Ecological Evolution Model and Simulation of Digital Educational Resources in Colleges and Universities

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Abstract

Enriching high-quality digital education resources and their efficient utilization are the key to the advancement of educational informatization. Digital education resource construction in colleges and universities is a kind of dynamic complex system with high order, nonlinear, multivariable and multiple feedbacks. In this paper, using the method of system dynamics and the theory of ecology, by regulating the variables, such as funding, personnel incentives and education training, observe its impact on development of the overall construction level, explore the mechanism of action between variables and the operation law of the whole system, to the scientific development of informatization construction to provide theoretical reference and decision-making basis.

Keywords

Education informatization, Digital Education Resources, System Dynamics.

1. Introduction

Digital education resources (DER) are the collection of resources specially designed for the purpose of teaching and learning after digital processing.Rich and high-quality DER is the key to the in-depth promotion of educational informatization, which has been attracting much attention in the development process of educational informatization in China.In 2010, China promulgated the Outline of National Medium and Long-term Educational Reform and Development Plan(2010-2020), pointing out that we should vigorously and comprehensively promote the development and application of DER, and strengthen the open sharing of high-quality education resources. In 2016, China's ministry of education "The 13th Five-year Plan for Educational Informatization" put forward the development task of "constructing a good ecological environment for educational informatization and providing convenient and fast services for learners to enjoy high-quality DER". DER's ecological construction emphasizes the use of ecology's system view, balance view and whole view to investigate the construction, application and service of resources, aiming to reflect the healthy and sustainable development of DER[1]. From the perspective of ecology, this paper adopts system dynamics (SD) method to study the influencing factors and operation mechanism of DER, so as to provide reference for the sustainable development of DER in in colleges and universities[2].

2. Principles and Methods

2.1 Ecological Perspective

Ecology is a science that studies the relationship between living organisms or groups of organisms and their living environments. Eco-chain refers to the chain-like interdependence of many biological and abiotic components in an ecological community through energy and material circulation[3]. In this study, DER are endowed with certain "life" attributes and regarded as an entity with life significance. It holds that the ecological chain of DER refers to the chain dependency relationship formed by capital, manpower and technology in the information environment. DER exists in a

specific educational information ecosystem. It provides resources and services to users by means of information technology, which makes resources flow between material, energy and information and realize value-added. In this study, the SD method will be used for analysis.

2.2 System Dynamics (SD)

SD was put forward by professor Forrester of Massachusetts institute of technology in 1950s, which is a computer simulation method based on cybernetics, system theory and information theory to study the structure, function and dynamic behavior of complex systems. SD considers that the behavior pattern and characteristics of the system mainly depend on its internal dynamic structure and feedback mechanism. Under the influence of internal and external forces and constraints, the system develops and evolves according to certain rules. SD studies the system from the micro-structure of the system, constructs the model of the system according to the interaction between the structure and the function of the system, and shows the future results of implementing various policy schemes on the model through computer simulation, and seeks the right way to solve the problem. Therefore, SD is known as the "laboratory" of the actual system. The advantages of the SD method in studying the construction of DER mainly lie in the following aspects.

1) SD is a computer simulation method combining qualitative and quantitative analysis, which is good at dealing with the problems of complex time-varying systems with highly nonlinear, higher-order, multivariable and multiple feedbacks. For complicated system problems such as DER construction, pure qualitative analysis is superficial, and complete mathematical description is defective because the accuracy and comprehensiveness of data cannot be guaranteed. Using SD to realize the combination of qualitative analysis and quantitative research, and through computer simulation to achieve man-machine interaction, it can be convenient and effective to deal with it.

2) SD is good at dealing with long-term, dynamic and strategic issues. Using SD to study the dynamic feedback mechanism inside DER construction system can effectively analyze its long-term dynamic operation rules.

3) SD model is a structure-dependent model, which focuses on the dynamic and behavior of the system, but requires little data. Even in the condition of incomplete data, it can still be studied, which is more suitable for DER construction.

4) SD USES graphics such as causality diagram and flow diagram to analyze problems and build models, which has good intuitiveness and transparency.

5) The SD model can conduct repeated dynamic simulation experiments. Therefore, dynamic behavior and change trend of the system when different parameters and policy factors are input in DER construction can be investigated to seek for better system structure and function, and to make long-term dynamic and strategic forecast.

3. Model Construction

3.1 Basic Assumptions and System Boundaries

Considering the operability and quantitative requirements of the model, the following assumptions are made.

H1: the construction of DER in colleges and universities is a continuous and gradual process;

H2: the impact of major policy changes, natural risks and other emergent factors is not considered.

The boundary of the system is an imaginary outline that includes what is considered for the purpose of modeling, but is separated from other parts. Inside the boundary, all concepts and variables related to the problem studied should be considered in the model, and vice versa.

3.2 Causal Analysis

Causal analysis is to use the causal relationship diagram to describe the relationship between variables, which is conducive to the overall understanding of the system, grasp the system structure, and understand the dynamic behavior of the system. The causal relationship of DER is shown in FIG. 1.

In the figure, the element of arrow tail acts on the element of arrow head, "+" represents a positive correlation, and "-" represents a negative correlation[4,5].

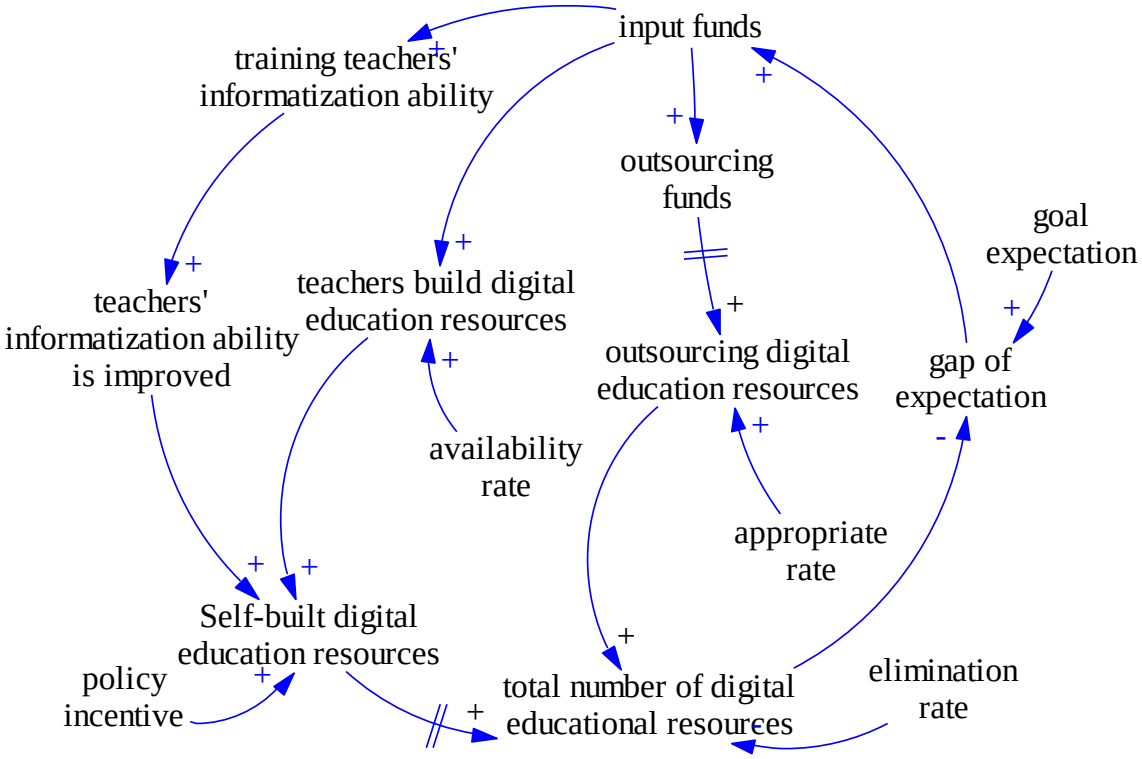

Fig. 1 Causality Model of DER

3.3 Flow Diagram

Although the causal diagram can intuitively describe the feedback mechanism of the system, it is a rough qualitative description and cannot show the difference of qualitative variables, nor can it distinguish the material flow, energy flow and information flow of the system. Therefore, it must be further represented by quantitative flow diagram. Through the causal relationship of ecological evolution of DER in colleges and universities, the flow diagram can be obtained, as shown in FIG. 2. There are 11 variables in the model, including 1 state variable, 2 rate variables and 15 constants. The main variable relationships involved in the flow diagram are as follows[6-9]:

(1) amount of training funds=input funds*proportion of training funds

(2) appropriate rate=C(constant)

(3) availability rate=C

(4) average construction time=C

(5) average expenditure on buying resources=C

(6) average expenditure on construction resources=C

(7) eliminated DER=total number of DER/mean life span

(8) funding factor=C

(9) gap of expectation=goal expectation-total number of DER

(10) goal expectation=C

(11) Incremental Number of DER=outsourcing DER +Self-built DER

(12) input funds=gap of expectation*funding factor/project duration

(13) mean life span=C

(14) outsourcing DER=DELAY1(outsourcing funds/average expenditure on buying resources, time to buy resources)*appropriate rate

(15) outsourcing funds=input funds-Teachers build DER-amount of training funds

(16) policy incentive factor=C

(17) project duration=C

(18) proportion of resources construction funds=C

(19) proportion of training funds=C

(20) reference cost=C

(21) Self-built DER=DELAY1(Teachers build DER /average expenditure on construction resources, average construction time)*policy incentive factor*teachers' informatization ability is improved

(22) Teachers build DER=input funds*proportion of resources construction funds1*availability rate

(23) teachers' informatization ability is improved=WITH LOOKUP (amount of training funds *training effect factor/reference cost)

(24) time to buy resources=C

(25) total number of DER= INTEG (Incremental Number of DER-eliminated DER, 3000)

(26) training effect factor=C

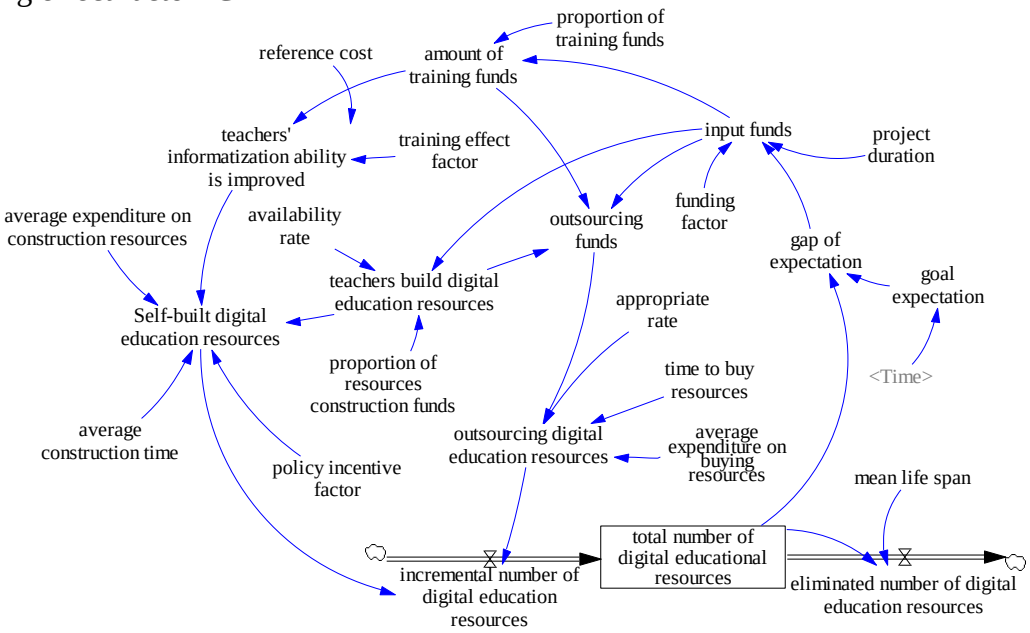

Fig. 2 Flow Diagram of DER

4. Simulation Analysis

In order to test the effectiveness of the model, take the DER construction of some college as an instance, and use the SD software Vensim for simulation analysis. Vensim simulation software is a visual modeling tool running on the Windows operating platform, featuring graphical programming, multiple analysis methods and authenticity verification.

4.1 Basic operation and policy simulation

The simulation starting time is January 2016 and ending time is March 2024, a total of 100 months. The simulation step size is 1Month, in which 2016-2018 is a realistic fitting and 2019-2024 is a trend forecast. By assigning initial values to each variable, the simulation results of the model can be obtained.

Due to the large number of parameters in DER ecological evolution model, it is impossible to simulate them one by one due to the limited space. Therefore, this paper takes input funds, informatization ability training and policy incentive as examples to conduct simulation and observe the dynamic changes of them and total number of DER.

Plan 1 is to adjust the investment structure. Other conditions remain unchanged, the ratio of training funds, construction funds and outsourcing funds shall be adjusted from the current 0.05:0.75:0.2 to 0.01：0.50：0.49, observe the trend of the system, as shown in curve 2 in fig.4.

Plan 2 provides increased input funds. Other conditions remain unchanged, and 50% is increased from the current basis to observe the trend of the system, as shown in curve 3 in fig.4.

Plan 3 is to adopt performance incentive policy to enhance teachers' enthusiasm in building resources. Other conditions remain unchanged, the current incentive policy intensity is increased by 30%, and the trend of the system is observed, as shown in curve 4 in fig.4.

Plan 4 is to strengthen management of teacher training. Other conditions remain unchanged, the training effect is increased to 10%, and the trend of the system is observed, as shown in curve 5 in fig.4.

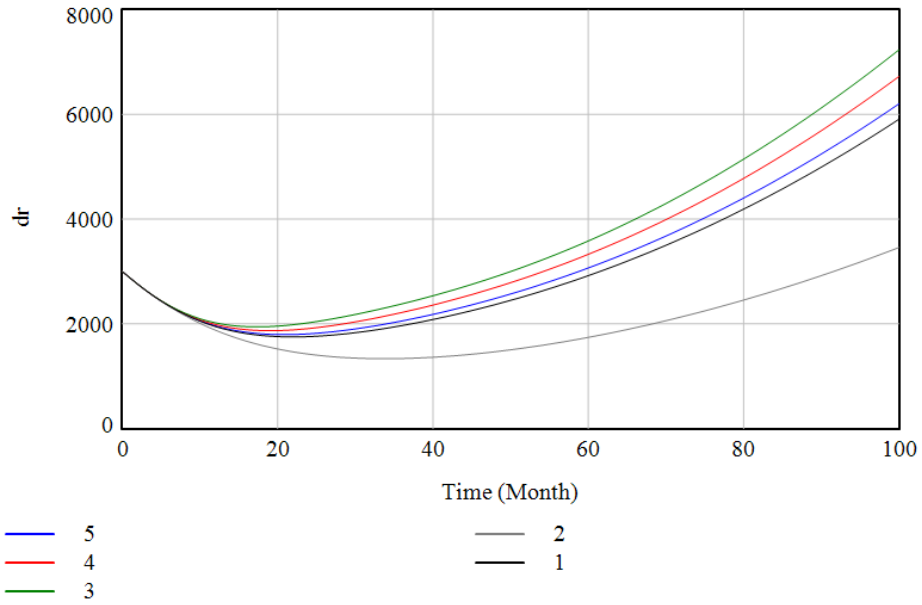

Fig. 3(a) Total Number of DER

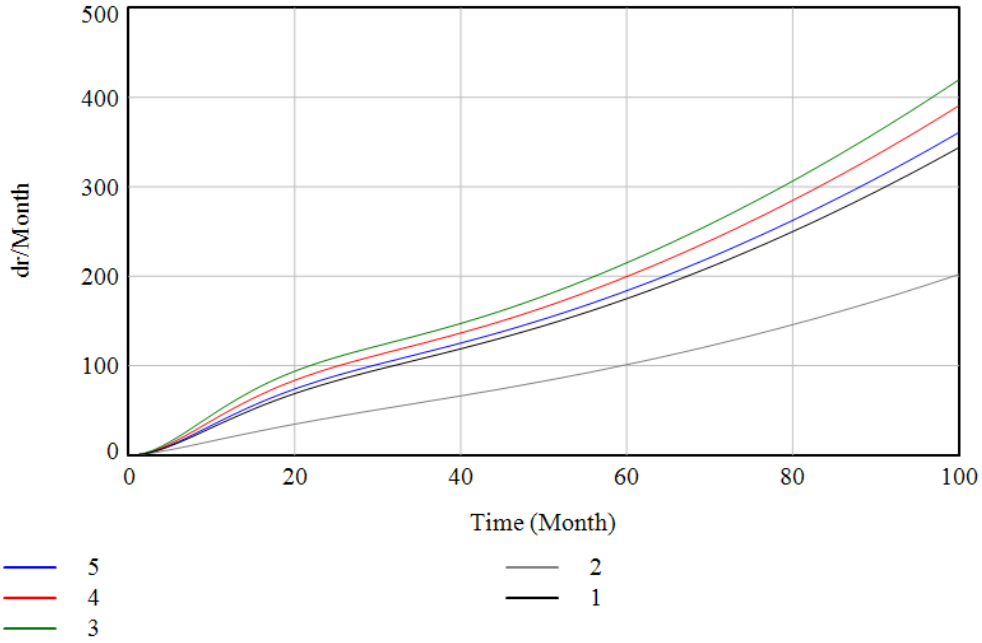

Fig. 3(b) Incremental Number of DER

4.2 Result Analysis

1) It can be seen from FIG.3 that the total number of DER is slightly reduced in the initial construction, and it is a dynamic development process with an upward trend on the whole. Since all DER have a life span, they are not replenished in time at the early stage of construction, thus showing a temporary downward trend. Generally speaking, DER of engineering category have shorter life span due to rapid technological update, while DER of humanities category have more mature content and slower update speed due to longer life span.

2) Through the simulation of policy regulation, it can be seen that there is a complex feedback coupling relationship between variables, with obvious system coordination and overall linkage. The change of one parameter will cause the change of other variables, which will have an impact on the development of the informatization construction level of colleges and universities. Therefore, in the process of construction, it is necessary to promote the overall coordination and consideration, not only to do a good job in the top-level design, but also to pay attention to the specific construction, there can be no "short board".

3) It can be seen from plan 1 that after the investment structure is adjusted from 0.05:0.75:0.2 to 0.01:0.50:0.49, the overall level of DER construction in colleges and universities is reduced in the long run. This is because the unreasonable investment structure makes the development of various elements cannot be synchronized, and the existence of a "short board" affects the construction process of the whole system. Therefore, a reasonable investment structure can improve the overall level of DER construction in colleges and universities, and on the contrary, reduce the level of DER construction.

4) It can be seen from plan 2 that increasing investment funding is of positive significance to the cultivation of informationized talents and the development of DER. The more funds are invested, the greater the total amount of DER will be.

5) It can be seen from plan 3 and plan 4 that adopting performance reward policy and strengthening teacher training management can promote the construction level of DER in colleges and universities, so the improvement of informatization policy and system is of great significance to improve the construction level of DER.

5. Conclusion

DER construction in colleges and universities is a kind of dynamic complex system with high order, nonlinear, multivariable and multiple feedbacks. The feedback relation of internal structure and its operation mechanism are quite complicated. it is of great superiority to study it quantitatively by using the method of SD on the basis of qualitative analysis. In this paper, the selection of input funds, informatization ability training and policy incentive to carry out simulation and regulation, and observed its impact on the overall level of development of construction, preliminary exploration of the role of variables between the mechanism. Of course, if we want to make a more profound exploration of the operation law of the whole system, we must carry out a comprehensive simulation and analysis of the whole system. Through the results of this paper, it is proved that using SD method to study the construction of DER can effectively reveal its basic operation rules, guide the construction practice, and provide theoretical reference and decision-making basis for the scientific development of the informatization construction in colleges and universities.

Acknowledgements

This paper was supported by Natural Science Foundation of Hunan Province (2019JJ70076), the Subject of Vocational Education Branch of China Association of Higher Education(GZYZD201817), the Subject of Hunan Industry Polytechnic(GYKY201802) and the Subject of CCF vocational education development (CCFVC2018039).

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