Trends in regional differences in information technology infrastructure for secondary education in China

Shuhan Li

Chinese Language and Culture College, Huaqiao University, Xiamen City, Fujian Province, 362021, China

shuhanli136@gmail.com

Abstract. China is currently in the era of education informatization 2.0, which has significant implications for the country's economic and social development. During the previous era, education informatization 1.0, the focus was on constructing and investing in informatization infrastructure. However, due to historical and economic factors, there were significant differences in the level of education informatization infrastructure construction across regions. This paper evaluates the construction of education informatization infrastructure in secondary schools during the education informatization 1.0 era, using a combination of data sources and analytical techniques. The results show that education informatization infrastructure construction has improved overall, with the central and eastern regions ahead of the western regions, also the central region has seen an increase in the ratio of both microcomputer room construction and voice classroom construction. However, the education informatization infrastructure construction in the western regions still requires improvement, which has significant implications for promoting regional equity in education and advancing China's education informatization agenda.

Keywords: education informatization, informatization infrastructure, regional differences, secondary schools

1 Introduction

Education informatization refers to the integration of computer multimedia and network information technology with education to promote education convergence. Since the 1970s, many countries have recognized the importance of education informatization and have been promoting its development through various policies. In China, education informatization began in 1995 [1] and has been supported by government policies such as the Decision on Deepening Education Reform and Promoting Quality Education Comprehensively and the Plan for Revitalizing Education in the 21st Century. These policies promoted the construction of infrastructure and the spread of information technology in primary and secondary schools. From 2012 to 2017, the focus shifted towards expanding digital education resources, constructing online education platforms, and

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training teachers. China released the Ten-Year Development Plan for Education Informatization (2011-2020) which presents the unbalanced development of infrastructure construction in our educational informationization, and further determines the development direction of education informationization in the future.

Infrastructure construction is the foundation for education informatization and is also a key component of China's education informatization 1.0 era. Education informatization infrastructure includes computers, multimedia classrooms, voice classrooms, electronic reading rooms, digital library resources, and campus network construction, among other things.

As China enters the education informatization 2.0 era, it is crucial to review and reflect on the previous phase of education informatization construction, understand the construction of education informatization infrastructure in various regions of China, and provide new perspectives and directions for the next phase of development.

2 Literature review

Unified and scientific assessment standards are essential for improving education informatization and promoting its construction. To achieve balanced development and narrow the digital divide between countries, diverse standards have been established by different regions and countries based on their unique characteristics. In 2009, UNESCO introduced a new assessment index system for education informatization that includes 8 primary and 53 secondary indicators [2]. Infrastructure is one of the primary indicators that focuses on the student-to-computer ratio, schools' usage of computer-assisted teaching, and virtual laboratories.

The Networked Readiness Index (NRI) is another index that measures a country or region's capacity and readiness to use Information and Communication Technologies (ICT) [3]. The NRI consists of two parts: network use and network support indicators that encompass parameters like environment, readiness, and use. It mainly measures the level of information technology construction by the infrastructure support facilities and usage.

A study by Korean scholar Kim (2012) subdivided four hierarchical indicators based on the NRI to comprehensively assess the level of educational informatization among students, teachers, and parents. These indicators are basic equipment requirements, the level of capacity necessary for educational information, the degree of utilization of educational information, and the educational informatization satisfaction index [4].

The STaR scale in the US assesses the level of education informatization in schools based on hardware and network connectivity, teacher professional development, digital resources, student achievement and assessment. The hardware and network connectivity indicator includes the student-to-computer ratio, the number of networked classrooms and offices, and the possession and use of other hardware equipment [5].

China's adoption of information technology in education began relatively late. Currently, there are two main directions in the development of an indicator system for evaluating the level of education informatization infrastructure construction. The first di-

rection involves the establishment of an indicator selection system, with the most influential being the basic indicator system for evaluating the development of education informatization proposed by Wang Zhuzhu et al. (2005). This system comprises five primary indicators and 26 secondary indicators that cover infrastructure, information resources, information literacy, ICT application, and information management, almost encompassing all aspects of education informatization [6].

The second direction involves the study of measurement standard systems, which currently rely on the hierarchical analysis method (APH) supplemented by a method to determine the weight of indicators through assessment. For example, Li Zhihe et al. (2019) used research tools such as the Delphi method and hierarchical analysis to construct indicators for measuring the development level of basic education informatization. They conducted an empirical test on the influence of government support and social informatization on the development level of basic education informatization [7]. Another example is Dai Wenfeng, who combined qualitative and quantitative analysis and the hierarchical analysis method to determine the index system and weights for evaluating the level of university education informatization in Gansu Province [8]. However, many evaluation index systems rely on expert opinions and experience to assign weights to each index, resulting in a high degree of subjectivity in the judgment criteria.

In conclusion, various assessment standards are available to evaluate the level of education informatization in different regions and countries. In both Chinese and international assessment systems for information technology in education, the evaluation of education information technology infrastructure is a crucial component. This paper will refer to previous studies to evaluate the level of educational informationization infrastructure construction in China.

3 Research Design Methodology

3.1 Data Sources

The data used in this study were obtained from the China Education Statistical Yearbook (2011-2019). The number of students enrolled in secondary schools, the number of computers, the area of microcomputer rooms, and the area of speech classrooms in each province from 2011 to 2019 were selected as the basic data for the study.

3.2 Research Methodology

3.2.1 Regional Division

Mainland China is divided into three economic zones based on historical development and geographic factors: the eastern, central, and western regions. This paper will take the province as the basic unit to analyze the differences in the changes in education information technology infrastructure in secondary schools across these three regions.

3.2.2 Selection of Research Indicators

This study considered the relationship between the construction of education informatization infrastructure and the six elements of the education informatization system proposed by the state, as shown in Figure 1. The research indicators were selected based on these six elements.

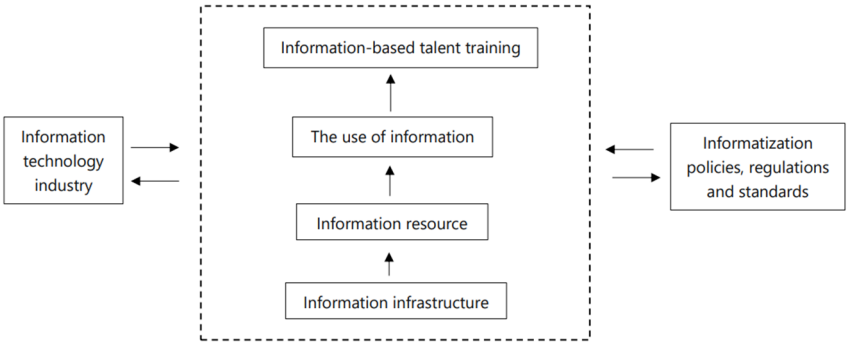

Fig. 1. Framework of basic elements of education informatics construction

The diagram above highlights the significant role of education informatization infrastructure in its construction. The development of informatization infrastructure facilitates the acquisition and improvement of information resources, which, in turn, promotes their utilization and fosters the cultivation of informatization talents. Additionally, the development and improvement of the informatization industry and corresponding legal frameworks can mutually promote the overall process of informatization and the cultivation of information technology talents.

Research in China continues to rely on Wang Zhuzhu's framework [6] for assessing education information technology infrastructure. Therefore, based on previous research, this study uses the student-to-computer ratio (later simplified as R1), the ratio of the area of microcomputer classrooms to the number of students (later simplified as R2), and the ratio of the area of speech classrooms to the number of students (later simplified as R3) in the junior secondary section as the criteria for judging the level of information technology infrastructure construction in the education department, as seen in Table 1.

While the indicators above may not provide a comprehensive assessment of infrastructure construction, these three ratios（R1,R2,R3）can still effectively reflect many of the challenges and issues present in the development of information infrastructure.

Table 1. Infrastructure index system

First-order index	Secondary index
Information infrastructure	The student-to-computer ratio (R1)
	The ratio of the area of microcomputer classrooms to the number of students (R2)
	The ratio of the area of speech classrooms to the number of students (R3)

4 Conclusion and Discussion

4.1 The Overall Situation of Education Informatization in China

By analyzing data from the China Education Statistical Yearbook between 2011 and 2019 from 31 provinces, the construction of education informatization infrastructure in China can be evaluated for the country as a whole, as well as for the eastern, central, and western regions of China.

Table 2. National Secondary Schools 2011 - 2019 Education IT Infrastructure Construction

	2011	2012	2013	2014	2015	2016	2017	2018	2019
R1	11.167	9.587	8.156	7.369	6.615	6.014	5.641	5.489	5.384
R2	5.952	5.391	4.780	4.542	4.294	4.034	3.965	3.980	3.958
R3	16.865	15.229	14.234	13.432	12.656	11.768	11.667	11.954	11.394

Table 3. Education Information Technology Infrastructure Construction in Secondary Schools in East, Central and West China 2011 - 2013

	2011			2012			2013		
	East	Mid-land	West	East	Mid-land	West	East	Mid-land	West
R1	7.79	1.48	14.53	6.79	1.49	12.48	5.92	1.51	10.60
R2	5.25	6.29	6.55	4.80	5.60	5.99	4.29	4.85	5.42
R3	13.23	17.30	23.47	12.28	15.00	21.38	12.01	13.33	19.74

Table 4. Education Information Technology Infrastructure Construction in Secondary Schools in East, Central and West China 2014 - 2016

	2014			2015			2016		
	East	Mid-land	West	East	Mid-land	West	East	Midland	West
R1	5.34	1.50	9.37	4.86	1.49	8.11	4.55	1.48	7.05
R2	4.00	4.77	5.09	3.76	4.60	4.75	3.60	4.32	4.35
R3	11.61	12.78	17.54	11.14	12.22	15.76	10.35	11.23	15.03

Table 5. Education Information Technology Infrastructure Construction in Secondary Schools in East, Central and West China 2014 - 2016

	2017			2018			2019		
	East	Mid-land	West	East	Mid-land	West	East	Midland	West
R1	4.39	1.48	6.43	4.32	1.49	6.19	4.24	1.50	6.11
R2	3.56	4.35	4.14	3.62	4.37	4.09	3.59	4.35	4.08
R3	10.20	11.35	14.77	10.94	11.48	14.34	10.02	11.28	14.07

4.2 The Overall Student-to-Computer Ratio of Secondary Schools in China Shows a Decreasing Trend Year by Year, with Differences between the Eastern, Central, and Western Regions

The overall student-to-computer ratio (R1) of secondary schools in China has demonstrated a decreasing trend from 11.17 in 2011 to 5.38 in 2019, indicating an increase in the number of computers and a gradual improvement in the computer penetration rate. Nevertheless, significant disparities in computer penetration rates exist among the eastern, central, and western regions. Combined with Fig.2, Table 3, Table4 and Table 5, it can be seen that the central region has maintained a relatively stable student-to-computer ratio of between 1.48 and 1.51 over the years. The student-to-computer ratio in other regions has declined year by year, but remains higher than that in the central region. As of 2019, the student-to-computer ratio in the central region is 1.50, while the western region's R1 is 6.11, and the eastern region's R1 is 4.24, indicating substantial regional disparities in computer infrastructure construction in China. Notably, the western region has experienced the fastest computer penetration rate, the statistic from Table 3 and Table 5 reveal that the R1 has declined from 14.53 in 2011 to 6.11 in 2019.

In summary, considerable differences in computer infrastructure construction still exist among the eastern, central, and western regions of China.

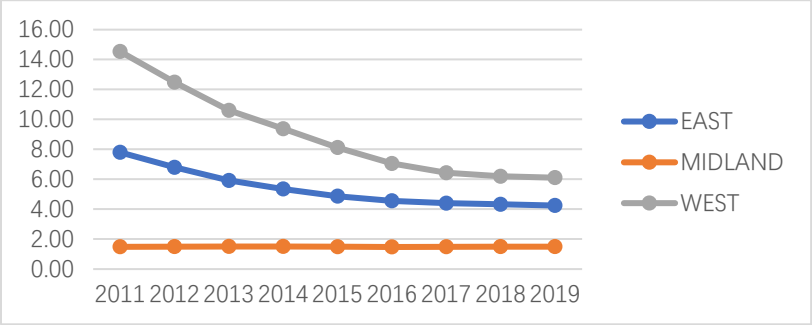

Fig. 2. The student-to-computer ratio (R1) in different regions of China in 2011-2019

4.3 The Construction of Microcomputer Classrooms in Secondary Schools in China Is Increasing, with Significant Development in the Western Region

Table 2 show that the overall ratio of microcomputer classroom space to student population (R2) in China has been decreasing year by year, from 5.95 in 2011 to 3.96 in 2019. This trend indicates that the construction of microcomputer classrooms in China is gradually increasing and improving. However, as shown in Fig.3, regional disparities persist, with the R2 in the eastern region consistently lower than in other regions. As of 2019, the R2 in the eastern region is 3.59, while the R2 in the western region is 4.08, and the R2 in the central region is 4.35. The R2 in central region showed a decline and then a rebound. In 2016, the R2 for the central region was 4.32, but it rose to 4.35 in 2017 and continued to increase to 4.37 in 2018, before falling back to 4.35 in 2019.

Combine with Fig.3 and Table 5, the western region is developing faster, and the differences between the central and western regions in terms of the R2 are not significant. However, the western region is developing faster than the central region. In 2017, the R2 in the western region was 4.14, compared to 4.35 in the central region. Since then, the R2 in the western region has been consistently lower than that in the central region. Overall, these findings suggest that significant development in microcomputer classroom construction has occurred in the western region of China.

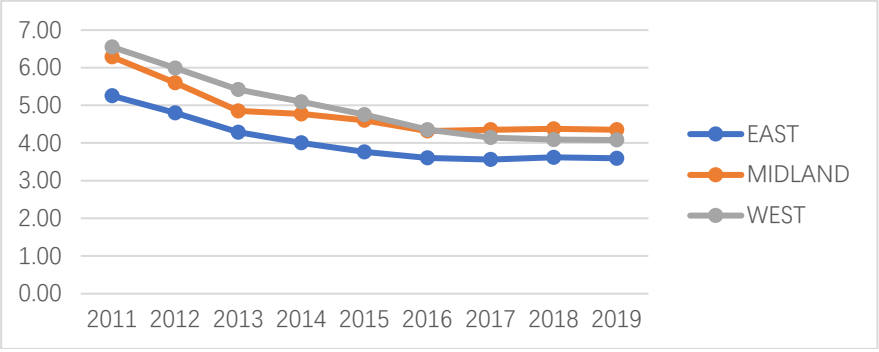

Fig. 3. The ratio of the area of microcomputer classrooms to the number of students (R2) in different regions of China in 2011-2019

4.4 The Overall Construction of Speech Classrooms in Secondary Schools in China Has Been Increasing, with Significant Differences between the Eastern, Central, and Western Regions

Table 2 shows that the ratio of speech classroom area to the number of students in secondary schools in China has been decreasing year by year, from 16.87 in 2011 to 11.39 in 2019. Notably, as can seen in Fig.4, the ratio in the western region has been consistently higher than that in the central and eastern regions. However, an examination of Tables 4 and 5 reveals that the R3 of the eastern region was 10.20 in 2017, but it rose to 11.48 in 2018 before falling back to 10.02 in 2019, indicating slight fluctuations overall. In contrast, the central region exhibited an upward trend, with the R3 increasing from 11.23 in 2016 to 11.35 in 2017, rising to 11.48 in 2018, and then declining to 11.28 in 2019. These results demonstrate significant differences in the construction of speech classrooms in secondary schools among the eastern, central, and western regions of China.

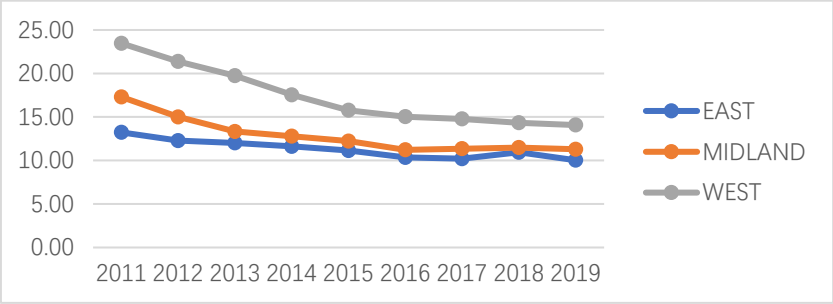

Fig. 4. The ratio of the area of speech classrooms to the number of students (R3) in different regions of China in 2011-2019

5 Recommendations

5.1 Establishing a Sound and Complete Assessment Mechanism for Information Technology Infrastructure

China's education informatization construction has led to an increase in computer penetration rate and enhanced people's information literacy. However, there are still significant differences in the construction of education informatization infrastructure between regions, with the western region lagging behind the central and eastern regions. Also, the central region has seen an increase in the ratio of both microcomputer room construction and voice classroom construction, which means the information technology infrastructure development in the central region is still inadequate. To promote regional equity in education informatization in China, a unified and sound evaluation mechanism for the construction of education informatization infrastructure needs to be established. Conducting timely statistics and surveys on the construction of education informatization infrastructure and regularly reviewing and updating the evaluation mechanism can ensure its relevance and validity.

5.2 Promoting the Development of Interoperability in the Construction of Education Informatization Within and Between Regions

Although the overall level of education informatization infrastructure construction in China has been improving, there are still significant differences in development between and within regions. This paper analyzes and measures the data within regions and finds that the development of education informatization within the eastern region also varies greatly. For example, in 2011, the raw ratio in Shanghai and Beijing reached 3.27 and 4.67, respectively, indicating a large difference within regions. To promote interoperability in education informatization, we should focus on bridging the development gap between and within regions. Specifically, promoting an interoperable learning mechanism for education informatization within regions, bridging the digital divide be-

tween urban and rural areas and economic regions, and promoting the balanced development of education informatization within and between regions can help achieve this goal.

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