation of an initial population by coding and then operating on the individuals according to their values of adaptation to the environment so as to realize the evolutionary process of superiority and inferiority.

2.2.3. PSO-GA algorithm. This paper appropriately adjusts the inertia weights, designs the elimination mechanism to eliminate the extremely poor individuals, and controls the variation of the mutation rate through the function.

1) Adjustment of inertia weights. In this paper, we keep the concept of dynamic inertia weights, and improve the linear decreasing to nonlinear decreasing, which makes the particle velocity change fast in the early stage and slow in the late stage, and better balances the global search and local search. The new inertia weight expression is as follows:

$$\omega^* = \omega_{\max} - \frac{4}{\pi} \arctan\left(\frac{k}{k_{\max}}\right) * \left(\omega_{\max} - \omega_{\min}\right) \tag{21}$$

Where, $\omega_{\max}$, $\omega_{\min}$ - the maximum and minimum values of ω^*, k - the number of generations of the current evolution, $k_{\max}$ - the maximum number of generations of the set evolution.

With the replacement of ω in Eq. (20) by Eq. (21), Eq. (20) becomes:

$$\begin{aligned} V(i)_{k+1} &= \omega * V(i)_k + c_1 r_1 \left(P(i)_{Best} - X(i)_k\right) \\ &\quad + c_2 r_2 \left(G_{Best} - X(i)_k\right) \\ X(i)_{k+1} &= X(i)_k + V(i)_{k+1} \end{aligned} \tag{22}$$

2) Design of elimination mechanism. From the normal distribution, the probability that the fitness value of an individual is below $\mu - 2\sigma$ is very low, so the individuals with fitness value below $\mu - 2\sigma$ are called “extremely poor” individuals, and this paper chooses to eliminate these individuals, which of course belongs to the problem of probability, and there will not be individuals eliminated in every generation. This step through certain mathematical means, some of the “very poor” individuals will be disposed of, the purpose is to improve the overall fitness of the population, improve the optimization algorithm's ability to find the best and stability.

In this section, μ refers to the average fitness value of the individuals in the kth generation, and σ refers to the mean squared deviation of the fitness value of the population in the kth generation, which is a measure of the degree of dispersion:

$$\sigma = \sqrt{\frac{1}{m} \sum_{i=1}^{m} \left[F\left(X(i)_k\right) - \mu\right]^2} \tag{23}$$

3) Mutation rate control. In this paper, we design a function to control the size of the mutation rate, so that the mutation rate is larger at the beginning of the algorithm search, and smaller at the end. The variation rate control function is:

$$\varphi(k) = 1 - \frac{1}{1 + e^{-20\left(\frac{k}{k_{\max}} - 0.5\right)}} \tag{24}$$

The rate of variation is rewritten as:

$$p_m' = p_m * \varphi(k) \tag{25}$$

3. Case studies on pathways to optimize study tours time

3.1. Experimental data

This paper takes the path planning of a school study trip as the research object, and selects 13 popular study tours in a certain area as the intermediate nodes, together with the starting point and the end point, there are 15 nodes in total, which constitute the network graph, noted as X1~X15.The positional coordinates of each node (x, y) are calculated in terms of the earth's longitude and latitude, and the source of the data is Gaode map.

3.2. Algorithm parameters

The software used in this case study is MATLAB R2018a running on Windows 10 with hardware configuration of Intel(R) Core(TM) i7-10510U CPU @ 1.80 GHz and 2.30 GHz processor laptop. In the algorithm, the parameters involved are as follows: time nodes t_1=2, t_2=4 in days, maximum number of iterations of the algorithm is 600, number of particles is 120, learning coefficient c_1 is 0.8, acceleration coefficient c_2 is 1.2, crossover probability P_c is 1, variance probability P_m is 0.1, and 25 independent experiments are conducted and the average is taken as the final conclusion.

3.3. *Experimental results*

Because the heuristic algorithm has a certain degree of randomness, the results of each experiment are not the same, and the experimental results below are the results of one experiment that is the closest to the average among 25 independent experiments, which has universal significance.

The results of the study tours time optimization path are shown in Figure 1. Tourists start from the entrance and travel in sequence according to the following path: X13→X8→X14→X12→X2→X11→X9→X7→X5→X1→X3→X6→X10→X15→X4, which ultimately realizes the shortest travel time of 8.2 days. While the traditional travel path planning path is shown in Fig. 2, the shortest distance obtained is 278.65km, and the travel time is 10.4 days. It can be seen that the time-optimized path planning method proposed in this paper can effectively shorten the students' study tours time and improve the quality of study tours.

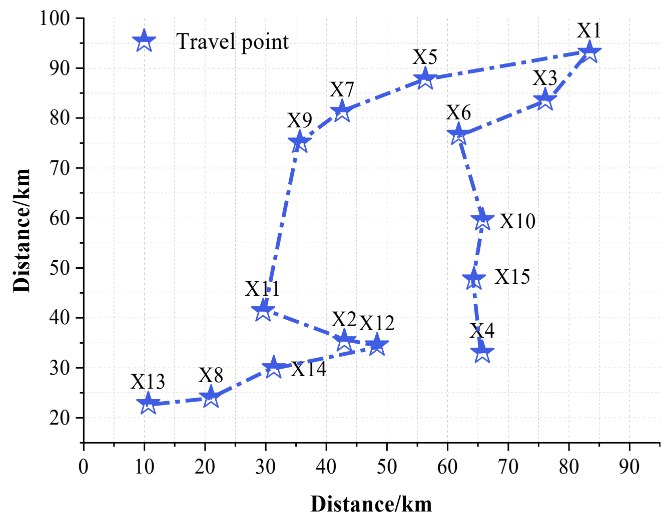

Fig. 1. The time optimization path result of the study trip

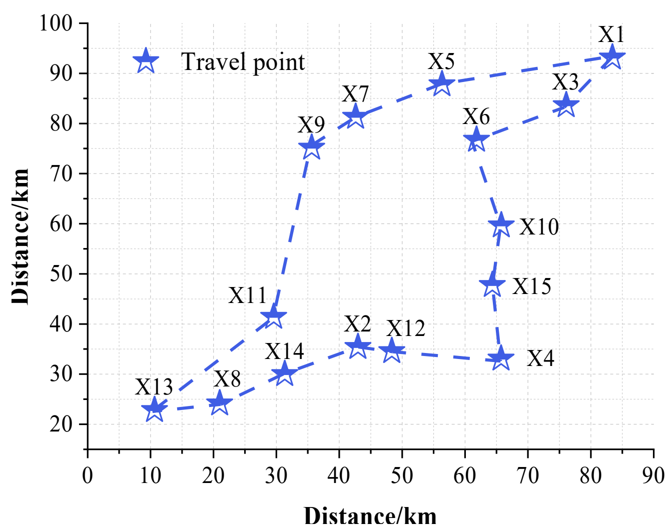

Fig. 2. Traditional travel path planning path

The convergence process of the algorithm in solving the time-optimized optimal path for the project tour is shown in Fig. 3. It can be seen that the optimal solution obtained by the algorithm keeps converging as the iteration proceeds, and at about the 300th iteration step, it jumps out of the local optimal solution, finds a better global solution, and finally converges to a fixed value. It is verified that the hybrid PSO-GA algorithm has better performance in solving the problem model.

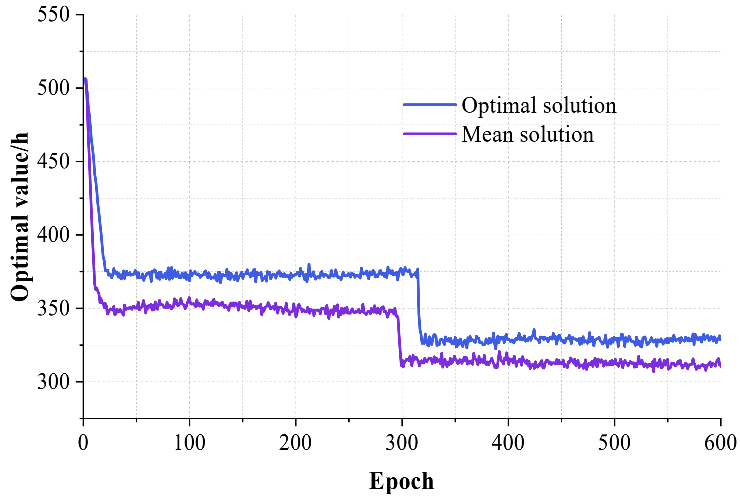

Fig. 3. The convergence of the algorithm

4. Study on improving the efficiency of study tour curriculum development

After analyzing the time-optimized path planning in study tours, this chapter focuses on the efficiency of curriculum setting in study tours, and adopts the fuzzy set qualitative comparison method to explore the combination path of curriculum setting efficiency improvement.

4.1. *Qualitative comparative analysis methods*

Qualitative Comparative Analysis (QCA) is an analytical method that reveals the intrinsic essential law of things through quantitative comparison and qualitative analysis of a large number of small samples of comparable or typical information.

According to the research needs, this paper adopts the applied fuzzy set analysis method (fsQCA), which, in general, is divided into the following steps: firstly, the outcome variables and condition variables are determined. The researcher combines theoretical knowledge with practical experience to organize and analyze the selected sample cases to determine the outcome variables and condition variables of the problem to be studied. Next, the operationalization process of QCA is carried out. fs/QCA3.0 is used in this study, and the specific operationalization process includes case sample assignment, univariate necessity analysis, truth table construction, and operation analysis, and the result of the operation has three solutions: complex solution, intermediate solution, and parsimonious solution. Finally, the results of the group state are analyzed, and the paths can be integrated based on comparing the combination of conditions between different group states to draw more objective and scientific conclusions. There are two main indicators for the assessment of conditions, namely consistency and coverage. Consistency can be understood as the degree of confidence in the results produced by a single variable, which is calculated as in equation (26):

$$\text{Consistency}\ (X_i \le Y_i) = \sum [\min(X_i, Y_i)] / \sum X_i \tag{26}$$

In Eq. (26), X_i denotes the affiliation of the condition variable and Y_i denotes the affiliation of the outcome variable. A univariate or group state with consistency greater than 0.9 is generally considered a sufficient condition for the outcome variable.

Coverage is the degree of coverage of cases that occur in conformity with a particular combination of causal variables, with the result expressed as the strength of explanation of the outcome variable by the combination of condition variables. The larger the value of the coverage metric, the stronger the individual conditions and combinations of conditions explain the outcome. The degree of coverage is calculated as in equation (27):

$$\text{Consistency}\ (X_i \le Y_i) = \sum[\min(X_i, Y_i)] / \sum Y_i \tag{27}$$

Where, the meaning of X_i, Y is the same as equation (26), and the variable result of Consistency takes the value range of (0, 1).

4.2. Selection of indicators and variables

Indicator selection needs to take into account the availability of indicator data, data representativeness and so on. Study tours is the main market target of young student tourists, so from the perspective of student tourists, the variables related to the improvement of the efficiency of the curriculum in study tours are selected.

Seven variables were selected as antecedent conditions, including infrastructure A1, research and study teaching environment A2, strong research atmosphere A3, clear learning objectives of research courses A4, scientific design of research course content A5, high fit between research course curriculum and scenic resources A6, and compatibility of research course curriculum with students' abilities A7.

This paper studies the influencing factors of study tours curriculum efficiency improvement, mainly analyzes the degree of influence between the factors on the efficiency of research and study curriculum improvement, the explanatory variables through the joint effect on the outcome variables, so the selection of the outcome variables should be representative and consistent with the cause and effect relationship. In this paper, based on the results of existing research, we use curriculum planning time, research courses to improve students' behavioral and hands-on skills, research courses to improve students' interpersonal skills, research courses to improve students' social adaptability, research courses to improve students' competitiveness and cooperation, research courses to improve students' self-management skills, and research courses to improve students' cognitive inquiry ability as the indexes of measurement.

4.3. Case Selection and Data Sources

4.3.1. Case Selection. This paper takes a village attraction as a case study. The village started to build a rural study tours base in 2018, and as of now, the number of visiting researchers has reached more than 170,000, and study tours has become the pillar industry of the village. As a rural tourism and study tours in one of the poverty alleviation villages, the village provides an excellent case study of impact study tours.

4.3.2. Data collection. This study conducted a pre-survey from June 1, 2023 to June 30, 2023, using a questionnaire to start data collection, with the sample research base as the object of study. The second survey was conducted from August 10, 2023 to August 25, 2023, following the theoretical sampling principle in QCA to ensure that there was sufficient heterogeneity. Rural study tours base belongs to small sample research, and the sample size of fsQCA method is adapted to 15-80. In this paper, after eliminating the invalid samples, considering the consistency of the number of group states, 50 samples are selected, and through the fsQCA software operation, combined with the actuality of the sample study tours bases, the indexes affecting the improvement of the efficiency of the curriculum of rural study tours are finally determined.

4.4. Data analysis

4.4.1. Necessity analysis. Necessity analysis is a separate process. That is, before constructing the truth table, it is tested whether individual antecedent conditions are necessary to form the result. When the fsQCA software simplifies a complex solution containing logical residuals to a simple solution, it may ignore certain necessary conditions. Therefore, when necessary conditions are ignored during the simplification process, it is necessary to integrate the final result based on the necessity analysis of individual conditions. The indicator of necessity is consistency. According to Larkin's theory, the criterion of threshold is 0.9. In QCA operation, necessity analysis is judged by consistency index, when the value of consistency index > 0.9, it indicates that the combination of conditional variables has explanatory power for the research results.

The analysis of the necessity of influencing factors for the improvement of curriculum efficiency is shown in Table 1, and in the specific representation "~" means "not", which represents that the condition does not exist. The consistency of research course content design science A5, research course curriculum and scenic resources fit A6, research course curriculum and students' ability to adapt A7 are more than 0.9, which can be regarded as a necessary condition, and by analyzing the coverage rate, we can see that it can explain 72% of the cases. And the consistency of research teaching environment A2, strong research atmosphere A3, and clear learning objectives of research courses A4 are in the range of 0.8-0.9, which can be regarded as sufficient conditions. That is, the research and study tourism environment, the overall atmosphere of research and study, and the goal setting of research and study courses have a contributing effect on the efficiency of study tours course settings. The relatively low consistency of the score of infrastructure A1 is 0.777, which indicates that it has limited explanatory power for the results and cannot be used as a necessary condition.

Table 1. Analysis of the impact factors of curriculum setting efficiency

Conditional variable	Coverage	Consistency
A1	0.837	0.777
A2	0.737	0.849
A3	0.765	0.855
A4	0.729	0.879
A5	0.774	0.928
A6	0.721	0.911
A7	0.727	0.927
~A1	0.681	0.767
~A2	0.718	0.846
~A3	0.882	0.857
~A4	0.832	0.871
~A5	0.789	0.915
~A6	0.755	0.904
~A7	0.797	0.923

4.4.2. Configuration analysis. In this paper, we take the intermediate solution to analyze the combination of conditions, the symbol * in the expression of the combination of variables indicates that the variables have an intersection relationship, and the symbol ~ indicates that the variable "must not exist" in the combination. With a large solid circle indicates the existence of core conditions exist, with a small solid circle indicates the existence of edge conditions. A large hollow circle indicates that the core condition does not exist, a small hollow circle represents that the edge condition does not exist, and a space indicates that the condition is optional.

The results of the group state analysis are shown in Table 2. There are 4 influencing factor group states that affect the efficiency improvement of the study tours curriculum setting. The consistency of the 4 group states is 0.936, 0.939, 0.914, 0.928, respectively, with a high level of consistency, which is in line with the criterion of the marginal condition that affects the efficiency improvement of the study tours curriculum setting. This is further supported by the consistency value of 0.876 for the group solution. From a coverage perspective, the overall coverage indicator is 0.851, indicating that the four groupings explain about 85.1% of the cases.

The highest consistency was found for grouping pattern H2, in which the research course curriculum is a good fit with scenic resources A6, the research course curriculum is compatible with students' abilities A7 is the core element, and the research course learning objectives are clear A4, and the research course content design is scientific A5 plays a supportive role as a marginal condition. The raw coverage is 0.792 and the net coverage is 0.657, indicating that 79.2% of the cases can be covered. This configuration covers the most cases, indicating that it is one of the combinations with the largest coverage among all combinations, suggesting that this configuration is a key factor affecting the efficiency improvement of the research course curriculum.

Table 2. Configuration analysis results

Condition	H1	H2	H3	H4
A1	◎	◎		◎
A2		◎	◎	●
A3	●		●	●
A4	●	●		
A5	●	●	●	●
A6		●	●	●
A7	●	●	●	●
Conditional combination	~A1*A3*A4 *A5*A7	A4*A5 *A6*A7	~A2*A3*A5 *A6*A7	A2*A3*A5 *A6*A7
Original coverage	0.076	0.792	0.129	0.196
Net coverage	0.065	0.657	0.087	0.096
Consistency	0.936	0.939	0.914	0.928
Overall coverage	0.851			
Overall consistency	0.876			

5. Strategies for the development of study tours

Combined with the previous analysis of the optimization of the path planning of the study trip time and the efficiency improvement of the curriculum, the overall development strategy of the study trip is explored.

5.1. Create an immersive learning environment

In terms of research curriculum, it should be based on the environmental characteristics of study tours, that is, dynamic, diversified and compounded educational places to create an immersive learning environment. In the design of the theme content of the study product based on the specialized knowledge of each school section, multiple cross-fertilization opens the disciplinary and spatial boundaries. Deep excavation and enrichment of the content of study tours, the development of nature, history, geography, science and technology, humanities, experience and other types of exploration and practical activities as an expansion of classroom teaching.

5.2. Rational planning and scientific organization

The implementation of study tours should be strengthened in the following three aspects: optimizing education and teaching methods, standardizing organization and management, and constructing and perfecting evaluation and safety guarantee mechanisms. According to the interpretation framework of the three phases of pre-research, research and post-research, rational planning of the pre-travel, strengthening of the mid-travel, and evaluation of the post-travel. Before the study, combined with the relevant professional background of students at all stages, teachers and students jointly participate in the design and planning of the study program, set the flow of activities, tasks and objectives, and do a good job of preparation will be conducive to the development of educational and teaching tasks. During the study, with high-quality themes and content as a strong support, students as the main participant should be given full physical freedom, through multiple experiences, real-time interaction, positive feedback and effective communication to strengthen the students' sense of physical participation, to complete the effective transformation of knowledge, to deepen the learning goals and actively follow up the learning progress. After the study, they need to summarize and share their experiences, and complete the output of knowledge through the display of study works and mutual evaluation.

At the same time, improve the relevant evaluation mechanism and improve the supervision and management system, strengthen the school study trip operation mechanism construction, linkage of various departments to promote the implementation of the policy, strengthen the study product market supervision, to ensure that the quality of various types of study products to achieve a certain degree of parenting effect.

5.3. Building Research Faculty

Utilizing the educational concepts of “research-based” learning and “experiential” travel in parallel, we strengthen the awareness of physical participation and guide students to make their bodies the real subjects of learning. Study tutors not only need to guide the organization and coordination skills, but also need to have professional education and teaching capabilities and a strong knowledge base and good personal qualities, shoulder “education” and “tourism” cross-border integration of composite The important task of “two-way tutor”.

6. Conclusion

Study tours is a continuation and supplement of school classroom teaching, which can effectively improve students' comprehensive ability. This study takes time planning into account in the path arrangement of study tours, establishes a travel route optimization model, and carries out a specific case study. Then, through the variable selection, the fuzzy set qualitative comparison method is used to explore the path of improving the efficiency of the curriculum in the study and learning travel course.

1) Particle swarm genetic hybrid algorithm is used to solve the travel route optimization model, which effectively solves the problems of slow search speed, premature convergence and poor local search ability of traditional algorithms, and improves the efficiency and speed of the algorithm. Through the actual case study, we obtain the best time-optimized path plan for the study trip, and achieve the completion of the study trip route in 8.2 days, which is 2.2 days less than the traditional planning path.

2) There are 4 groupings that realize the efficiency improvement of the curriculum of study tours, and the overall coverage rate of the 4 groupings can reach more than 0.85, which can support the reasonableness of the selection of the antecedent variables affecting the efficiency improvement of the curriculum from the side. H2 is the combination with the largest coverage of all combinations, with a raw coverage of 79.2%, suggesting that this pathway is a key combination of factors affecting the increased efficiency of the research and study trip curriculum.

3) Strategies for the development of study tours are proposed: the dynamic, diversified and composite characteristics of the study tour environment should be fully taken into account to create an immersive learning environment, promote in-depth learning and enrich the study experience. According to the three-stage explanation framework of study and learning, rational planning and scientific organization should be carried out to improve the quality of study and learning. In addition, in order to ensure that study tours are carried out in an orderly, standardized and efficient manner, a specialized study teacher team is being built through an innovative and optimized talent training model.

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