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Development Trend of Preschool Education Resources Based on the Internet of Things Technology Environment

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Abstract Preschool education occupies an important position in the national education system. It has the function of laying the foundation for school education and lifelong education, which is a social welfare undertaking within the scope of public services. With the economic development and the improvement of national quality, the demand for preschool education resources has increased significantly. The problem of preschool education has been alleviated in most areas. However, the issues of "who enters the kindergarten" and "what kind of kindergarten" are issues of equity in preschool education. The balanced development of preschool education resources is a problem worthy of study. Relying on the Internet of Things technology, this research studied the development and countermeasures of preschool education resources from the perspective of educational equity and urban and rural development. The conclusion showed that there were certain differences in preschool education resources in urban, urban and rural areas. Based on this, this paper used research methods such as survey research, qualitative and quantitative analysis, and Internet of Things technology to analyze the problems and causes of the balanced development of urban and rural preschool education resources in the region. It not only narrowed the 11.8% gap between urban and rural preschool education resources, but also theoretically promoted the development of urban and rural preschool education resources balance, which had certain practical guiding significance.

Index Terms IoT Technology, Preschool Resources, DEA Model, Resource Allocation

I. Introduction

Preschool education lays the foundation for social progress, national development, and national rejuvenation. As an important part of national public service, preschool education, the development direction, scale, speed and quality of preschool education are significantly affected by national policies. Reasonable national policies can make up for market defects. The rational allocation of resources can protect and promote the development of the early childhood industry to give play to the late-mover advantage, thereby enhancing the adaptability. A large number of facts show that the more development of preschool education, the higher the quality of the population. The degree of civilization, harmony and economic development of the society has also been improved accordingly.

There are scholars' related research on the Internet of Things technology. Beyene Y D believed that the Internet of Things (IOT) was based on the Internet, traditional telecommunication networks and other information carriers, which interconnected all common physical objects that could be independently addressed and used [1]. Through research, Muji E found that the Internet of Things provided a basic channel for information transmission and service support. He put forward suggestions on how to meet business requirements such as low mobility and low data rate of the Internet of Things by enhancing the professionalism and interconnection capabilities of existing network communication technologies [2]. Han W pointed out that the Internet of Things technology actually referred to a stage for the overall circulation of information through the combination of multiple technologies [3]. Sisavath C believed that the technical model of the Internet of Things was similar to the technical model of computer networks. However, the level of the Internet of Things technology model was higher than the computer network technology model [4]. Yang J found through research that the Internet of Things technology had a perception layer, a network layer, an application layer, and a sensor layer. The sensing layer was the foundation of sensor technology. The network layer was responsible for connecting the received information together and delivering it to the desired location through the network. The application layer applied techniques to each object to make the object more resilient [5]. In simple terms, the Internet of Things technology is the integration of three major fields of technology and the connection of things based on the Internet.

There are scholars' related research on preschool education resources. Juliana A's research believed that preschool education focused on promoting children's physical and mental development, which laid the foundation

for children's lifelong development. Preschool education played an important role in the whole preschool education. It was also an important link in the scientific system of preschool education [6]. Saffardin F S believed that children's physical and mental development was gradual. Preschool education should also follow the principles of gradual progress and respect for the laws of physical and mental growth of children [7]. Su-Ping L I researched that preschool education resources were regarded as conditional factors. It included not only subjective resources that play a leading role, but also conditional resources that play a basic and preconditional role. Creative resources can function both directly and indirectly, which is the sum of conditional resources, subjective resources and developmental resources [8]. Davis K L found through research that preschool education resources had the characteristics of public welfare, industry, ideology, inheritance, difference and mobility [9]. Jing C A believed that preschool education was in the first place in human system education. A large number of studies have proved that preschool education had a direct impact on children's primary school learning, thereby affecting the development of children throughout their lives. Preschool education plays a pivotal role in laying the foundation for a person's lifelong development [10]. Preschool education resources are not only the premise and basis of preschool education activities, but also the results and features of preschool education activities. Preschool education resources with high quality and abundant resources reflect the high development level of preschool education, which lays the foundation for the further development of preschool education.

Unequal preschool education resources often lead to a widening gap between urban and rural preschool education and the difficulty of achieving the goal of "education for all". The key to narrowing the preschool education gap between urban and rural areas and reflecting the fairness of the starting point of preschool education is an important starting point for the government to coordinate the balance of preschool education resources between urban and rural areas. This article discussed the development trend of kindergarten preschool education resources based on the Internet of Things technology. The purpose was to improve the development level of preschool education resources in kindergartens.

II. IoT Applications and Related Technologies

(1) Application of the Internet of Things

The Internet of Things is a very important part of the new generation of information technology, which is a network connected by things [11]. The Internet of Things can access the wide-area Internet and realize remote interactive operations with users. Although the Internet of Things technology belongs to a new generation of information technology, its fundamental core is the Internet technology [12]. The Internet of Things can constitute many intelligent applications. The field of application is very broad, which can include almost any industry. At present, in the aspects of environmental protection, community service, commercial finance, etc., such as "mobile payment", "mobile shopping pin", "big brother wallet", "big brother bank", "electronic ticket", etc., as shown in Figure 1, it has broad prospects and great application potential. It is not only an economic market for services, but also a national strategic demand. IoT technology can not only identify its own information, but also collect physical information of the surrounding environment and execute commands to run the physical environment [13]. Therefore, the Internet of Things is regarded as a network that combines the superposition of three spaces on the basis of the original technology of the Internet. It is an extension of the application of Internet technology [14]. Currently, from IoT platforms to short-range communications to low-power wide-area networks, from embedded fusion operating systems to sensors, the development of IoT technology is rapidly iterating. In the next five years, there would be 30 billion IoT devices connected to the Internet worldwide.

The service capabilities and business scale of IoT platforms are growing rapidly. In the next 10 years, the scale would be as high as tens of billions or even larger. The development power of the platform stems from the actual needs of social resource integration. The development of the IoT platform accelerates the evolution of the industrial value towards the information service form dominated by software and supplemented by data services [15]. IoT platforms and tools form the main body of the IoT ecosystem. Any IoT device can be connected to other IoT devices and applications for information transfer using standard internet protocols. IoT platforms make up for the inadequacy of device sensors and data networks. IoT platforms connect with sensor systems and use back-end applications to provide analytics and insights, which enables companies to access massive amounts of data generated by numerous sensors [16]. With the continuous advancement of short-range communication technology, the construction of low-power LAN/WAN is increasingly popular. The ubiquitous capabilities of IoT devices are enhanced.

(2) Internet of Things related technologies

The Internet of Things is a network of interconnected things. It plays an increasingly important role in the context of the Internet of Everything era. There are several popular communication technologies in the Internet of Things: Bluetooth technology, ZigBee technology, Wi-Fi technology, voice interaction technology, etc. [17], as shown in

Figure 2. Among them, the Bluetooth bandwidth is greater than the ZigBee bandwidth. However, ZigBee device nodes are larger than Bluetooth. In recent years, Wi-Fi, a wireless local area network access technology, has been widely used in the connection control of IoT devices, especially in persistent power supply IoT devices. With the continuous increase of IoT products with various sensor access technologies, IoT gateways and other compatible sensor network relay devices have also been widely used.

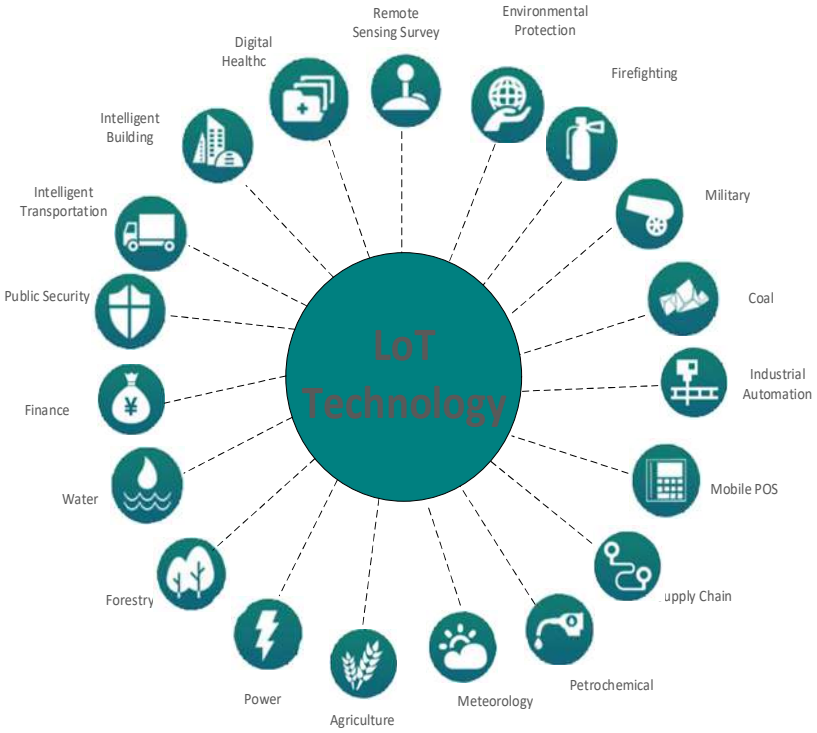

Figure 1: Application of IoT technology

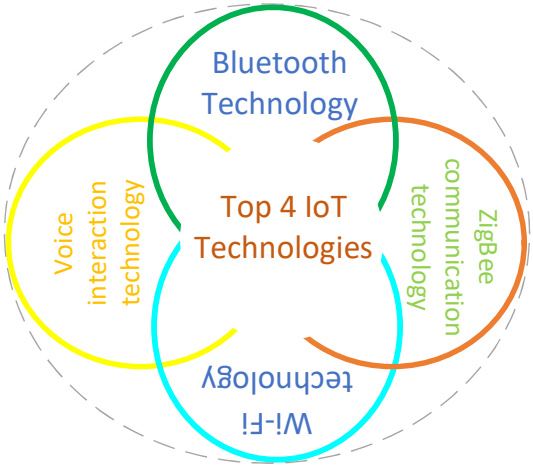

Figure 2: Top 4 technologies for the Internet of Things

a) Bluetooth technology

Bluetooth is one of the wireless technology standards. It enables data exchange between devices over short distances. Using 2.4GHZ-2.485GHZ ultra-high frequency radio waves as the communication carrier, Bluetooth is now managed by the Bluetooth Technology Alliance. It is mainly divided into several specifications such as classic Bluetooth technology, high-speed Bluetooth technology and low-power Bluetooth technology. Its data throughput ranges from 1 Mbps in version 1.0 to tens of Mbps in version 4.x. The transmission rate of Bluetooth is also getting

bigger and bigger. However, since the introduction of the Bluetooth 4.0 standard Bluetooth low energy, Bluetooth has been widely used in IoT devices, which meets people's various requirements for near field communication [18].

b) ZigBee communication technology

As a short-range, low-power, low-speed, low-power, low-cost two-way wireless communication technology, ZigBee complies with the IEEE802.15.4 protocol standard. Its transmission rate is as high as 40kbit/s, and the transmission distance is from 10 to 75m. However, it can still continue to improve. Compared with Bluetooth and WI-FI, ZigBee's biggest feature is its ability to form large-scale networking. Star structure ZigBee can carry up to 254 slave devices and one master device. A single area can have more than 100 ZigBee at the same time. The networking is very flexible [19].

c) Wi-Fi technology

As one of the technologies for connecting electronic devices and wireless local area networks, Wi-Fi occupies an important position in WLANs. It is based on the IEEE802.11 protocol standard and uses the 2.4 GUHF or 5G SHF ISM frequency band. The main content of the 802.11 protocol is the promotion of 802.11a, 802.11b, 802.11g, 802.11n and so on. 802.11b has a rate of 11Mbps, while 802.11g and 802.11n are more general. They are up to 54Mbps and 300Mbps respectively and support longer transmission distance [20].

d) Voice interaction technology

Voice interaction is based on voice recognition input and human-computer interaction in the form of voice (synthesis/recording) broadcast output. This simple voice command usually does not require cloud services. These local speech recognition chips usually use statistical pattern recognition methods for recognition, mainly including template matching, stochastic modeling, and probabilistic syntax analysis. The mainstream algorithm used is the Hidden Markov Model method.

III. Current Situation of Preschool Education Resources

(1) Basic information of the questionnaire

This study uses a questionnaire to investigate the current situation of preschool education resources in cities, towns and townships in a province. By analyzing the existing research literature, the research designs a questionnaire for the balanced development of preschool education resources in cities, towns and townships. The questionnaire is mainly composed of four parts: the basic situation of the kindergarten, financial resources, human resources, and material resources. The final questionnaire is formed after pre-investigation and revision with expert opinions.

(2) Regional preschool education human resources

From the survey data, it can be seen from the education survey of kindergarten teachers in urban areas, towns and villages in the province that the proportion of high school education, technical secondary school education, college education, university education, and postgraduate education in the urban area are 0.29%, 13.9%, 51.2%, 31.8%, and 0.2%, respectively, as shown in Figure 3. Among them, the proportion of education in the township is 0.3%, 16.5%, 63.2%, 20.2%, and 0.0%, respectively, as shown in Figure 4. Among them, the proportion of rural education is 0.5%, 34.1%, 55.0%, 10.3%, and 0.0%, respectively, as shown in Figure 5.

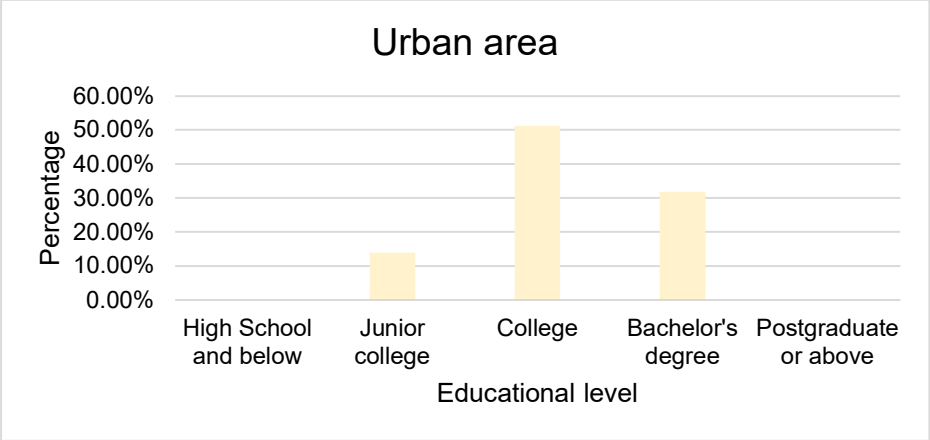

Figure 3: Education level of kindergarten teachers in urban areas

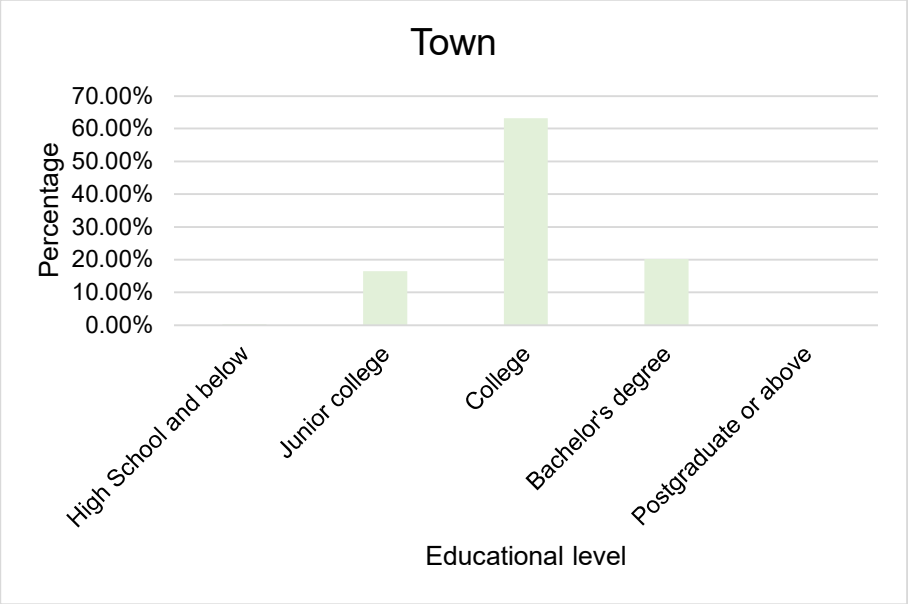

Figure 4: Education level of kindergarten teachers in the township

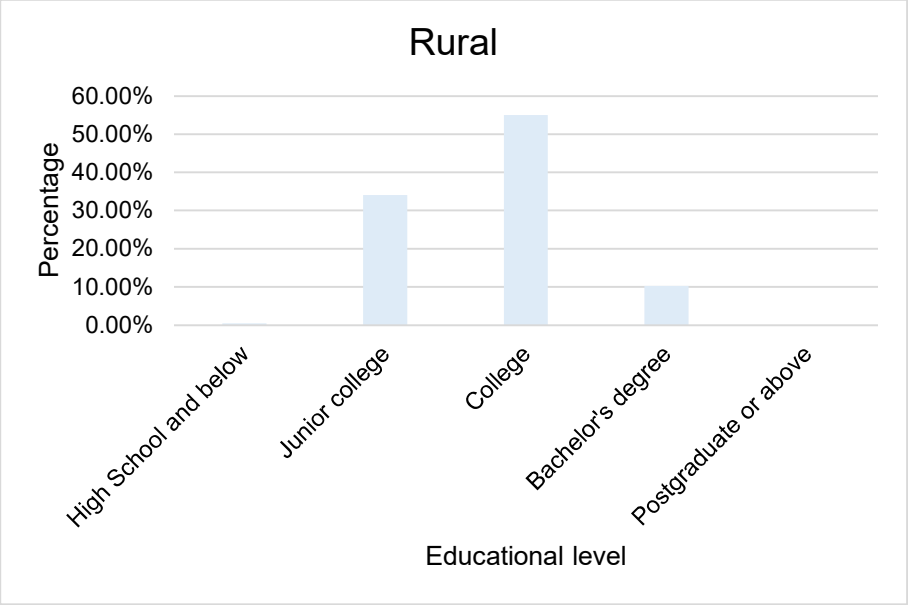

Figure 5: The educational level of rural kindergarten teachers

Survey data shows that 90.5% of urban kindergarten teachers in the province hold qualification certificates. The proportion of urban kindergarten teachers holding qualification certificates accounts for 87.6%. The proportion of rural kindergarten teachers holding qualification certificates accounts for 78.3%. The overall proportion of kindergarten teacher qualification certificates in the urban area accounts for 55.17%, as shown in Table 1.

Table 1: Kindergarten teacher qualification holding status

	Licensed personnel	Unlicensed personnel
Urban area	90.5%	9.5%
Township	87.6%	12.4%
Rural	78.3%	22.7%

(3) Regional preschool education material resources

Urban kindergartens participated in the construction of local preschool education network resources accounts for 72%. Urban kindergartens participate in the construction of local preschool education network resources accounts for 60%. Rural kindergartens participated in the construction of local preschool education network resources accounts for 56%, as shown in Table 2.

Table 2: When urban and rural kindergartens participate in the construction of local preschool education network resources

	Yes	No
Urban area	72%	28%
Township	60%	40%
Rural	56%	44%
Total	55.17%	44.83%

(4) Financial resources of preschool education in urban and rural areas

It can be seen from the survey data that in the survey of the provincial urban, town and rural kindergarten financial funding coordinating departments, the urban kindergarten financial funding coordinating departments and town-level governments and other channels accounts for 56% and 44% respectively. The city-level government, town-level government, township-level government, and other channels accounts for 2.6%, 60.5%, 10.5%, and 26.3% respectively. The coordinating departments of rural kindergarten financial funds accounts for 4.2%, 70.8%, 0.0% and 25% respectively, as shown in Table 3.

Table 3: Urban, town and village kindergartens main financial resources to coordinate the sector share

	Municipal governments mainly	District-level government	Township-level government	Other
Urban area	0	56%	0	44%
Township	2.6%	60.5%	10.5%	26.3%
Rural	4.2%	70.8%	0	25%

IV. DEA Model Based on IoT Technology

(1) DEA model of learning and educational resource allocation efficiency

The DEA method is the data envelopment analysis (DEA) method, which is mainly used to evaluate the relative benefit of the allocation of learning and educational resources. The DEA method has various modes such as 2BC, ST, and FG. No matter what mode is based on the RC^2 mode. Therefore, the classic RC^2 mode is used in the analysis below.

Let A be a decision-making group composed of n learning and educational resource decision-making units. DMUj is the jth learning and educational resource decision-making unit in A. The input vector and output vector of DMUj are:

$$x_j = \left(x_{1j}, \cdots, x_{ij}, \cdots, x_{sj}\right)^T \geq 0 \tag{1}$$

$$y_j = \left(y_{1j}, \cdots, y_{kj}, \cdots, y_{pj}\right)^T \geq 0 \tag{2}$$

Among them, it is assumed that $x_{ij} \in \left[x_{ij}, \overline{x_{ij}}\right], y_{ij} \in \left[y_{kj}, \overline{y_{kj}}\right]$.

Let $\theta_j^* = \left[\theta_j^*, \overline{\theta_j^*}\right]$ be the efficiency interval of the learning and educational resource decision-making unit DMUj. If and only if $\theta_j^*, \overline{\theta_j^*}$ are the optimal solutions for learning and educational resources of deterministic linear programming, respectively:

$$\min\theta = s.t. \sum_{j=1}^{n} \lambda_j x_{ij} + \lambda_j \overline{x_{ij}} \leq \theta \overline{x_{ij}} \quad i = 1, 2, \cdots s, \tag{3}$$

$$\min\theta = \sum_{j=1}^{n} \lambda_j y_{ij} + \lambda_j \overline{y_{ij}} \leq y_{kj} \quad k = 1, 2, \cdots, p \tag{4}$$

$$H_j = \max\left(\sum_{i=1}^{n} \mu_i, y_j\right) \tag{5}$$

The learning and education efficiency interval includes all possible efficiency values of DMUj.
The learning and education efficiency evaluation index is:

$$h_j = \frac{s^T y_j}{k^T x_j} \le 1 \qquad j(j = 1,2,\cdots,n) \tag{6}$$

Taking Formula (6) as the target, the following formulas are formed:

$$\max h_j = \frac{s^T y_0}{k^T x_0} \tag{7}$$

$$\text{s.}t.h_j = \frac{s^T y_j}{k^T x_j} \le 1, \quad j = 0,1,\cdots,n \tag{8}$$

$$\text{s.}t.s = \left(s_1, s_2, \cdots s_m\right) \le 0 \tag{9}$$

$$\text{s.}t.k = \left(k_1, k_2, \cdots k_m\right) \le 0 \tag{10}$$

Fractions can be programmed into an equivalent linear programming form using transformations. make:

$$t = \frac{1}{k^T x_0} > 0, \omega = tk, \mu = ts \tag{11}$$

Then the objective function of learning educational resources is:

$$\frac{s^T y_0}{k^T x_0} = \mu^T y_0 \tag{12}$$

The constraints are:

$$\frac{s^T y_j}{k^T x_j} = \frac{\mu^T y_j}{\omega^T x_j} \le 1 \qquad j(j = 1,2,\cdots,n) \tag{13}$$

$$\text{s.}t.\omega^T x_0 \ge 0, \quad \mu \ge 0 \tag{14}$$

$$\text{s.}t.\omega \ge 0, \quad \mu \ge 0 \tag{15}$$

In this way, the distributed programming is transformed into the following linear programming:

$$P = \begin{cases} \max \mu^T y_0 \\ \omega^T x_j - \mu^T y_j \ge 0, j = 0,1,2,\cdots,n \\ \omega^T x_0 = 1 \\ \omega \ge 0, \mu \ge 0 \end{cases} \tag{16}$$

In machine learning, the linear regression model of learning education can be written as:

$$y = f\left(x\right) = \omega^T x + b = \sum_{i=1}^{n} \omega_i x_i + b \tag{17}$$

The logic function uses the sigmoid function:

$$y = s\left(x\right) = \frac{1}{1 + e^{-x}} \tag{18}$$

From Formulas (17) and (18), it can be deduced that the mathematical expression of the learning education model are:

$$y = s\left(f\left(x\right)\right) = \frac{1}{1+e^{-f(x)}} \tag{19}$$

$$y = s\left(f\left(x\right)\right) = \frac{1}{1+e^{-\left(\omega^{T}x+b\right)}} \tag{20}$$

(2) Empirical study on the allocation of preschool education resources based on the data of province A

The DEA indicators selected in the research mainly include financial investment, the number of full-time teachers, the number of kindergartens, the gross enrollment rate of preschool education, the number of students in kindergartens, and the proportion of outstanding kindergartens. Taking financial investment, the number of full-time teachers and the number of kindergartens as input indicators, the gross enrollment rate of preschool education, the number of students in kindergartens and the proportion of outstanding kindergartens are used as output indicators.

Table 4 is calculated using relevant software. The DEA efficiency of preschool education resource allocation in the province from 2011 to 2021 can be obtained. The efficiency evaluation in the Table is mainly determined by the Score column. If the score is lower than 1, it indicates that the configuration efficiency is not high. Score equal to 1 indicates high configuration efficiency. The purpose of economies of scale is to analyze how to adjust the indicators in order to improve the benefits. The scale benefit is constant, the scale benefit decreases, and the scale benefit increases. It can be seen from Table 4 that the DEA invalid evaluation units are the five years of 2014, 2016, 2019, 2020, and 2021. Other evaluation units performed better, with an efficiency of 6 points.

Table 4: DEA efficiency of preschool education resource allocation

Years	Score	Financial income	Full-time teachers	Number of kindergartens	Gross Enrollment Rate	Number of students in kindergarten	Percentage of outstanding kindergartens	Scale Effectiveness
2011	1.000	0.00	0.00	0.00	0.00	0.00	0.00	unchanged
2012	1.000	0.00	0.00	0.00	0.00	0.00	0.00	unchanged
2013	1.000	0.00	0.00	0.00	0.00	0.00	0.00	unchanged
2014	0.994	0.00	-139.27	0.00	0.00	608.64	0.01	Increasing
2015	1.000	0.00	0.00	0.00	0.00	0.00	0.00	unchanged
2016	0.892	0.00	-128.73	0.00	0.00	0.00	0.03	Increasing
2017	1.000	0.00	0.00	0.00	0.00	0.00	0.00	unchanged
2018	1.000	0.00	0.00	0.00	0.00	0.00	0.00	unchanged
2019	0.992	-400111.16	-465.24	0.00	6.33	0.00	0.00	Decreasing
2020	0.925	-464677.19	0.00	-21.58	6.33	0.00	0.03	Decreasing
2021	0.849	-345069.85	0.00	-4.66	7.18	0.00	0.07	Increasing

(3) Effective improvement of DEA in preschool education resource allocation

After analyzing the data in 2021, the direction of future adjustment and improvement can be estimated (as shown in Table 5). This Table describes how the input and output variables should be adjusted to target values for DEA to hold. From the empirical data, it can be seen that the DEA method can better analyze the effect of preschool education resource allocation. Quantitative data is used to analyze future improvement strategies, which can close the 11.8% gap between urban and rural preschool education resources. The application of this method has a good decision-making support for the policy recommendations of this study.

Table 5: Preschools effectively improve DEA calculations

Score	0.849
Financial income	985783.28
Full-time teachers	12714
Number of kindergartens	1528
Gross Enrollment Rate	80.48
Number of students in kindergarten	313878
Percentage of outstanding kindergartens	0.21
Scale Effectiveness	Increasing

V. Countermeasures and Suggestions for the Balanced Development of Preschool Education Resources

(1) Actively carry out the creation and promotion of graded kindergartens

In recent years, preschool education has been slowly accepted by society. Penetration rates are rising, and so is the level of preschool education. However, parents also have more demands. To this end, the government should actively promote the creation and promotion of graded kindergartens and increase the proportion of graded kindergartens. First, the government should formulate measures for the implementation of kindergarten rating. The government should clarify the grade evaluation standards for kindergartens, the implementation standards and management methods for graded kindergartens. It is necessary to promote reform through evaluation and increase capital investment in graded kindergartens, so as to improve the grade of graded kindergartens and expand the coverage of graded kindergartens. The second is to rationally plan the distribution of urban and rural kindergartens. Some tertiary kindergartens are renovated and upgraded according to the standards of secondary kindergartens. On the surface, the government has concentrated resources on improving the level of kindergartens by transforming and upgrading township kindergartens. However, such a move to expand the scope of kindergarten services may cause "difficulty in entering the kindergarten".

(2) Improve treatment and stabilize the team of preschool teachers in townships

The stability of township kindergarten teachers is greatly affected by their salary. The current salary of preschool teachers in townships is not optimistic. In particular, the salary of preschool teachers under the contract system is more important. In addition, township (town) kindergarten teachers are basically from other places. The government should actively implement the policy of subsidies given by the state to townships (towns) and rural teachers. As far as career development is concerned, due to relevant policies, professional title evaluation and training are biased towards township preschool teachers. For these kindergarten teachers, the salary level should be greatly increased.

(3) Improve system construction to ensure the development and improvement of preschool teachers

At the national level, a number of guidelines and policies that are conducive to the development of the teaching staff have been promulgated. Local governments and education authorities should implement and refine the concerns of kindergarten teachers. For example, policies have been introduced to ensure the status of teachers in township kindergartens. The number of students and classes in township kindergartens are strictly controlled, and the teacher-to-child ratio is achieved in accordance with regulations. The participation of kindergarten teachers in various training, further study and lecture activities is strengthened. Incentive mechanisms are used to motivate kindergarten teachers in on-the-job education and degree study, especially various lectures and professional title declaration training. It is necessary to improve the job evaluation system for teachers in private kindergartens to promote teacher mobility and implement the county (city) teacher mobility mechanism.

(4) Establish a resource platform for urban-rural integrated preschool education

Informatization of preschool education is the proper application of information technology to the field of preschool education. It is necessary to build an urban-rural integrated preschool education resource platform and optimize conservation and education activities. The government should play a leading role. In particular, for the construction of software and hardware resources for preschool education, the specific construction direction should be clarified and special financial funds and other resources should be allocated in accordance with the requirements of the outline of the preschool education informatization development plan. To achieve the balanced development of urban and rural preschool education resources, the information platform is a necessary "sharp weapon".

(5) Increase financial subsidies to ensure balanced development of resource allocation

To achieve balanced development of preschool education resources, the most critical factor is funding. The funding allocation system is an important measure to reduce differences in educational development between regions. The government needs to increase the financial support for private kindergartens per student year by year, and increase the proportion of each private kindergarten’s education expenses, so as to reduce the financial gap between public and private kindergartens and increase the compensation and subsidies for rural disadvantaged groups. The government promulgated a policy to support rural kindergartens, which improved the facilities and scale of rural kindergartens and increased the wages of rural kindergarten teachers. Rewards and subsidies are given to the popularization of kindergartens, mainly for the construction of central kindergartens in rural backward areas, support for inclusive kindergartens, subsidies for children in needy households, and training of kindergarten teachers.

VI. Conclusion

Preschool education is the starting point of lifelong learning for students. Its problem is related to the educational satisfaction level of most people. The country should attach importance to early childhood education, so that

children of the same age in developed and backward regions can obtain equal educational resources, which plays a very important role in improving the quality of the whole people. By investigating the status quo of urban and rural preschool education resources allocation, this research has found that there were some problems in the government's allocation of urban and rural early childhood education resources. Among them, the government's lack of attention to preschool education is an important reason for the low total amount of high-quality educational resources. The lack of incentive environment in rural preschool education makes the whole educational resources scarce. The government should strengthen macro-control of preschool education resources, and plan urban and rural kindergartens scientifically and rationally. It is also necessary to establish a preschool education investment supervision and accountability mechanism to promote the sound development of preschool education.

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