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System Dynamic Modeling and Simulation of High-quality Educational Resources Sharing Model

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ABSTRACT

With the deepening of educational reform triggered by information technology, the imbalance of education resources the prominent problem in the reform and development process of education. Aiming at the "sharing education" model, this paper conducted the causal analysis of the system structure of high-quality education information resources allocation, established the relationship between the flow diagram and equation of high-quality education information resource allocation system, mined the influencing factors of high-quality education information sharing rate and analyzed the impact of different factors on the sharing rate of high-quality education information resources. Finally, this paper proposed suggestions for the improvement of high-quality education information resources allocation model based on the simulation results.

Keywords: educational resource, sharing model, system dynamics

INTRODUCTION

The information technology has exerted a profound impact on our study life. With the development of information technology, "projection" and "multimedia courseware" have been replaced by "ubiquitous learning", "flipped class" and "wisdom education", which have become the mainstream learning model of the times. With the advent of the digital era, the educational reform caused by information technology has gradually deepening. The transformation from "educational informationization" to "the deep integration of information technology and education" reveals the "revolutionary impact of information technology on the development of education". The information technology has become the most effective method for future educational reform. The imbalance of education resources is the greatest difficulty in the process of educational reform and development, which has attracted the attention of relevant government departments, attracting the attention of many education policy makers and academic researchers. The key to the deepening of educational informationization is rich and high-quality educational information resources. However, problems like uneven allocation of funds, poor quality of educational resources and low using efficiency still exist in the construction process of educational information resources. How to achieve the maximum sharing of high-quality education information resources and narrow the digital gap between different regions, between urban, rural areas and between different schools has become a new issue for education equalization development.

The "sharing education" model can achieve the transformation of educational resource allocation concept from static, closed, single to dynamic, open, multi-change, realize the resource complementarity between different regions, and raise the quality of resources and increase the number of resources. This model can also solve the problem of imbalanced education information resource allocation between different regions, between urban, rural areas and between different schools, and promote the service uniformization of high-quality education information resources in a larger scale. Aiming at current "sharing education" model, this paper conducted the causal analysis of the system structure of high-quality education information resources allocation, established the relationship between the flow diagram and equation of high-quality education information resource allocation system, mined the influencing factors of actual use ratio of high-quality education information resources, analyzed the impact of different factors on the actual use ratio of high-quality education information resources, explored the improvement

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Contribution of this paper to the literature

- It combines resource development systems, user-use systems and education authorities to conduct complex causal analyzes as an organic whole.
- The factors that influence the sharing rate of quality educational resources can provide reference for other studies of the same type.
- The conclusion of the research is in favor of the improvement and perfection of the current "shared education" mode.

path of investment efficiency, service quality and use efficiency of basic education information resources and optimized the allocation model of basic education information resources.

APPLICABILITY ANALYSIS OF SYSTEM DYNAMICS

System Dynamics (SD) is created by the Jay W. Forrester, a professor at the Massachusetts Institute of Technology in the early 1950s (Zheng and Le, 2011; Forrester, 1961). The system dynamics is used to analyze the characteristics of the system to clarify the structure of system, behavior and the dynamic characteristics relationship between them. The whole system is divided into several subsystems by using the method of system thought, and the causal relationship between different subsystems and inside the subsystem is found. And then the system dynamics model is established to conduct the computer-aided simulation of objective and actual systems. The system dynamics model can be used as the actual system, especially as the "laboratory" of the complex system of society, economy and ecology.

The system dynamics method shows good applicability in the study of "sharing education", including: (1) System dynamics can solve some complex, dynamic and non-linear socioeconomic problems. The "sharing education" model involves many subsystems such as resource developments, customer use and education authorities. Moreover, the number of system elements and objects is large and their relationship is complex; the improvement of the quality of educational resources, the transformation from potential users to active users and the regulation of the use of funds by education authorities are all time-varying dynamic changes. (2) System dynamics is suitable for dealing with the problem of insufficient data. System dynamics can use limited data and structure to calculate and analyze the mathematical relationship between data based on the causal relationship among various elements, thus solving difficult problems such as insufficient historical data or unavailability of data encountered in mathematical modeling. (3) System dynamics is applicable to solving periodic and long-term problems. On the one hand, in the short term, the regional education authorities allocate funds to the development and using system in proportion to maximize the improvement of the resources quality, encourage the active use of users and give full play to the sharing of information resources under the established fund input; on the other hand, according to the principle of long-term and sustainable development, the "policy experiment" in system dynamics is used to predict and analyze the behavior of future system elements and the overall trend of the system under the premise of different situations.

Some scholars have made some theoretical research on the informationization of education by using the theory of system dynamics and the basic model analysis method, which lays the foundation for the research in this paper. Some scholars have analyzed the education authorities. Jiao and Huang (2014) built the growth limit model of educational informationization system in elementary and secondary schools in underdeveloped regions and proposed that the key factors to promote the implementation of educational informationization in primary and secondary schools in underdeveloped regions were the ideas of leaders, policy measures of leadership and input of funds (Jiao and Huang, 2014). Zheng and Lei (2011) used the basic theory and method of system dynamics to construct the system dynamics model of government information resource allocation. The results showed that the rational allocation of government information resources depended on the improvement of users' information ability, the strengthening of government intervention and the improvement of information policies and regulations. Some scholars have analyzed the resource developers. Yang et al. (2013) used the basic mode analysis to obtain the main feedback structure of the "co-construction and sharing" mechanism of information resources, and made simulation on use ratio of information resources and established and improved a set of incentive mechanism for resource development and use. Wu (2015) used cloud computing technology to explore the model of regional educational resources sharing and put forward some constructive suggestions on how to achieve the optimization and reasonable planning of high-quality education resources constriction (Yang et al., 2013). Wang and Niu (2017) built the game model of innovation behavior evolution of innovation demander and college students and used the system dynamics method to further describe the dynamic decision-making process of both sides on the basis of analyzing the evolution of innovation decision-making and innovation behavior of college students under public innovation model. Some scholars focus on the education resources users, and the most important is to analyze the

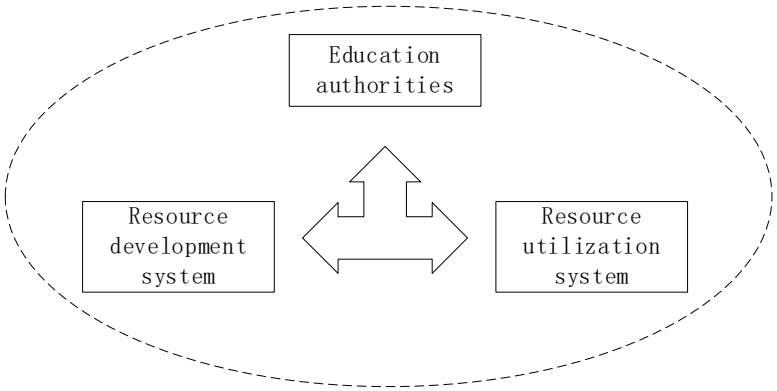

Figure 1. System Boundary Diagram

school. Shang and Wu (2016) constructed the hierarchical framework model oriented to regional high-quality educational resources sharing in cloud environment and conducted analysis combining typical cases based on the analysis of the demand of hierarchical framework for educational resources sharing, which made contributions to the constriction of the public service platform of regional education resources (Shang et al., 2016). Tang (2015) believed that from the perspective of resource allocation, the reduction of administrative intervention, the opening of gradual higher education market, the change of teacher evaluation system and the upgrade of educational resources allocation model can effectively improve the uneven distribution of educational resources.

Previous studies focused on one of these aspects, some directed at the government's education authorities, some targeting users of quality educational resources such as schools, and others targeting developers of quality educational resources. However, the use of educational resources is a complex system for designing resource developers, resource users, and education authorities. In this paper, the three subjects involved in the utilization of educational resources are put in the same model, and the three are combined by the causation and taken into consideration. Finally, this paper analyzed the factors that exerted a significant impact on the utilization of educational resources.

CONSTRUCTION OF SYSTEM DYNAMICS MODEL

Research Object and Boundary Definition

The quality of education information resources and consumer use system are mainly composed of three modules: resource development and quality improvement, consumer use and regional education authorities. Moreover, the improvement of resources quality, user incentive measures and government funding are launched around resources utilization, as is shown in **Figure 1**.

The overall operation mechanism of the system can be described as follows: according to the users' demand for resources and the government's entrustment or customization, the development enterprises of educational resources produce the information resources conforming to the corresponding technical standards by making full use of their own technical and financial advantages, provide quality improvement in later period and technical support and develop new products; the active users selectively use high-quality educational information resources based on the purpose of teaching and learning. The school is responsible for the construction of an informational environment and encourages active involvement of teachers and students. The school can also make reasonable evaluation and recommendations for improvement based on teaching effectiveness and satisfaction in the process of using to and send the feedback to the software development enterprises timely to facilitate the improvement of the quality of resources; education authorities, as the organizer of regional education information resources development and utilization, are mainly responsible for the price adjustment of resources and services, formulation of the allocation scheme of annual education information special funds, construction of the cloud service platform for information resources and the scientific and reasonable provision of incentive based on the users and the resource utilization performance.

Causal Relationship Model of Sharing Model

Based on the above explanation and analysis of influencing factors of sharing rate of high quality education resources, Vensim software is used to draw the causality diagram of high-quality educational resources sharing model according to the causal and logical relationship between each influencing factor and the sharing rate of a

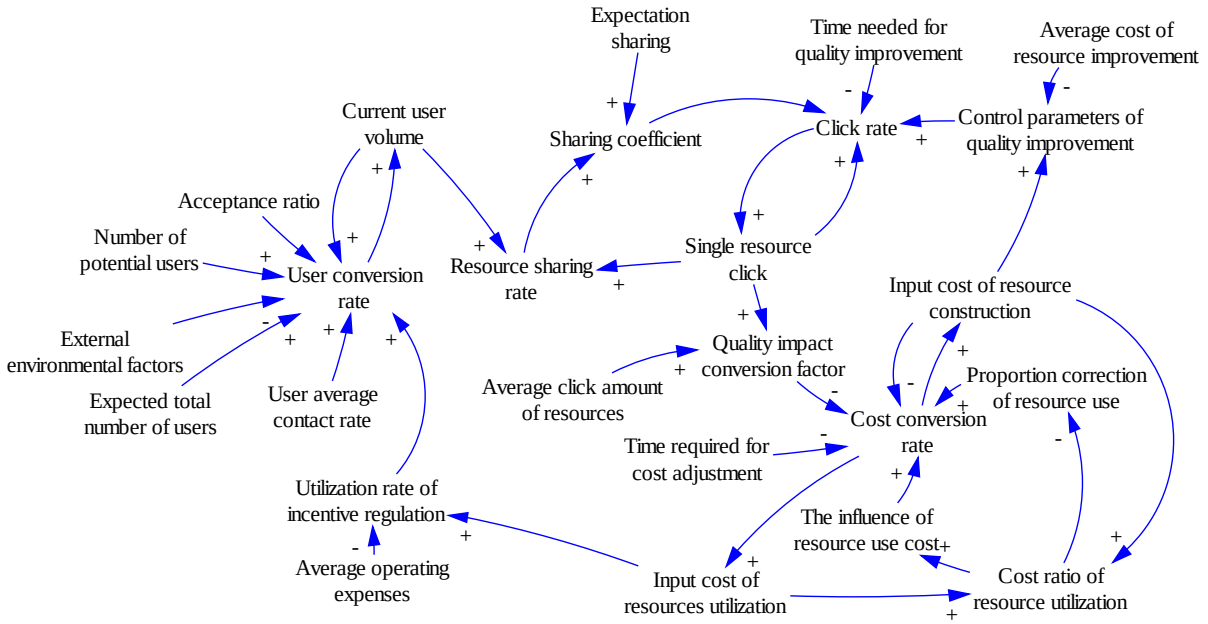

Figure 2. Causality Diagram of Sharing Education Model

certain educational resource under the premise of considering the relationship among system internal factors, as is shown in **Figure 2**.

When multiple variables (n>3) in the system can form a causal, closed loop, then a feedback loop is formed. The positive feedback loop and the negative feedback loop can play an important role in different periods in the evolution of the system alternatively, thus promoting the system towards different states. In the system causality diagram, there are many feedback loops. A feedback loop is a closed chain of causality, starting from a certain stock and depending on the stock's current conditions. Through a series of rules, the feedback loop affects the stock-related flow and, in turn, changes the stock. The system dynamics model is to study the influencing factors of resource utilization. The main feedback loop in the causality diagram is:

(1) input cost of resource construction - control parameters of quality improvement - click rate - single resource hits - quality impact conversion factor - rate of cost conversion - investment costs of resource construction;

(2) single resource hits - quality impact conversion factor - cost conversion rate - input cost of resource use - usage rate of incentive regulation - user conversion rate - number of active users - resources sharing rate - sharing coefficient - click rate - single resource hits;

(3) number of active users - resource sharing rate - sharing coefficient - click rate - single resource hits - quality impact conversion factor - cost conversion rate - input costs of resource use - usage rate of incentive regulation - user conversion rate - number of active users.

System Flowchart of Sharing Education

According to the above analysis results, based on the actual situation and combined with the causality diagram, the system flow graph of high-quality educational resource sharing model is obtained considering the computability and reality of data, as is shown in **Figure 3**.

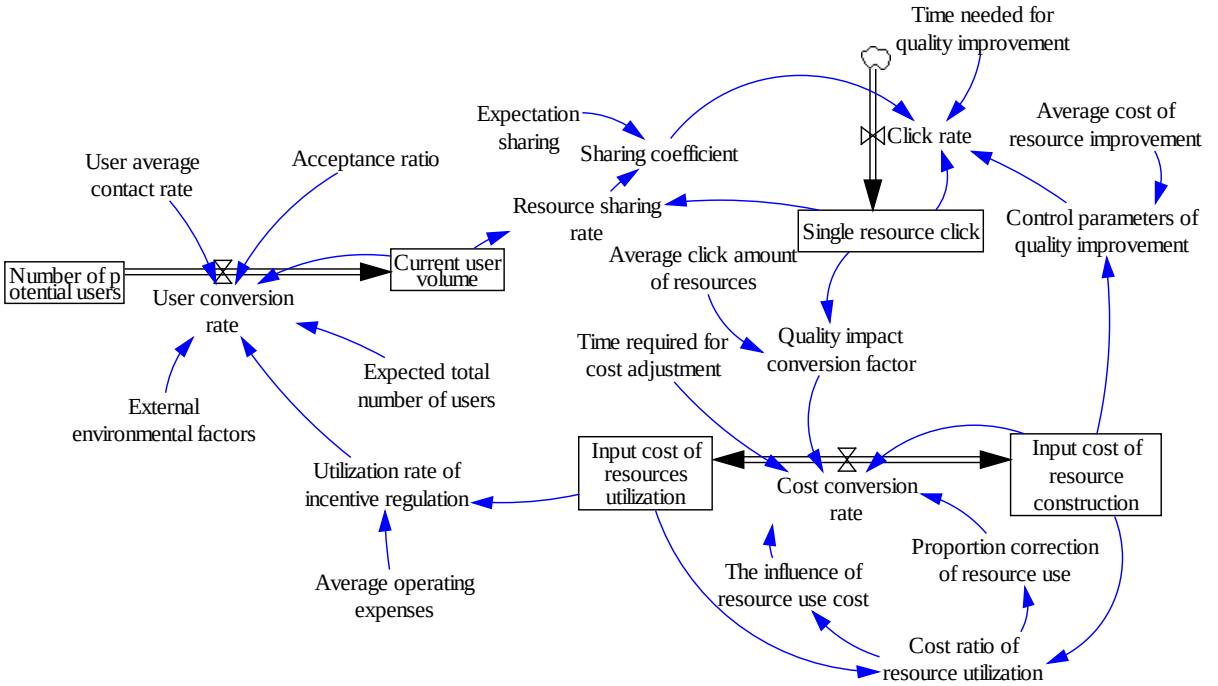

Figure 3. System Flowchart of Sharing Education Model

Table 1. Main Variable Parameters and Function Expressions

Serial number	Variable name	Function expression	Initial value	Unit
1	Resource sharing rate	Resource sharing rate = Single resource click / Current user volume	—	Times / person
2	Coefficient sharing	Coefficient sharing = Resource sharing rate / Expectation sharing	—	Dmnl
3	Single resource click	Single resource click =INTEG (Click rate,, 100)	100	Times
4	Current user volume	Current user volume = INTEG (User conversion rate,, 20)	20	Person
5	Number of potential users	Number of potential users = INTEG (-User conversion rate,, 480)	480	Person
6	Click rate	Click rate =(Control parameters of quality improvement * Sharing coefficient * Single resource click)/ Time needed for quality improvement	—	Times / month
7	User conversion rate	User conversion rate =(External environmental factors * Utilization rate of incentive regulation * Average user contact rate * Acceptance ratio *(Current user volume / Expected total number of users)* Number of potential users)	—	Person / month
8	Cost conversion rate	Cost conversion rate= Quality impact conversion factor * Input cost of resource construction *(1- Proportion correction of resource use)* The influence of resource use cost / Time required for cost adjustment	—	Yuan / month
9	Input cost of resources utilization	Input cost of resources utilization =INTEG(Cost conversion rate,, 2000)	2000	Yuan
10	The influence of resource use cost	The influence of resource use cost = Cost ratio of resource utilization		Dmnl
11	Cost ratio of resource utilization	Cost ratio of resource utilization = Input cost of resources utilization /(Input cost of resources utilization + Input cost of resource construction)		Dmnl
12	Input cost of resource construction	Input cost of resource construction =INTEG(- Cost switching rate,, 8000)	—	Dmnl

This model flowchart contains a total of 26 variables, including 5 state variables, 3 rate variables, 8 auxiliary variables and 10 constants. In this paper, the resources sharing rate variable is used to represent the utilization rate of resources. The specific variable parameters and function expressions are shown in **Table 1**.

Figure 4. Impact Analysis Diagram of User Average Contact Rate on Resources Sharing Rate

Model Test

The model test mainly includes the validity test, mechanical error test and dimensional consistency test of the model. This model has passed the mechanical error test, dimensional consistency test and validity test of vensim software, which can be used for simulation prediction.

SIMULATION AND ANALYSIS OF SYSTEM MODEL

The average user contact rate in the initial setting of model simulation is 8 (person * times / month), and at this moment, and the resources sharing rate curve is shown as the red curve in **Figure 4**; when the value of average user contact rate is adjusted to 6, the resource sharing rate curve is shown as the blue curve in **Figure 4**; when the value of user average contact rate is adjusted to 10, the resource sharing rate curve is shown as the green curve in **Figure 4**. It can be seen from the system simulation that the resources utilization rate increases dramatically with user average contact rate, which is due to the fact that more potential customers come into contact and choose to use new information resources.

The external environment factor in the initial setting of model simulation is 0.2, and at this moment, the resources sharing rate curve is shown as the red curve in **Figure 5**; when the value of external environment factor is adjusted to 0.15, the resource sharing rate curve is shown as the blue curve in **Figure 5**; when the value of external environment factor is adjusted to 0.25, the resource sharing rate curve is shown as the green curve in **Figure 5**. The value of informational environment in the model, as the inhibitory factor of resource sharing rate, represents the negative impact of environment restricts the extent of the negative impact of resource use. It can be seen from the system simulation that a high level of informational environment can better promote the use of information resources.

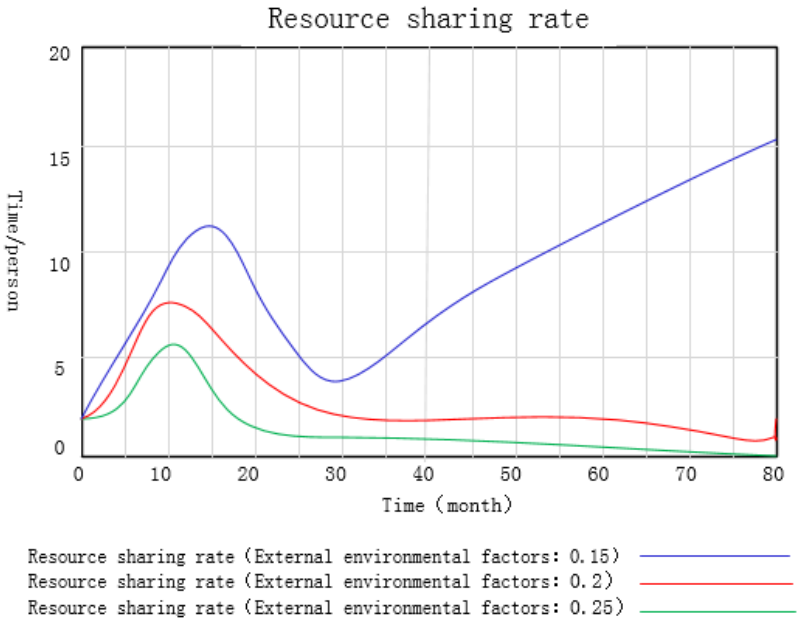

Figure 5. Impact Analysis Diagram of External Environmental Factors on Resources Sharing Rate

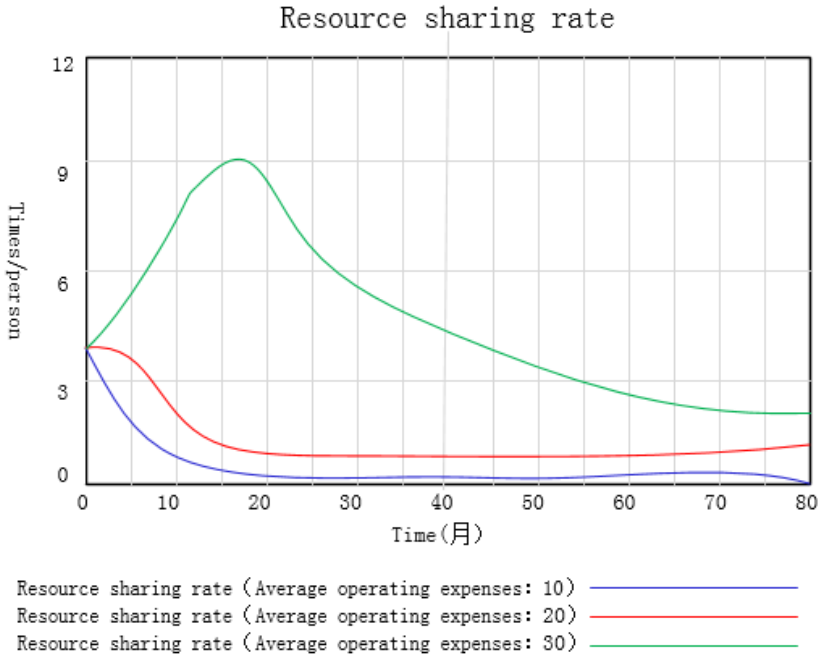

Figure 6. Impact Analysis Diagram of Average Usage Costs on Resources Sharing Rate

The average usage costs in the initial setting of model simulation is 20, and at this moment, the resource sharing rate curve is shown as the red curve in **Figure 6**; when average usage cost is adjusted to 10, the resource sharing rate curve is shown as the blue curve in **Figure 6**; when average usage cost is adjusted to 30, the resource sharing rate curve is shown as the green curve in **Figure 6**. It can be seen from the system simulation that the utilization rate of resources increases with average usage fee, which is due to the fact that although low use cost or free trial experience can speed up the user conversion rate, it is difficult to achieve lasting results. It is difficult for the low cost to meet the consuming desire of users.

Through system dynamics, users of educational resources, such as school teachers and students, educational resource developers and local education authorities, can be fully and organically connected to form a complex system. In this dynamic and complex system, the feedback loop of system dynamics can be used to effectively

analyze the impact of a certain influencing factor on the actual utilization of resources. Thus, the method of promoting resource utilization can be obtained. For example, (1) a high level of information environment can promote the use of educational resources. According to this conclusion, schools can strengthen the construction of school information platform and promote the use of educational resources; (2) As the average usage fee increases within a certain range, the utilization rate of resources has increased. According to this conclusion, educational authorities can reasonably price educational resources and choose the most appropriate price to maximize the benefits while promoting the utilization of educational resources. Readers and future researchers can further study on this basis, for example, how to build a high-level information platform and how to choose the most reasonable average usage cost of resources.

CONCLUSIONS

The systematic dynamic model of high-quality educational resources sharing model constructed in this paper is reasonable and effective, which can express the interrelationship among various factors in the system. The simulation results better reflect the reality of high-quality education resources sharing. Aiming at the efficiency of high-quality education resources, this paper conducted analysis from different aspects and influencing factors, drew some conclusions and proposed corresponding countermeasures:

(1) The utilization rate resources increase dramatically with user average contact rate. Therefore, schools should systematically put forward the requirements for developing new resources, expand the number of targeted user groups, increase the intensity of publicity of educational resources among teachers and students, and provide more opportunities for teachers and students to enjoy high-quality educational resources.

(2) High level of informational environment can better promote the use of information resources. Based on this, schools can optimize campus equipment, improve the equipment level, such as ensuring the network broadband. In addition, schools also need to increase their training in user skills and qualifications and expand the scope of the application of information resources.

(3) The utilization rate of resources increases with average usage fee. High-quality education resources are characterized by high costs and low marginal costs, which may easily give rise to "monopoly", manifested by "market failure". Therefore, we should give full play to the role of the government regulation and formulate a type of price measurement system suitable for educational information resources.

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