



# Article Artificial Intelligence Empowers Postgraduate Education Ecologically Sustainable Development Model Construction

Zhe Zhu and Lizhi Zhang \*

School of Marxism, Jilin University, Changchun 130000, China \* Correspondence: zhanglz20@mails.jlu.edu.cn

Abstract: Postgraduate education provides valuable intellectual resources for the development and progress of human society. At present, the development of postgraduate education in China is at a moderate level. The level of internationalization is not high, and there remain objective problems, such as a shortage of educational resources. To solve these problems, this paper proposes the use of artificial intelligence technology to build a sustainable development model for graduate students. It is aims to study the means of building a favorable environment for the development of postgraduate education and to optimize the educational structure of postgraduate studies, so as to improve the training model and enhance China's international influence. Under the influence of the sustainable development model of educational ecology, developed under the background of artificial intelligence, this study included a questionnaire survey of current tutors, as well as doctoral and master's students; a total of 30% of master's students and 37% of doctoral students were "very satisfied" and "relatively satisfied" with the evaluation of "teaching content".

**Keywords:** postgraduate education ecology; postgraduate sustainable development model; artificial intelligence; AR model



Citation: Zhu, Z.; Zhang, L. Artificial Intelligence Empowers Postgraduate Education Ecologically Sustainable Development Model Construction. *Sustainability* **2023**, *15*, 6157. https:// doi.org/10.3390/su15076157

Academic Editors: Chia-Huei Wu and Yu-Hsi Yuan

Received: 9 February 2023 Revised: 6 March 2023 Accepted: 15 March 2023 Published: 3 April 2023



**Copyright:** © 2023 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https:// creativecommons.org/licenses/by/ 4.0/).

# 1. Introduction

Advanced education assumes a significant role in communist modernization. It is a starting point for the advancement of social education and a mechanism to help to understand and serve the interests of individuals. Its development is a critical undertaking to ensure the manageable improvement of China's economy and society through the study of the advancement of higher education, particularly postgraduate schooling. On this basis, the authors hope to provide a specific theoretical framework and reference value for postgraduate training in China through empirical analysis. Under the background of informationization, there is a close relationship between graduate education in China and its social environment, presenting a dynamic of transformation and change. Because of its characteristics, graduate education is different from other forms of education. Postgraduate training is simultaneously different in various nations and districts. Even within the same country or district, there will be different issues experienced and improvement processes implemented. In addition, the experiences of developed nations or more advanced districts are often not applicable to developing countries or locales. In this manner, it is important to conduct a top-down examination of postgraduate training in China to find the common factors and best practices in terms of the development of postgraduate schooling. The results of this study can offer guidance to stakeholders for the improvement of postgraduate education in China and globally. For instance, in this review, the qualities and benefits of postgraduate schooling in nations with moderately effective postgraduate training in the West, including the US, England, Germany, and Japan, were analyzed and considered, being found to offer significant examples and references for change and improvement in China.

The construction of a sustainable development model for postgraduate education has long been a popular research topic. Rybakov (2018) presented the results of a pilot

study of the first graduates of the doctoral program in Social Studies and Humanities at Lobachevsky State University, which was prepared under the framework of the new model of postgraduate education in Russia. The views of the graduates on the educational process under this new format, as well as the existing difficulties and teaching challenges, were analyzed [1]. Through active interviews and thematic discourse analysis, Melles (2019) focused on lecturers in the move toward ESD (education for sustainable development), considering student attitudes and characteristics, as well as the nature of the curriculum in relation to institutions, disciplines, individuals, and other drivers [2]. Rey-Garcia (2020) sought to understand the role that social capital and real-world learning may play in enhancing the impact of university education in sustainable development of social sustainability [3]. The Foster (2018) inverted classroom model (ICM) has become the most commonly used teaching tool; it has achieved remarkable results when applied to graduate students in the fields of economics and sustainable development [4]. Borrego (2018) longitudinally tested the construction of sustainable development models in a sample of 732 engineering students. The model was designed to explain students' satisfaction with their major degree and their willingness to continue their studies [5]. However, due to insufficient data sources and a lack of in-depth analysis of graduate students, the above research has remained at the theoretical stage and has not achieved practical application.

The use of artificial intelligence technology to build a sustainable development model for postgraduate education ecology is a relatively new topic. Aljkovi-Kadri (2020) suggested that the development of sustainable educational systems, curricula, and teaching practices under the three components of sustainable development is a particular challenge for professionals working in parenting and education [6]. Bismilla (2019) developed a tool for use in a simulation setting to assess trainee satisfaction and opinions on sustainable development models [7]. Rutt (2019) proposed the Sustainability Cases (MSC) initiative to provide case studies for ESD. Located at the University of Michigan's School of Environment and Sustainability, the MSC builds on a tradition of case-based learning by combining engaging narratives around complex sustainability issues with informative multimedia elements and engaging learning exercises [8]. Nazdrol (2017) aimed to investigate the relationship between psychological empowerment and organizational commitment among nurses at the Kelantan University Hospital in Kupang, Malaysia [9]. Melles (2020) suggested that the relationship between espoused views on sustainability and the development and institutionalization of these views in curricula requires further investigation. Existing qualitative interview data from lecturers have identified a range of perspectives on sustainability and education for sustainable development; however, little attention has been paid to the postgraduate setting in terms of thematic discourse analysis [2]. The aforementioned research relies on traditional definitions and thinking and has not devoted sufficient attention to new methodologies of education in sustainable development.

The main innovations of this paper are: (1) Aiming at the main problems of postgraduate education in China, a questionnaire on the environmental sustainability of postgraduate education in Chinese universities was designed, including for the provinces (cities) and their surrounding universities. (2) The comprehensive evaluation index system and evaluation model of the ecologically sustainable development level of postgraduate education in Chinese colleges and universities were established, and the ecologically sustainable development level of postgraduate education in Chinese colleges and universities was comprehensively evaluated from the four aspects of educational foundation and educational background. (3) Taking the number of postgraduate students in colleges and universities, per capita GDP, education funding, national science and technology funding, and the number of lecturers as the prediction objects, the least-squares method and AR model in the prediction model were used to study the ecological model of postgraduate education in Chinese universities.

## 2. Manageable Improvement Model of Postgraduates in Schools and Colleges

### 2.1. Research Method

(1) Literature analysis method

Literature refers to all carriers that record relevant knowledge; these have certain historical value and reference value for scientific research. This paper mainly refers to and studies books and documents on developmental economics, philosophy, management, leadership, school management, pedagogy, educational philosophy and other related stops. We obtained the ideas and viewpoints of this paper on the basis of the analysis of predecessors' literature.

### (2) Systematic thinking method

The systematic thinking here does not constitute general systematic thinking. At present, there have been many studies and discussions on the system of sharing graduate education funds and the principles of graduate education development. However, these studies and discussions are generally only aimed at a certain problem, and rarely start with the whole system of graduate education development. This paper changes the method of single-problem breakthrough research and adopts the method of systematic thinking to discuss the development model of postgraduate education in colleges and universities.

### (3) Modeling method

Modeling is an important scientific operation and scientific thinking method in solving specific problems and reproducing some essential characteristics of prototype objects under certain abstract, simplified and hypothetical conditions, so as to better understand and transform prototype objects and construct new objects. Using modeling methods to analyze the problem can simplify the problem and solve it easily.

(4) Comparative study

This paper discusses the development course and experience of postgraduate education in developed countries and analyzes the experience for use as a reference in the development of postgraduate education in order to guide the development of postgraduate education in China.

(5) Empirical research.

This article attempts to understand the opinions and suggestions of contemporary college students and graduate tutors on the development of graduate education through the use of questionnaires and interviews. SPSS statistical software is used to conduct quantitative research on the survey results to identify common issues raised by them in the development of graduate education in order to guide the practice of graduate educational development in Chinese universities.

### 2.2. External Operating Environment

The external operating environment elements of the ecologically sustainable development of graduate education in universities. These mainly include four components: government, market, society, and universities. These are interdependent and mutually influencing.

# (1) Government control

As can be seen from Figure 1, under the conditions of a market economy, the government has shifted from the direct administration of postgraduate education to assisting in its operation. In addition, in the relationship between the central and local governments, the focus of governance has shifted downward. The central government has delegated powers to provincial and educational units, especially in degree grant auditing, program enrollment, and educational evaluation, that is, the central and local governments have established hierarchical management and accountability. [10]. At this point, it is necessary to carry out the education of ecological civilization in depth and realize the innovation of ecological civilization-centered education. Specifically, it is necessary to systematically strengthen education on the national conditions of the ecological environment, the legal system of the ecological environment, and ecological ethics and morality to achieve innovation in the content of ecological civilization education. Traditional classroom teaching should be combined with new media, and theory should be combined with practice to better play its subtle functions, to promote innovation in educational methods. It is necessary to establish and improve the network legal system via the joint efforts of universities, society, and the government to promote the reform of the education management system.



Figure 1. Composition diagram of the operating environment for postgraduate education development.

### (2) Market supervision

Market factors are the lever and driving mechanism in the sustainable development of postgraduate education ecology and provide an opportunity for the reform and development of postgraduate education. Supervision helps to establish a mechanism of mutual competition and efficiency [11]. At the same time, postgraduate education in colleges and universities should be adjusted according to the feedback of market supply and demand information to control the scope, speed, structure and efficiency of postgraduate education, as well as the standard, quantity and quality of postgraduate training.

### (3) Autonomous operation of the university

University is the foundation of the sustainable development of postgraduate education ecology and the cradle for cultivating high-level talents. In order to survive under the socialist market economy, higher education institutions must solve the problem of higher education autonomy through legislation so that higher education institutions can exercise autonomy within the scope permitted by law, and at the same time undertake their own responsibilities and obligations. For example, the current types of postgraduate learning are divided into two categories: managed and non-managed national plans, and commissioned education and self-funded national plans [12].

### 2.3. Construction of the System Model

The postgraduate education evaluation system consists of a variety of factors that are interrelated and complement each other. The educational foundation, educational resources, internationalization level and educational achievements together constitute an overall evaluation system. These four components are interrelated and complementary, as shown in Figure 2.



Figure 2. Systematic model of the development level of graduate education.

- 2.4. Evaluation System of the Sustainable Development of Graduate Students
- (1) The principle of introducing the index system

The evaluation of the ecologically sustainable development level of postgraduate education in China is a complex systematic project, and it is necessary to design a set of evaluation index systems that can scientifically and objectively reflect the status quo of the ecologically sustainable development of postgraduate education. The following principles should be followed when designing an assessment:

The principle of combining inside and outside

When designing evaluation indicators, in addition to the internal indicators of colleges and universities such as faculty and scientific research achievements, external indicators such as the evaluation of college graduates by employers and the evaluation of the academic reputation of postgraduate education by society should also be considered [13].

The principle of combining qualitative evaluation and quantitative evaluation

Judging from the current development situation, due to the weak foundation of China's higher education, its late start, weak economic strength, low level of investment in education, lack of competitiveness in higher education, and lack of national education system, the evaluation should use quantifiable indicators as much as possible, and focus on the objective scientific collection and quantification of evaluation results. At the same time, by comparing China's graduate education with international graduate education, the positioning and current situation of Chinese graduate students are clarified.

The principle of combining international Chinese comparison

In the design of indicators, this paper pays special attention to the design of international indicators, such as setting up "social investment" in the "investment in education" indicator, which includes the establishment of social grants and extraordinary scholarships. In the indicator of "teacher strength", indicators include "the number of professional teachers with one or more foreign education degrees" and "the number of foreign teachers". The indicator of "research results" contains "settings of international cooperation projects". The settings of these indicators above reflect the international nature of postgraduate education evaluation [14].

### (2) Construction of evaluation index system

This paper has established an evaluation system for the ecologically sustainable development level of China's postgraduate education from four aspects in a systematic perspective: educational foundation, educational input, educational resource transformation and educational output. It focuses on the investment, efficiency and effectiveness of postgraduate education so as to connect with the goal of improving the international competitiveness of postgraduate education [15]. This system is shown in Figure 3.



Figure 3. Evaluation system of postgraduate education development level.

As can be seen from Figure 3, the foundation of education is the accumulation of postgraduate education in the long-term practice process, representing the growth and long-term sustainable development of postgraduate education. The educational foundation includes four main elements: social reputation, subject specialization, educational scope and student quality. This article is based on the principle of combining internal evaluation with external evaluation. The social reputation of postgraduate education is introduced to evaluate the level and strength of postgraduate education from a social perspective [16]. Since social reputation is generally a reflection of a university's past achievements, this paper uses this indicator as part of the educational foundation.

# 2.5. Selection of Predictors for the Scale of Ecologically Sustainable Development of Postgraduate Education in Colleges and Universities

This paper takes the number of postgraduates as the forecast target with which to predict the degree of development of postgraduate education in Chinese universities. Among them, "GDP per capita" reflects the income level and economic strength of the population. This paper chooses this index as the evaluation index to measure the payment ability of graduate students. The state's investment in postgraduate education is reflected mainly in financial and human resources. The financial resources include the state's investment in education and scientific research. Human resources mainly include the number of lecturers. Therefore, this paper chooses "educational budget investment", "national financial science and technology investment" and "number of lecturers" as the evaluation indicators with which to measure the state's investment in postgraduate education. Table 1 shows the statistics of ecologically sustainable development of postgraduate education in China from 1994 to 2003 [17].

Years Project	Graduate Student	Per Capita GDP	Education Investment in Budget	National Fiscal Science and Technology Allocation	Number of Tutors
1994	127,925	3903	93.6	267.3	51,496
1995	145,453	4825	108.74	304.4	54,214
1996	162,362	5544	126.69	345.6	57,115
1997	176,343	6025	139.44	404.9	59,471
1998	198,835	6363	156.46	436.6	62,923
1999	233,543	6504	176.38	549.9	65,154
2000	301,259	7064	202.25	577.5	70,332
2001	393,246	7650	238.89	704.3	78,095
2002	500,950	8188	280.79	812.2	92,464
2003	651,264	9103	325.34	975.3	104,654

Table 1. Statistical table of national postgraduate education development data from 1994 to 2003.

It can be seen from Table 1 that, in order to realize the prediction of the sustainable development scale of postgraduate education (such as the prediction of the number of graduate students in school from 2004 to 2010), the following tasks must be realized:

The mathematical model of the dependent variable y, represented by the independent variable  $x_1, x_2, x_3, x_4$ , is established; that is, the functional relationship between the dependent variable and the independent variable is established:  $v = f(x_1, x_2, x_3, x_4)$  and the correctness of the model is verified. The mathematical model of the independent variable  $x_1, x_2, x_3, x_4$  is established; that is, the numerical relationship of the independent variable with time is established, and the correctness of the model is verified. Finally, the functional relationship  $f(x_1, x_2, x_3, x_4)$  is used to predict the development of the dependent variable from 2004 to 2010, and it is tested and verified in a certain way [18,19]. The flowchart corresponding to the above modeling prediction is shown in Figure 4.



Figure 4. Flow chart of graduate student scale development forecast.

### 2.6. Application of Artificial Intelligence-Based Prediction Model

### (1) Least-squares data fitting of graduate scale development (dependent variable y)

In production practice and scientific research, it is often necessary to obtain the approximate expression of the function y = f(x) from a set of measured data. Another way of describing this function is to obtain the approximate graph of the curve from the given n + 1 points  $(x_i, y_i), i = 0, 1, 2, 3, ..., n$  on the curve y = f(x). Let the following polynomials of degree m be used:

$$p_m(x) = a_0 + a_1 x + a_2 x^2 + \ldots + a_m x^m \tag{1}$$

Using this to fit a set of data  $(x_i, y_i)$ , i = 0, 1, 2, 3, ..., n, if the deviation at node is recorded as:

$$\varphi = \sum_{t=0}^{n} R_t^2 = \sum_{t=0}^{n} [p_m(x_t) - y_t]^2$$
(2)

Then least-squares method of fitting problems is used to find such a fitting curve  $y = p_m(x)$ , so that the sum of squares of deviations  $R_i$  is:

$$\varphi = \sum_{t=0}^{n} \left[ \sum_{j=0}^{m} a_j x_i^j - y^t \right]^2$$
(3)

Since  $x_i$  and  $y_i$  are known values,  $\varphi$  can be regarded as a function of  $a_j$  (j = 0, 1, 2, 3, ..., m). Therefore, for different polynomials, there are different values of  $\varphi$ , namely:

$$\varphi = \varphi(a_0, a_1, a_2, \dots, a_m) \tag{4}$$

Formula (4) for minimal  $a_0, a_1, a_2, \ldots, m$  must fit the following formula:

$$\frac{\partial \varphi}{\partial a_k} = 0, k = 0, 1, 2, 3, \dots, m \tag{5}$$

Thus, it can be obtained:

$$\frac{\partial \varphi}{\partial a_k} = 2 \left\{ \sum_{i=0}^m a_j s_{j+k} - t_k \right\}$$
(6)

Among them,

$$S_l = \sum_{i=0}^n x_i^l \tag{7}$$

$$t_k = \sum_{t=0}^n y_t x_l^k \tag{8}$$

If the function shown in Formula (1) is written in vector form, it can be obtained:

$$p = \Phi B + E \tag{9}$$

Using the least-squares method, the least-squares estimate of the Vector *B* can be obtained as:

$$B = \left(\Phi^T \Phi\right)^{-1} \Phi^T Y \tag{10}$$

According to the statistics of the postgraduate scale development data given in Table 1 and the change rule of each variable, we determined that researchers must use a linear formula to mathematically model the postgraduate development scale. According

to the setting of independent variables and dependent variables, the established linear relationship is as follows:

$$\begin{cases} y(1) = b_1 x_1(1) + b_2 x_2(1) + b_3 x_3(1) + b_4 x_4(1) + e(1) \\ y(2) = b_1 x_1(2) + b_2 x_2(2) + b_3 x_3(2) + b_4 x_4(2) + e(2) \\ \dots \\ y(10) = b_1 x_1(10) + b_2 x_2(10) + b_3 x_3(10) + b_4 x_4(10) + e(10) \end{cases}$$

$$(11)$$

Writing Formula (9) in vector form, it can be obtained:

$$Y = XB + E \tag{12}$$

Among them:

$$Y^T = (y(1) \quad y(2) \dots \quad y(10))$$
 (13)

$$B^T = (b(1) \quad b(2) \dots \quad b(6))$$
 (14)

In order to verify the validity of the data fitting using the least-squares method, the data from 1994–2001 are used for fitting, and then the data from 2001, 2002, and 2003 are used for testing [20]. According to the statistical data from 1994 to 2001 and the fitting formula given by Formula (10), the optimal estimation result of B can be obtained as:

$$B = \begin{bmatrix} -30.9334 & 2671.883 & -184.7842 & 1.00956 \end{bmatrix}^T$$
(15)

According to the simulation fitting results of the least-squares and the independent variable data from 2001 to 2003, the estimated value of the postgraduate development scale from 2001 to 2003 can be obtained, as shown in Table 2:

Years<br/>ProjectGraduate Student Size EstimateGraduate Student Size Statistics2001358,749462,4682002471,033501,9802003618,647652,265

Table 2. 2001–2003 postgraduate development scale estimation and statistical results.

From Table 2, it can be seen from the comparison of statistical values and estimated values that fitting a curve using the least-squares method can reflect the development scale of graduate students well in universities, per capita GDP, education investment within the budget, national financial science and technology grants, and the number of mentors [21].

(2) AR model parameter estimation of independent variables  $(x_1, x_2, x_3, x_4)$ 

Definition: The random sequence  $\{X(n), n = ..., -1, 0, 1, ...\}$  is called the AR sequence model or the self-regressive sequence model. X(n) satisfies:

$$\sum_{i=0}^{p} a_{T} X(n-j) = \xi(n)$$
(16)

Among them, { $\xi(n), n = ..., -1, 0, 1, ...$ } is the white noise sequence and  $E\xi(n) = \delta^2$ , *P* is the order of the AR model. If the random sequence {X(n), n = ..., -1, 0, 1, ...} satisfies the above definition, then the recursive least-squares estimation  $\widehat{a}_i(N+1), i = 1, 2, 3, ..., n$  of the parameter { $a_i, i = 1, 2, 3, ..., p$ }, then p is:

$$a(N+1) = a(N) + K(N+1)$$
  $N \ge 2p$  (17)

Among them, K(N + 1) is called the time-varying gain matrix:

$$K(N+1) = \frac{P_N \varphi_{N+1}}{1 + \varphi_{N+1}^T P_N \varphi_{N+1}}$$
(18)

$$P_{N+1} = \left(1 - \frac{P_N \varphi_N + 1 \varphi_{N+1}^T}{1 + \varphi_{N+1}^T P_N \varphi_{N+1}}\right) P_N$$
(19)

$$\varphi_{N+1}^T = [-X(N), -X(N-1), \dots, -X(N_P+1)]$$
 (20)

$$\hat{a}T(N) = (\hat{a}_1(N), \hat{a}_2(N), \dots, \hat{a}_p(N))$$
(21)

Then the initial value of the above recursive formula is taken as:

$$P_{2p} = \left[\Phi_{2p}^{T}\Phi_{2p}\right]^{-1}, \ \widehat{a}(2p) = \left[\Phi_{2p}^{T}\Phi_{2p}\right]^{-1}P_{0} = I * 10^{4}$$
(22)

The initial value of the recursive formula determined by Formula (22) has the advantage of improving the accuracy of parameter estimation. However, the algorithm needs to increase the operation of matrix inversion. If  $P_0 = I * 10^4$  is taken for simplicity, the parameter estimates converge slowly. Considering the amount of original data and the accuracy of model fitting, we determined to use a second-order AR model (p = 2) to mathematically model the four independent variables.

# 3. Investigation into the Status Quo of Ecologically Sustainable Development of Postgraduate Education in a City Circle

Based on a comprehensive understanding of the status quo of the ecologically sustainable development of postgraduate education and an analysis of the existing problems, opportunities and challenges, this paper has reviewed and analyzed the current situation and strategic situation of the ecologically sustainable development of urban postgraduate education.

In order to comprehensively and objectively understand the status quo of the ecologically sustainable development of urban postgraduate education, and to provide a solid basis for formulating the ecologically sustainable development strategy of urban postgraduate education, this paper has conducted a sample survey on this topic. A cohort of 680 postgraduates, 146 doctoral students and 212 postgraduate supervisors (hereinafter referred to as supervisors) from 9 universities in a city circle (six "985 Project" and "211 Project" universities, 3 local key universities) participated in the survey.

In the examination of the poll, this paper has assessed the improvement status of postgraduate schooling in a specific city from two significant elements that contributed to the execution of postgraduate training exercises. Graduate managers surveyed understudies' quality, information structure, advancement capacity, inspiration, exposition quality, obligation and genuineness, autonomous work capacity, and learning support conditions, and the investigation results are displayed beneath.

### 3.1. Quality of Postgraduate Education in a Certain Urban Circle Is Not Optimistic

### (1) The quality of graduate students

The quality of graduate students is the most direct factor affecting the quality of graduate education, as shown in Figure 5.

As shown in Figure 5a, in the evaluation of the resource quality of master students, 40% of the tutors chose "significantly improved" and "slightly improved", and 25% of the tutors chose "basically unchanged". Thirty-five percent of mentors chose "slightly down" and "significantly down." The results in Figure 5b show that 33% of supervisors believed that the resource quality of doctoral students had "remarkably improved" and "slightly improved" in recent years, and 42% of supervisors believed that the resource quality of



doctoral students had "slightly decreased" and "remarkably decreased". A 25% proportion of mentors thought it was "flat".

**Figure 5.** The quality of graduate students in a city circle. (**a**) Quality of students for master students. (**b**) Quality of students for doctoral students.

### (2) The knowledge structure of graduate students

Knowledge structure is the basis for improving one's education and abilities. If the knowledge structure is insufficient, it will be difficult to grow a person's comprehensive quality and research potential. Therefore, the knowledge structure of graduate students in a city circle is shown in Figure 6.

It can be seen from Figure 6a that the proportion of tutors who chose the "very reasonable" option for the knowledge structure of master's students was 3%, the proportion opting for the "more reasonable" option was 41%, and the total was 44%. The remaining options summed up to 56%. In Figure 6b, 12% of the tutors thought the knowledge structure of doctoral students was "very reasonable", and 48% were more reasonable. The rest summed up to 40%. Therefore, the knowledge structure of graduate students in urban areas, especially the knowledge structure of master students, is unreasonable and still needs to be improved.

### (3) Postgraduate courses

In the survey of "graduate course setting satisfaction", 35% of master students thought the course setting was "very reasonable" and "more reasonable", and 49% thought it was "general". A total of 16% thought it was "unreasonable" and "very unreasonable". A total of 58% of doctoral students considered the curriculum to be "very reasonable" and "more reasonable". A total of 30% thought it was "general", and 12% thought it was "unreasonable" and "very unreasonable", as shown in Figure 7.



**Figure 6.** Statistical chart of postgraduate knowledge structure. (**a**) The knowledge structure of master students. (**b**) The knowledge structure of doctoral students.



Figure 7. The evaluation of the curriculum by graduate students in a city circle.

(4) Postgraduate course teaching quality

Tutors are the main undertakers of postgraduate course teaching, and the quality of postgraduate course teaching reflects the academic level and teaching skills of postgraduate tutors, as shown in Figure 8.



**Figure 8.** Postgraduates' satisfaction of course teaching quality in a city circle. (**a**) Statistical chart of evaluation of master students. (**b**) Statistical chart of doctoral students.

From the situation in Figure 8a, it can be observed that the survey showed that master students were not satisfied with the current course teaching. The proportion of those choosing "very satisfied" and "somewhat satisfied" was 32%. On the contrary, in Figure 8b, the doctoral students gave a high affirmation to the teaching quality of the course, and the proportion of students choosing "very satisfied" and "somewhat satisfied" was 62%. This shows that the current doctoral teaching quality is passable, but that the master's teaching quality needs to be improved urgently.

### (5) Postgraduate course teaching content and methods

The survey shows that doctoral students are slightly more satisfied with content and teaching methods than master students, as shown in Figure 9:

It can be seen from Figure 9a,b that 30% of master students and 37% of doctoral students chose "very satisfied" and "relatively satisfied" when evaluating "teaching content". When evaluating "teaching methods", 36% of master's students rated it as "very satisfied" or "quite satisfied", and 43% of doctoral students rated it as "very satisfied" or "quite satisfied". The proportions of master's and doctoral students who rated "teaching methods" as "generally" were 52% and 50%, respectively. This shows that the teaching content of postgraduate courses must keep pace with the times and broaden the research frontier to ensure the internationalization of talent training. Correspondingly, the teaching methods should also be updated and flexibly adjusted to the teaching content according to the needs of the target group.

### (6) Auxiliary support conditions for postgraduate training

Survey results have shown that many teachers are dissatisfied with library material conditions, laboratory teaching conditions, computer and Internet use, and research funding in urban areas. For example, in the case of "library materials" and "laboratory teaching conditions", the proportion of teachers who chose the "very satisfied" option was 64%, and the proportion choosing the "quite satisfied" option was 51%. Among them, 36% and 33%



chose "generally", and the proportion of "dissatisfied" and "very dissatisfied" reached 9% and 7%, respectively, as shown in Table 3.

**Figure 9.** The evaluation of the tutor's teaching content and methods by graduate students in a city circle. (a) Master's evaluation of the tutor's teaching content and methods. (b) Doctoral students' evaluation of the tutor's teaching content and methods.

Evaluation	Very Satisfied	Quite Satisfied	Generally	Dissatisfied	Very Dissatisfied
Book information	27%	31%	36%	3%	3%
Experimental teaching conditions	37%	20%	33%	6%	4%
Computer and internet conditions	20%	43%	36%	1%	0%
Student research grants	8%	37%	43%	9%	3%
Research funding support	9%	32 %	42%	12%	5%

**Table 3.** Satisfaction of postgraduate tutors with postgraduate training support conditions in Wuhan metropolitan area.

Obviously, the National Postgraduate Scholarship is only equivalent to the regional minimum living allowance and can only cover the basic living expenses of postgraduates, which makes most postgraduates unable to concentrate on their studies. In the question "how much effort do you put into your studies and research", 49% of masters chose the options "generally", "a bit less" and "rare". Conversely, the situation for doctoral students was more reassuring, with 20% choosing the options "average" "less" and "none", as shown in Table 4.

Evaluation	Master Student	PhD Student	
a lot of	14%	30%	
more	37%	50%	
generally	42%	10%	
a bit less	6%	5%	
rare	1%	5%	

Table 4. Postgraduates' investment in school and research in a city circle.

### 3.2. Postgraduate Education Structure of a Certain City Circle Is Not Reasonable

# (1) Hierarchy and type structure

Postgraduate education in China is divided into two levels: postgraduate education and doctoral education. It can be seen from the development history of higher education that doctoral education is a kind of elite education, and its scope of access should be reasonable due to the number of master's students. There are two types of postgraduate education in China: degree postgraduates and professional degree postgraduates. Academic doctoral students focus on academic research and cultivate professional talents for teaching and research, while professional doctoral students have specific professional backgrounds and cultivate complex and applied senior professionals. The data have shown that the enrollment of vocational students in a certain province and urban area accounts for 39% of the total number of graduates, which is higher than the national average. However, the training scale is still small, far behind the pace of urban industrial restructuring and optimization.

## (2) Class and formal structure

Class structure, also known as subject specialization structure, is the composition state of each subject within the framework of ecologically sustainable development of postgraduate education. The majors and professional structure of postgraduate education in China mainly include 12 majors including philosophy, law, economics, education, history, literature, science, engineering, medicine, agriculture, management, and military science. With the continuous optimization and modernization of the urban industrial structure, new technology industries are continuing to emerge, and the demand for high-quality talent in new fields and humanities and social sciences is increasing day by day [22].

Postgraduate education in China is divided into two forms: full-time postgraduate and part-time postgraduate. The first is established around a more standardized and advanced system and is mainly based on off-job learning in school. The second has not yet established standards, mainly being based on workplace research. The optimization and modernization of the industrial structure of an urban area has put forward new requirements for the knowledge level and skill structure of its specific specialty. Part-time postgraduate education with professional degrees provides opportunities for the majority of workers to obtain higher education. However, data have shown that the ratio of full-time and part-time graduates in a certain urban area is only about 1:10.

# 4. Countermeasures to Promote the Ecologically Sustainable Development of Postgraduate Education in Colleges and Universities

Supporting the ecologically sustainable development of postgraduate education in colleges and universities and building and cultivating a good school administrative environment is the guarantee for the sustainable development of higher education and postgraduate education.

The idea of green advancement is the central idea of a publicly reasonable turn of events, and it is likewise the center substance of postgraduate natural civilization schooling. In such manner, it is important to complete natural civilization schooling top to bottom and understand the advancement of postgraduate environmental development training. In particular, it is important to fortify the biological climate and public circumstances

methodically. Schooling, legal training in nature and ecology, and education in bioethics and morality comprise the development content of education which will allow researchers to understand the environment and human progress. Traditional family education should be combined with new media education, combining hypothetical training with useful training, to give full play to the passive role of graduate tutors and understand the development of graduate biological progress training technology. Through the establishment and improvement of organizational charters and guidelines, we must construct cooperation between universities, society, and the government to act in conjunction with the progressive education of persons in order to understand the development of the education board system.

First, a nationwide and social postgraduate education quality evaluation system should be gradually established. The state should issue regulations on the evaluation of postgraduate education as soon as possible to clarify the rights and obligations of both the evaluator and the evaluator, allowing the standardization of the organization and implementation of the evaluation work so that the evaluation results can be more abundant, fair and objective.

According to the current situation of postgraduate education development, in order to realize the scale target of postgraduate education, the development scale of postgraduate education must be stabilized. Specific measures which can play a role in this include actively striving to support the expansion of doctoral and master's degree authorization units and degree authorization points. Particular targets for expansion must include the scale of professional degree authorization, the emerging interdisciplinary and interdisciplinary degree authorization points, degree authorization units and degree authorization points, and the regional structure layout.

The first objective must be to update the concept of talent education. To deepen the reform of the educational system and mechanism, we must update the educational concept. The core principle in this is to innovate the talent training system, and the ultimate goal is to improve the quality of talent training. The key responsibilities of tour postgraduate education and training units are to firmly establish the concept of comprehensive and sustainable development and cultivate high-quality talents via the comprehensive development of students in morality, intelligence, physique, and aesthetics. Diversified talent cultivation concepts have been established to respect individual wishes, promote personal development, and cultivate high-quality talents without any restrictions. The concept of lifelong learning has been established to lay the foundation for sustainable development. The concept of systematic education has been established, and new mechanisms for joint talent cultivation such as school enterprise alliances, school enterprise alliances, and international cooperation have been explored to cultivate innovative, high-level, composite, and applied talents.

The second objective is to innovate talent cultivation methods and optimize the structure of postgraduate education. The strategic emerging industry talent cultivation plan has been implemented to vigorously develop professional degree postgraduate education. New mechanisms and approaches for full-time professional degree postgraduate education have been explored to accelerate the cultivation of various high-level professional talents, especially engineering talents, and to adapt to the continuous optimization and modernization of the industrial structure of the surrounding cities of Wuhan. It has been embraced by diversified development of governments at all levels, linkage between industry, university, and research, integration of high-quality resources, and mutual assistance and cooperation between schools.

The third is objective to improve the postgraduate education quality evaluation system. As an important means of quality control, evaluation plays an important role in postgraduate education. It is necessary to clarify the rights and obligations of evaluators, and to standardize the organization and methods of evaluation work by formulating norms for postgraduate education evaluation work as soon as possible in combination with reality, so as to ensure that the evaluation results are more fair, impartial, and objective, and can be better used for macroeconomic regulation and editing. The government evaluation, social evaluation, and self-evaluation of postgraduate education units have been further improved, and a reasonably structured postgraduate education quality evaluation system has been constructed. Social forces are encouraged to participate in the supervision of postgraduate education, and intermediary agencies are encouraged and supported to carry out social evaluation of postgraduate education, strengthening the benign communication and interaction between the government, society, and postgraduate education units.

Finally, theory is the precursor to practice. At a time when China's postgraduate education is booming, there is an urgent need to strengthen theoretical research on postgraduate education. Correct theories and perspectives should be used to guide work, so that the work in the field of postgraduate education avoid detours, achieves greater success and embarks on a healthy development path. The establishment of the theoretical system of graduate education needs to analyze various phenomena and problems of graduate education through multidisciplinary knowledge in order to form a variety of fields of the theoretical system of graduate education. Through the research on various disciplines of graduate education theory, a complex discipline system with organic connections can be formed.

## 5. Conclusions

The thesis of this work is based on the theory of sustainable development and educational ecology and relies on AHP, fuzzy comprehensive evaluation, and an AR model. Combining theory with models, the development of postgraduate education in China has been deeply studied. This article investigated the development of postgraduate education in universities, including several universities in a city, through a questionnaire survey of teachers, masters, and doctors. According to statistical analysis, it can be found that there are significant differences in the cultivation of postgraduate students in China. Therefore, efforts should be made to build a sustainable development model for postgraduate students based on the theory of educational ecology, and necessary policy preferences should be given. However, there remain some problems in this article.

**Author Contributions:** Writing—original draft, Z.Z.; Writing—review & editing, L.Z. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data sharing not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

### References

- Rybakov, N.V. A New Model of Russian Postgraduate Education: Pilot Study of the First Graduation of PhD Students. *Vyss. Obraz.* V Ross. High. Educ. Russ. 2018, 27, 86–95. [CrossRef]
- 2. Melles, G. Views on education for sustainable development (ESD) among lecturers in UK MSc taught courses: Personal, institutional and disciplinary factors. *Int. J. Sustain. High. Educ.* **2019**, *20*, 115–138. [CrossRef]
- 3. Rey-Garcia, M.; Mato-Santiso, V. Enhancing the effects of university education for sustainable development on social sustainability: The role of social capital and real-world learning. *Int. J. Sustain. High. Educ.* **2020**, *21*, 1451–1476. [CrossRef]
- 4. Foster, G.; Stagl, S. Design, implementation, and evaluation of an inverted (flipped) classroom model economics for sustainable education course. *J. Clean. Prod.* **2018**, *183*, 1323–1336. [CrossRef]
- Borrego, M.; Knight, D.B.; Gibbs, K.J.; Crede, E. Pursuing Graduate Study: Factors Underlying Undergraduate Engineering Students' Decisions. J. Eng. Educ. 2018, 107, 140–163. [CrossRef]
- 6. Aljkovi-Kadri, S.; Skenderovi, I. Ecological education and sustainable development. Ekon. Izazovi 2020, 9, 62–70. [CrossRef]
- 7. Bismilla, Z.; Boyle, T.; Mangold, K.; Ittersum, W.V.; Mallory, L. Development of a Simulation-Based Interprofessional Teamwork Assessment Tool. *J. Grad. Med. Educ.* **2019**, *11*, 168–176. [CrossRef]
- Rutt, R.; Wagner, M. Michigan Sustainability Case: Struggles over Science: What Is the Role for Science in Community Forestry in Nepal? Sustain. J. Rec. 2019, 12, 10–17. [CrossRef]

- 9. Nazdrol, W.; Rusuli, M.; Nagarubini, P.; Hakim, M. Psychological Empowerment Enthusiastic and Organisational Commitment: Measurement and Validation. *Int. Bus. Manag.* 2017, *11*, 140–147.
- Nagpal, S.; Haber, N.E.; Young, S. Graduate Competencies and Disposition for Sustainable Development: The Nexus of Curriculum And Pedagogy in Business Education. Soc. Bus. 2019, 8, 345–368. [CrossRef]
- 11. Laurido, L.; Frontera, W.R.; Huertas, A. 4143 HiREC Endowment: Building Models in Research Capacity for Infrastructure Sustainability and Productivity. *J. Clin. Transl. Sci.* 2020, *4*, 62–63. [CrossRef]
- 12. Ali, M.; Wang, J.; Himmelberger, H.; Thacher, J. An Economic Perspective on Fiscal Sustainability of U.S. Water Utilities: What We Know and Think We Know. *Water Econ. Policy* **2021**, *07*, 81–102. [CrossRef]
- 13. Karaoulanis, A.; Karaoulanis, A. Information and Communication Technology in Organizational Operations. Ethical and Operational Implications. *Bus. Ethics Leadersh.* **2020**, *4*, 6–13. [CrossRef]
- 14. Vasiliev, A.A.; Pechatnova, Y.V.; Mamychev, A.Y. Digital ecology: Artificial intelligence impact on legal and environmental sphere. *Ukr. J. Ecol.* **2020**, *10*, 150–154. [CrossRef]
- 15. Omar, M.; Mehmood, A.; Choi, G.S.; Han, W.P. Global mapping of artificial intelligence in Google and Google Scholar. *Scientometrics* **2017**, *113*, 1269–1305. [CrossRef]
- Linnen, D.T.; Javed, P.S.; D'Alfonso, J.N. Ripe for Disruption? Adopting Nurse-Led Data Science and Artificial Intelligence to Predict and Reduce Hospital-Acquired Outcomes in the Learning Health System. Nurs. Adm. Q. 2019, 43, 246–255. [CrossRef]
- 17. Yang, R.; Man, S. Improved Text Feature Selection Algorithms in Classification Search of Environmental Protection Information. *J. Environ. Prot. Ecol.* **2019**, *20*, 1462–1469.
- 18. Talan, T. Artificial Intelligence in Education: A Bibliometric Study. Int. J. Res. Educ. Sci. 2021, 7, 822–837. [CrossRef]
- 19. Farrow, E. Organisational Artificial Intelligence Future Scenarios: Futurists Insights and Implications for the Organisational Adaptation Approach, Leader and Team. *J. Futures Stud.* **2020**, *24*, 1–15.
- Grencikova, A.; Kordos, M.; Berkovic, V. Expected Changes in Slovak Industry Environment in Terms of Industry 4.0. Int. J. Qual. Res. 2021, 15, 225–240. [CrossRef]
- Koch, J.W. On Digital Ethics for Artificial Intelligence and Information Fusion in the Defense Domain. *IEEE Aerosp. Electron.* Syst. Mag. 2021, 36, 94–111. [CrossRef]
- Leidinger, F. Brave New Psychiatry? Or: What Astray is Artificial Intelligence Leading Psychiatry? Psychiatr. Prax. 2021, 48, S11–S15. [PubMed]

**Disclaimer/Publisher's Note:** The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.