



# Analysis on the Layout of Education Industry Under Information Science: A Case Study of Hefei

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**Abstract.** With the development of information science, the technology based on data mining and data analysis has more and more applications in reality. Based on POI geographic big data, this paper uses kernel density estimation to describe the spatial agglomeration state of education industry in Hefei, determines the core range of education industry distribution, and uses bivariate spatial autocorrelation analysis to explore the spatial correlation between education industries. The results show that: 1. The distribution of all kinds of educational institutions in Hefei city has a strong commonality, and the spatial agglomeration characteristics are obvious. However, the distribution of different types of educational institutions still has many characteristics of their own. 2. There are great differences in spatial correlation between different industries. Kindergarten, primary school and middle school are closely related. Colleges and universities have very low spatial correlation with other industries. Other institutions also have certain characteristics.

**Keywords:** point of interest · education · big data · correlation analysis · information Science

## 1 Introduction

As a new comprehensive science, information science is playing a more and more important role in many research fields. With the rise of information science, human beings have made a more accurate, real and comprehensive evaluation of the objective world. Based on the description of the real system, people make further analysis and decision-making. The rise of information science has had a far-reaching impact on all aspects of social life.

Education plays an important role in the physical and mental growth of individuals and the development of a country. Educational entities such as schools and various training institutions are the main body of education. The reasonable distribution of educational entities plays an important role in meeting the needs of citizens, making full use of educational resources and promoting urban economic development<sup>1</sup>. As for the spatial distribution of various entities in the education and training industry,

the international research in this field started earlier, and some research results have appeared<sup>2</sup>.

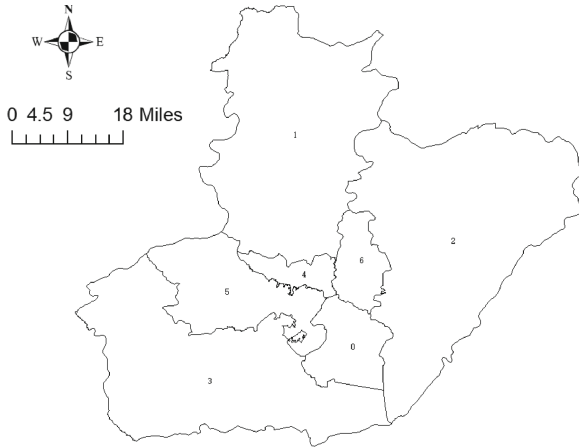
Point of interest (POI) is the data of all kinds of geographical entities, which is the product of the development of geographic information. POI stores all kinds of landmarks, such as schools, banks and hospitals, in the form of two-dimensional arrays, including coordinates and function information. The abstract and organized characteristics of POI data make it play an important role in the analysis of urban spatial region. Therefore, POI data has been widely used in the research of various disciplines, and the research results in various fields such as economy and social security have begun to approach the practical application. For example, Gao Yanhui and Yang Qingqing studied the spatial pattern and influencing factors of retail industry in Xi'an, and conducted in-depth research on the relationship between retail industry distribution and transportation facilities<sup>3</sup>. Duan Yaming et al. identified the multi centers in the main urban area of Chongqing<sup>4</sup>. Taking robbery cases in a city as an example, Zhu Jianxu analyzes the time and space of crime hot spots, and puts forward the prevention and control countermeasures<sup>5</sup>.

Hefei has developed rapidly in recent years, and has made great progress in economy, science and education, transportation and so on. Hefei is a sub central city of Yangtze River Delta urban agglomeration, an important national research and education base, and a comprehensive transportation hub. At present, the analysis of spatial distribution of various industries in Hefei is mostly concentrated in the fields of industry, transportation, etc., while the regional research on culture and education is relatively backward, with few research results. This paper uses Gaode map data, poi (point of interest) as the analysis material, takes the main urban areas of Hefei (namely the four districts of the city and Feidong County and Feixi County) as the research object, and uses ArcGIS software to analyze the spatial distribution pattern of various entities in the education and training industry of Hefei through kernel density analysis, correlation analysis and other methods, find the distribution characteristics of various schools and training institutions. Then this paper gives a conclusion from a scientific point of view. The conclusion of this paper can provide a new perspective on how to optimize the spatial distribution of education and training industry in Hefei, and can also be used as a reference for students' school selection and teachers' work.

## 2 Materials and Methods

### 2.1 Area to Study

Hefei includes four districts, four counties and Chaohu City at county level. The research object of this paper is the education industry in Hefei City, so we select Luyang District, Shushan District, Baohe District, Yaohai District, Feidong County, Feixi County, Changfeng County (considering the New District of Beicheng) to obtain the data. Their jurisdiction covers the whole urban area of Hefei. There are two obvious characteristics of Hefei's urban space. The first is the cluster development of the city. The urban area is composed of old urban area, lakeside new area, economic development zone, administrative district, etc. The size of each cluster is different, and the distribution of population and industry within the cluster is much denser than that between the clusters.



**Fig. 1.** Area to study (involved the major city area of Hefei).

The second is the obvious functional differentiation of different urban areas. For example, the high-tech zone is dominated by high-tech industries, the economic development zone has developed industries, and the cultural, educational and artistic industries in the old urban areas are relatively developed. This unique spatial layout of Hefei is different from most of the provincial capitals in China. This leads to the problem that the layout of public services, especially education, is difficult to adapt to the urban development. Therefore, considering the situation of Hefei, it is necessary to carry out the research on the layout of education industry in Hefei city according to local conditions Figs. 1 and 2.

## 2.2 Source of Data

The basic base map data comes from Gaode map open platform. The POI data of all kinds of schools and training institutions in Hefei in 2021 were obtained through Gaode map, and then preprocessed to remove the data and duplicate data outside the study area, and 8477 POI data were obtained. The identification and quantity of various educational institutions are shown in Table 1.

## 2.3 Analysis Method

Kernel density analysis (kDa) is used to describe the spatial agglomeration of analysis objects. The principle is to cover a smooth surface above each target point. The height of the smooth surface in the vertical direction is the highest just above the target point, and the peripheral height decreases in turn. The height value is zero where the distance from the point is equal to the search radius<sup>6</sup>. When the image is output, the density of each output grid pixel is the superposition of the density of each target point at this pixel (the numerical value is the superposition of the height of each smooth surface here).

Global spatial autocorrelation is used to describe whether all kinds of educational institutions have spatial agglomeration. It is usually expressed by Moran index. The

**Table 1.** Retailing classification and POI data distribution.

Industry code	Category of POI	quantity	proportion (%)
101	Kindergarten	1080	12.74
102	Primary school	796	9.39
103	High school	261	3.07
104	Colleges and universities	132	1.55
105	Tutoring organization for postgraduate entrance examination	56	0.66
106	Service organization for studying abroad	54	0.63
107	Training organization	6098	71.93

formula is as follows:

$$I = \frac{n \sum_{i=1}^n \sum_{j=1}^n W_{ij}(x_i - \bar{x})(x_j - \bar{x})}{(\sum_{i=1}^n \sum_{j=1}^n W_{ij}) \sum_{i=1}^n (x_i - \bar{x})^2}, (i \neq j) \tag{1}$$

In the formula,  $x_i, x_j$  are the point density of education industry in the spatial unit of geographical analysis of the two places,  $i, j$ ;  $n$  is number of grid cells;  $W_{ij}$  is spatial weight;  $\bar{x}$  is the average value of  $x$ .

Bivariate spatial autocorrelation is used to reflect the spatial dependence of different types of educational institutions. The larger the value is, the stronger the dependence is. The formula is as follows:

$$I_{zy}^a = \left( \frac{X_y^a - \bar{X}_y}{d_y} \right) \sum_{c=1}^n W_{ac} \left( \frac{X_z^c - \bar{X}_z}{d_z} \right), (z \neq c) \tag{2}$$

In the formula,  $X_y^a$  is the value of attribute  $y$  of spatial grid  $a$ ;  $X_z^c$  is the value of attribute  $z$  of spatial grid  $c$ ;  $\bar{X}_y$  and  $\bar{X}_z$  are the average values of attributes  $y$  and  $z$ , respectively.  $d_y$  and  $d_z$  are the variances of attributes  $y$  and  $z$ , respectively;  $n$  is number of grid cells;  $W_{ij}$  is spatial weight.

### 3 Results and Discussion

#### 3.1 Spatial Pattern

Firstly, the core density analysis is carried out to determine the basic spatial layout of the education industry. The search radius is set to 1 km, and the core density is divided into five levels by using the natural breakpoint method. Finally, the core density distribution of seven main sub industries of education industry is formed. From the nuclear density distribution map, we can see that the distribution of all kinds of educational institutions in Hefei city has a strong commonality, which is mainly distributed in the old urban area, government affairs area, economic development area, Binhu New Area, as well as the

peripheral areas of MODIAN, Beicheng, Feidong and Feixi. However, the distribution of different types of educational institutions still has many characteristics of their own.

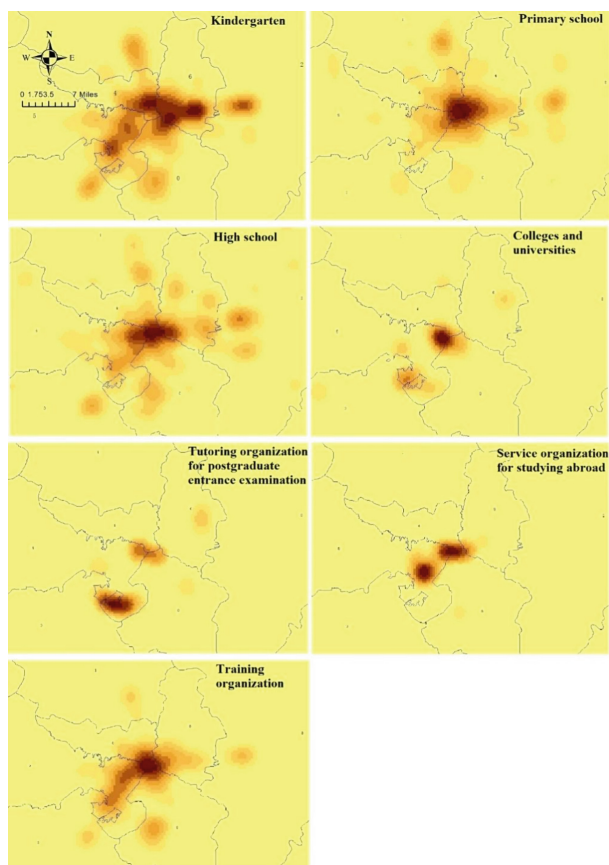
(1) Kindergartens, primary schools and middle schools are closely related to residents' life, and they are widely distributed. All three cover the whole city. The situation of kindergartens is almost equivalent to the distribution of population in different regions of Hefei city. The nuclear density of North 1st ring road, Tongling Road Yuxi Road area and Longgang subway station is in the maximum range, and Longgang is the highest, reaching 60.188. Swan Lake area and Feicui Lake area are the two new urban areas of Hefei which have been developed for a long time, with a large population and a high distribution density of kindergartens. In other regions, except Feidong County, the density of the region center is only 30% to 40% of Longgang region.

The situation in primary and secondary schools is quite different from that in kindergartens. Although their distribution areas are basically the same as that of kindergartens, the highest density in each area shows a certain degree of polarity. The primary school is along Shengli Road, and the middle school is along the South first ring road. Its nuclear density reaches the highest value, which is more than twice that of all other regions. The primary and secondary schools as the primary stage of education, the regional radiation radius is small, which indicates that in the emerging urban areas of Hefei, the number of primary and secondary schools may increase in the future.

(2) The distribution of colleges and universities is mainly affected by policy, history and other factors, so it is different from the situation of primary and secondary schools and kindergartens, and needs to be studied separately. It can be seen from the figure that the most densely distributed areas of universities in Hefei are located in the northeast of Shushan district and the north of Baohe district. This is the cultural and educational center of Hefei, with a large number of institutions of higher learning such as China University of science and technology, Hefei University of technology and Anhui University. The second is the University Town, which is located in the economic development zone. There are new campuses of Hefei University of technology and Anhui University, as well as emerging universities such as Hefei University. MODIAN area in the northeast corner is the vocational education base under construction in Hefei. It mainly cultivates professional application-oriented undergraduate and specialized talents. Near Dashu mountain is the high-tech zone of Hefei, with some scientific research institutes.

(3) Postgraduate entrance examination and study abroad institutions are the help of higher education students to improve their academic qualifications. It is also of great practical significance to analyze their distribution. It can be seen from the figure that the distribution of postgraduate entrance examination guidance institutions in Hefei is basically the same as that of universities mentioned in the previous article, but the density is higher in the university town area. The study abroad service institutions show different characteristics. Study abroad service agencies are concentrated in two areas, one is centered on sanxiaokou - nanyihuan - Baohe Wanda, and the other is centered on Swan Lake. The agglomeration effect of study abroad service institutions in Hefei is very obvious.

(4) Training institutions. The training institutions in this paper include primary school, junior high school and senior high school extracurricular counseling institutions, various interest training institutions, vocational education and adult education



**Fig. 2.** Kernel density of different education industries in Hefei.

institutions, early childhood education institutions, etc. The distribution of various training institutions is basically presented according to the scope of urban areas. From the nuclear density map, the distribution of training institutions is not obvious. Except for Beicheng, Feidong, Feixi and Binhu, the distribution of training institutions in the main urban area of Hefei is basically connected as a whole. The density of Sipailou area is the highest, followed by Jinzhai Road, which extends to the university town. With Sipailou and Jinzhai Road as the center, the distribution density of training institutions around gradually decreased, and dropped to zero at 5–10 km.

### 3.2 Correlation Analysis

It can be seen from Table 2 that the global spatial autocorrelation coefficients of all kinds of educational institutions in Hefei are all above 0.9, indicating that the education industry in Hefei has obvious spatial autocorrelation. On this basis, the bivariate global spatial autocorrelation analysis of seven types of educational institutions is carried out to explore the spatial dependence between different types of educational institutions.

**Table 2.** Global and bivariate spatial autocorrelation of different education industries in Hefei.

Industry code	101	102	103	104	105	106	107
<b>101</b>		0.844	0.845	0.527	0.380	0.555	0.881
<b>102</b>			0.829	0.517	0.345	0.564	0.842
<b>103</b>				0.627	0.425	0.648	0.875
<b>104</b>					0.721	0.570	0.673
<b>105</b>						0.357	0.471
<b>106</b>							0.756
<b>107</b>							
<b>Global spatial autocorrelation</b>	0.970	0.973	0.960	0.935	0.921	0.930	0.920

The research shows that there are some obvious points worthy of attention in the relationship between education industries in Hefei.

(1) Kindergarten, primary school and middle school are closely related, and the bivariate spatial autocorrelation index is above 0.8, showing a strong spatial correlation. This kind of relationship may be caused by many factors, but no matter what the reason is, the strong spatial correlation will inevitably lead to the possibility of communication between schools at all levels in teaching, management, logistics and even personnel. This point can remind the education management department to consider the relationship in geographical space when carrying out the long-term consistent teaching and research activities, so as to optimize the activity arrangement. Business units related to education, such as bookstores, can also use this feature to cover multiple categories and all age groups of products in the same area, so as to face more customers and save operating costs.

(2) The university has a low degree of spatial correlation with other industries, and its relative independence is obvious. The correlation index between universities and other institutions is between 0.5 and 0.7, except that the correlation between universities and other institutions is relatively high, which is 0.721. The low degree of relevance is conducive to the formation of specialization, but it also reflects that higher education, as an important part of national education, is obviously separated from other types of educational institutions in Hefei, which may not be conducive to the understanding and practice of college students, as well as learning and improvement through a variety of off campus ways.

(3) The comparison between postgraduate entrance examination counseling institutions and study abroad service institutions. The degree of association between study abroad service institutions and other industries is about 0.2 higher than that of postgraduate entrance examination counseling institutions. The spatial connection between study abroad institutions and universities is lower than that between postgraduate entrance examination institutions and universities, but the spatial connection between study abroad institutions and primary and secondary schools, kindergartens and other training institutions is higher than that between study abroad institutions and postgraduate entrance examination institutions.

(4) All kinds of training institutions have strong spatial correlation with other educational entities except universities and postgraduate entrance examination service institutions.

## 4 Conclusions

Education is the great plan of our country, and it is something that everyone will experience. It is of great practical significance to analyze the spatial distribution of education industry in a region. This paper uses POI big data to analyze the spatial pattern of education industry in Hefei city and the relationship between each sub industry, the conclusions are as follows:

(1) Group distribution, regional agglomeration is obvious. At the same time, the distribution of different mechanisms is different.

(2) There are great differences in spatial correlation between different industries. Kindergarten, primary school and middle school are closely related. The university has a low degree of spatial correlation with other industries, and its relative independence is obvious. There are also some characteristics of postgraduate entrance examination counseling institutions, study abroad service institutions and training institutions.

This paper makes some basic analysis on the spatial distribution of education industry in Hefei City, but there are still some deficiencies in this study, which need to be further studied in the future. 1. This paper only makes a correlation analysis of the education industry itself, and then studies the relationship between the education industry and population density, road network and other data, so as to further explore the role of various types of educational institutions in social life and the factors affecting the layout of educational institutions. 2. To describe the same type of schools from multiple perspectives, for example, colleges and universities can be classified from the perspective of Humanities and science and engineering, and then from the enrollment scale to form different school portraits, and then make a more detailed correlation analysis.

**Acknowledgments.** During the internship at iFLYTEK education business group this spring, the author contacted various schools at all levels in different regions and found that the distribution of educational institutions in a city has certain laws, and these laws can be studied in the way of information science. These laws have strong practical significance. Therefore, the author wrote this article, hoping to provide some reference for other researchers and relevant practitioners.

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