Article

Spatiotemporal Analysis of the Achievement of Equitable Quality Basic Education in Gansu Province, Northwest China

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Abstract: This paper holds that educational research, at a local scale, is more meaningful than that at a macro-scale. To analyze the achievements of basic education at a local scale in Gansu Province, Northwest China, an index system, and an educational development index (EDI), were designed and implemented. The results show that the distribution of basic education schools is more suitable for meeting the needs of the population distribution compared to the years prior to 2013. Improvement in resource allocation in the province since 2013 has provided better educational conditions. However, educational equality between urban and rural areas has changed differently at provincial, prefectural, and county scales. The EDI scores reveal that most prefectures and counties are at medium- or low-quality levels of equality, with remote mountainous prefectures and counties even falling into the ultra-low-quality category of inequality. Educational inequality, quality of teachers, and deficiencies in educational investments are the major restrictions on basic education development in Gansu Province.

Keywords: spatiotemporal analysis; equitable quality education; basic education; policy objective; educational development index

1. Introduction

Although the global goal of “inclusive and equitable quality education” was not officially proposed until the United Nations published its Sustainable Development Goal Four (SDG4) [1] (p. 8) in 2015, equitable quality education has long been the pursuit of modern education [2,3]. With the development of basic education in developing countries, the focus of educational research has gradually shifted from equality of opportunities [4,5] to equitable quality education [2,6]. However, much attention has been paid to equitable and quality education at macro spatial scales, such as educational inequality between countries, between inland and coastal areas [7], and between rural and urban areas of a country [8,9], as well as equitable quality education at the continent [10,11] and country [12,13] scales. More, long-term, attention has also been paid to equitable quality education at global and country scales, especially by international organizations, such as the Organization for Economic Cooperation and Development (OECD), which publishes education-related data on its Education GPS website (https://gpseducation.oecd.org/, accessed on 3 January 2021). These achievements at macro scales can help to understand the difference of equality, and quality of education, in macro-scale spaces with different economic conditions and social development levels.

However, it is necessary to emphasize that education, as a type of spatial social activity, is affected by both the national and local environment. Regularities obtained from macro-spaces generally cannot be directly applied to small regions [14,15]. Compared to research conducted at macro scales, research in multi-scale spaces enables a better understanding of progress and the nuances of spatial behaviors [16]. Thus, focusing solely
on macro-scale studies of equitable quality education is inadequate, and attention should be paid to equitable quality education at small scales. A couple of small-scale studies have been published. Musa and Bichi [17] analyzed how increasing enrollment affected improvements in educational quality in Kano State, Nigeria; Dodman [18] verified the success of equitable access to quality education in the inner-city area of Kingston, Jamaica. These studies verify that analysis at local scales is more helpful in revealing the status quo, progress, and significant factors that would not show up in a macro-analysis at national, or other macro, scales [15].

This view of conducting research at local scales is also encouraged by China’s management system for basic education. The core of this management system is “overall planning at the provincial level, with the counties as its base” [19]. According to the obvious differences in natural and social conditions among Chinese provinces, this system gives relatively independent decision-making power to the provincial government. Under this framework, the reform, resource allocation, and other national and local policies for basic education have been implemented smoothly in practice. Therefore, a province is relatively independent in the management system of basic education in China. As is pointed out by culturally responsive pedagogy [20–24], education will be more meaningful when it is rooted in culture and local environment. Research at provincial and intra-provincial scales will be more helpful for revealing the nuances in education development because the progress, and gaps, in education can thus be analyzed in the local environment that directly affects the development of education. In this sense, a province is, relatively, the most objective spatial scale for analyzing the development of basic education in China [25].

Basic education, as the foundation of kindergarten through university-level education [26], plays an important role in global economic growth and poverty reduction [27]. Thus, it is a long-standing hot point of educational research and sustainable development [1]. In 2010, China implemented the policy of “popularizing three-year preschool education and senior high school education” [28]. This expands basic education to include kindergarten, primary school (grades 1–6), junior high (grades 7–9), and senior high school (grades 10–12). However, research in China is still focused on nine-year compulsory education (grades 1–9) [29], which is not the basic education that Chinese governments are striving to develop. Furthermore, Northwest China is a vast area with an under-developed economy, a more rural society, and a very different population distribution compared to other areas of the country. There are great challenges brought on by the shortage of educational resources, the large gap in education between western and eastern China, and educational inequality [30,31]. In such a region, the development of basic education is not only a practice of inclusive and equitable quality education but also is a significant effort to prevent the intergenerational transmission of poverty [32].

When analyzing the achievement of basic education, using a reasonable and effective reference is essential. Policy, as a very important, and unique, educational resource [33], establishes governing statements on what education can and should do [34,35] towards the expected goal. China has implemented a series of policies and measures, since the 1980s, that have successfully promoted the development of basic education. The quantitative indices, preset by policies, have always been the practical reference for education government and assessment. However, these indices have rarely been used to analyze the achievement of education due to researchers’ confusion and uncertainty regarding whether the policies can adapt to, and promote, education development [36]. This study only analyzes the achievement of some compulsory indices (e.g., school size, student-teacher ratios) with strong stability and continuity, so all involved educational indices are assumed to be positive and reasonable in view of their positive contributions toward achieving equitable and quality basic education in recent decades [37,38].
For the above reasons, the goal of this study is to address the issue of insufficient research at local scales, and to systematically understand the level of progress in educational development, by analyzing whether basic education in Gansu Province meets the objectives determined by policies. The results of this study will contribute a practical perspective and method for educational research, and identify existing problems and their causes, which could lead to breakthroughs in education reform and optimization.

To achieve the goal, an index system is designed in this study according to “The statistical index system of educational monitoring and evaluation in China (2015 version)” [39], which includes education size (i.e., school size and school district population size), resource allocation, and educational equality. Then, the geometric mean of the three components is defined as the education development index (EDI) following the multiplicative structure of the Human Development Index (HDI) proposed by the United Nations in 2010. Using this approach, the paper analyzes the achievement of basic education in Gansu province. This study is performed at three scales: provincial, prefectural (i.e., prefecture level cities and autonomous prefectures of ethnic minorities), and county (i.e., counties, county-level cities, and municipal districts).

The remainder of the paper is arranged as follows. Section 2 describes the research area and the data used in the analysis. Sections 3 and 4 describe the method, including the composition of the index system, normalization of the indices, and EDI scoring. Section 5 analyzes the results at province, prefecture, and county scales. Section 6 compares the analysis results with educational competitiveness scores issued by official investigations. Section 7 discusses the results and conclusions.

2. Research Materials

2.1. Research Area

As shown in Figure 1, Gansu Province is located in Northwest China. It has 12 prefecture-level cities and two autonomous prefectures of ethnic minorities consisting of 86 counties (i.e., 64 counties, 17 municipal districts, and five county-level cities). The total area of the province is 453,700 km², and it has more than 26 million permanent residents. As Gansu Province is one of the birthplaces of the Chinese nation, public and private schools developed earlier, in this province, than in many other provinces in the country. According to China’s official reports, the environment of basic education development in Gansu Province can be described as follows.

(a) It was identified as one of the national demonstration provinces for “alleviating targeted poverty through education” in China in 2017 [40].
(b) Some indices of educational development, such as gross enrollment rates of preschool education, nine-year compulsory education (grades 1–9), and senior high school (grades 10–12), are higher than the national average.
(c) It has a complex geographical environment and a vast territory.
(d) The society is primarily rural with an under-developed economy.
(e) It has substantial spatial differences in population distribution and social development.

Although it is a national demonstration province, and is required to provide a set of reproducible, referable, and propagable experiences for the whole country [40], disadvantages in the educational environment, such as its under-developed economy, rural society, and differences in population density, greatly restrict educational development. Therefore, spatiotemporal analysis of basic education achievement in Gansu Province is an urgent need. It will also be useful for the country, as it could lead to a systematic understanding of the progress and restrictive factors of basic education at a local scale in China.
2.2. Data

The data used in the study fall into three categories. (1) Statistical data, that were freely downloaded from public data platforms on governments’ official websites, e.g., National Data. (2) A paid vector map, provided by the Geographical Information Monitoring Cloud Platform, employed as the base map. (3) Educational policy documents, that were obtained from the official websites of the Ministry of Education of the People’s Republic of China (http://www.moe.gov.cn/, accessed on 15 December 2020) and the Education Department of Gansu Province (http://jyt.gansu.gov.cn/, accessed on 15 December 2020). These sources are listed in Table 1. All the policy documents were derived from current policies guiding the practice of educational innovation and assessment, although some are not recent.

Table 1. Data and data sources.

| Data Type                      | Sources                                                                 |
|-------------------------------|-------------------------------------------------------------------------|
| statistical data              |                                                                         |
| National population data      | China’s Economic and Social Big Data Research Platform, http://data.cnki.net/ (accessed on 11 December 2020). |
| National education data       | National Data, http://data.stats.gov.cn/ (accessed on 11 December 2020). |
| Educational data of Gansu     | Ministry of Education, http://www.moe.gov.cn/ (accessed on 12 December 2020). |
| Province                      | Education Department of Gansu Province, http://jyt.gansu.gov.cn/ (accessed on 12 December 2020). |
| National education investment | National statistics on the implementation of education funds, http://www.moe.gov.cn/jyb_sjzl/sjzl_jfzgg/ (accessed on 12 December 2020). |
| Education investment of       | Gansu statistics on the implementation of education funds, http://jyt.gansu.gov.cn/ (accessed on 13 December 2020). |
| Gansu Province                |                                                                         |
Table 1. Cont.

| Data Type | Sources |
|-----------|---------|
| School district population | Urban public facilities planning standards [41], 2018. Construction standard of general primary and secondary schools in rural areas [42], 2008. Standards for the construction of urban general primary and secondary schools [43], 2002. |
| School size | Notice on uniform staffing standards for primary and secondary school teachers in urban and rural areas [44], 2014. |
| Student-teacher ratios | The statistical index system of educational monitoring and evaluation in China [39], 2015 |
| Per-student educational appropriations | Interim measures for supervision and evaluation of equitable development of compulsory education at the county level [45], 2012. Geographical Information Monitoring Cloud Platform, http://www.dsac.cn/DataProduct/Index/201842 (accessed on 10 August 2020). |
| Educational equality | A vector map of Gansu Province |

3. Index System

3.1. Three Dimensions Used in the Analysis

China’s basic education policies established clear objectives for school size, school district population, and student-teacher ratios. To keep the indices simple and the data available, this study summarized the policy objectives into three dimensions: education size, resource allocation, and educational equality. Some indices selected from “The statistical index system of educational monitoring and evaluation in China (2015 version)” [39] are used to evaluate these three dimensions. The indices for each dimension are treated equally in this study.

(a) Educational size refers to school size and school district population size. School size affects educational costs [46], performance [47], equality, and quality [48,49]. Population size is often a companion index of school size in China’s educational policies, as it is difficult to control school size when a school district’s population is too large or too small. For example, in the past decade, China has made great efforts to resolve the problem of large schools and classes. Considerable investments have also been made in the development of small schools in rural areas. Thus, this index measures these two aspects of education size.

(b) Resource allocation is the essential content of equitable equality education. It generally includes educational funds, teachers, and teaching infrastructure (e.g., school land area, school buildings, accommodation facilities, and electronic medium). To ensure data availability, education resources were divided into teachers and education funds. This approach was taken because teaching infrastructure is the accumulation of educational funds, so it can belong to funds in multi-year data. Both the number and the quality of teachers significantly impacts equality and quality in education achievement [50]. Thus, resource allocation considered both teachers and funds. The indices include per-student educational appropriations, student-teacher ratios, and the proportion of teachers with the required academic certifications and above.

(c) Educational equality is the crucial features of equitable quality education. However, it is difficult to find a definitive evaluation method due to its complex interpretations in different ways [50]. Considering that teachers play the most important role in education development [51–53], educational equality measures the spatial equality of basic education via the allocation of teachers. The advantage of this method is that it can keep the indices in line with policy objectives and ensures that data are available and comparable. The index is the ratio of rural-to-urban teacher allocation indices.

3.2. Hypothesis

Any changes in the indices that are used in this study could be a case of education adapting to the local culture and environment. However, the development of basic ed-
ucation is adjusted and assessed according to the policy objectives in practice [37,38,45]. Therefore, this study assumes that the values of the indices, within the thresholds established by policies, will indicate a good development of basic education. The closer the values of the indices are to the upper limits of the thresholds, the nearer the development of basic education is to what it is expected to be. Otherwise, there are some problems that want to be solved for achieving the equitable quality education expected by governments. Armed with this hypothesis, the thresholds established by current policies were taken as the success criteria for normalization of the indices and analysis of the results in this study.

3.3. Normalization of the Indices

To make the indices comparable, the raw data were normalized with thresholds that are established by corresponding policies. Table 2 shows the normalizing methods and the meaning of different values for each index: \( S_p \) represents the school district population, \( S_s \) represents the average school size, \( S_{p\min} \) and \( S_{p\max} \) represent the lower and upper limits of school district population preset by policy documents, \( S_{s\min} \) and \( S_{s\max} \) represent the lower and upper limits of school size preset by policy documents, \( T_s \) represents the policy objective of teacher allocation, \( t \) represents student-teacher ratio, \( t_p \) represents the proportion of teachers with the required academic qualifications and above, \( E_f \) represents per-student educational appropriations, \( G_p \) represents the per-capita GDP of the region.

| Dimension       | Index                          | Method                                      | Threshold       | Meaning                                   |
|-----------------|--------------------------------|---------------------------------------------|-----------------|-------------------------------------------|
| Education size  | school district population index (\( S_p \)) | \( \frac{S_p - S_{p\min}}{S_{p\max} - S_{p\min}} \) | \(<0\)           | School district population is too large   |
|                 | Average school size index (\( S_s \)) | \( \frac{S_s - S_{s\min}}{S_{s\max} - S_{s\min}} \) | \(0–1\)         | School district population is moderate    |
|                 |                                |                                             | \(>1\)           | School district population is too small    |
| Resource allocation | Teacher allocation index (\( T \)) | \( \frac{T_s}{T} \times t_p \) | \(>1\)           | Student-teacher ratios achieved the policy objectives |
|                 | Per-student educational appropriations index (\( E_f \)) | \( \frac{E_f}{E_p} \) | \(>0\)           | The larger the value, the more the investment |
| Educational equality | Equality index (\( E_{equality} \)) | \( \frac{T}{T_e} \) | \(0–1\)         | The larger the value, the more the equality of urban-rural areas |

4. Educational Development Index

4.1. Parameter Integration Formulae

Quantitative models are commonly used in educational development research. In many cases, the educational development index is calculated with linear models, such as an arithmetic average or weighted average [54,55], which carries the assumption of perfect substitutability among its components [56]. However, many studies have suggested that the multiplier model is more suitable for educational research [57] because it requires good performance in all dimensions [58]. Thus, based on the multiplicative structure of the Human Development Index (HDI), proposed by the United Nations in 2010, a formula for the education development index (\( EDI \)) can be expressed as follows:

\[
EDI = \sqrt[3]{E_{size} \times E_{resource} \times E_{equality}}
\]  

(1)

where \( EDI \) is the education development index, \( E_{size} \) is the index of education size, \( E_{resource} \) is the index of resource allocation, and \( E_{equality} \) is the index of educational equality. These are all comprehensive indices calculated by the following formula:

\[
E_{size} = \frac{(S_p + S_s)}{2}
\]  

(2)
resource = \left( \frac{T + E_f}{2} \right) \quad (3)

E_{\text{equality}} = \frac{T_r}{T_u} \quad (4)

Here, $S_p$ represents the school district population, $S_s$ represents the average school size, and $T$ represents the teacher allocation index calculated by the product of the student-teacher ratio and the proportion of teachers with the required academic qualifications and above; $E_f$ represents the index of per-student educational appropriations, and $T_r$ and $T_u$ represent the teacher allocation index in rural and urban areas.

4.2. Classification and Evaluation

According to the thresholds of all five indices, normally, the EDI value should be in the range of 0–1. The reasons are as follows:

(a) An EDI value in the range of 0–1 means that the achievement of policy objectives is progressing normally. The larger the value, the better achievement of policy objectives and the closer their status to what current policies expect them to be. Therefore, the study evaluated achievement levels, according to the EDI value, in this interval.

(b) An EDI > 1 means that at least one of three dimensions has not been controlled below its upper limit. This implies that there are still some problems restricting the realization of equitable quality development of basic education (e.g., the problem of large schools). This is defined as ultra-high-quality inequality because this is one aspect that current policies are intended to control.

(c) An EDI < 0 means that at least one of the three dimensions lies below its lower limit. This implies some other problems. For example, there are too many small schools or student emigration restricts the improvement of educational quality. This may not be a problem, but it can impose new requirements on current policies. Thus, it is defined as ultra-low-quality inequality in this study because it is another aspect that current policies were intended to solve over the last two decades.

For these reasons, the EDI was divided into five grades based on “the interim measures for supervision and evaluation of equitable development of compulsory education at the county level” published by Ministry of Education of the People’s Republic of China [45]. The grades of the EDI and evaluation are shown in Table 3.

Table 3. The categories and evaluation of EDI.

| Threshold  | Grade    | Evaluation                        |
|------------|----------|-----------------------------------|
| >1         | Ultra-high | Ultra-high-quality inequality     |
| 0.80–1     | High     | High-quality equality             |
| 0.40–0.799 | Medium   | Medium-quality equality           |
| 0–0.399    | Low      | Low-quality equality              |
| <0         | Ultra-low | Ultra-low-quality inequality      |

5. Results and Analysis

To ensure the integrity and uniformity of data, this study analyzed changes in the EDI of basic education, in Gansu Province, from 2013 to 2018. The reason for doing research in this period is that it is both the key stage of achieving the goal of “National medium- and long-term education reform and development plan (2010–2020)” [28] and the beginning of basic education development transforms from basic equality to equitable quality in China.

5.1. Provincial Level

From 2013 to 2018, the EDI increased from −0.373 to 0.240 in primary schools, and from 0.576 to 0.670 in senior high schools, but it decreased from −0.158 to −0.289 in junior high schools. These EDI values show that the quality of primary schools, junior high schools, and senior high schools, in Gansu Province, belong to the levels of low-, medium-quality equality, and the level of ultra-low-quality inequality, respectively. Both primary
and junior high schools ranked the lowest among the 31 provinces in the mainland of China, while senior high schools ranked 27th in 2018. The differences in the EDIs among primary, junior high, and senior high schools is also obvious, indicating that, although the policy objectives of basic education development were well achieved in Gansu Province in the five years prior to 2018, the overall level of development is still low.

5.1.1. Typical Small-Size Education

According to the calculation, the normal value of both the school district population index ($S_p$) and the average school size index ($S_s$) should be in the range of 0–1. However, neither the primary nor the junior high schools in Gansu Province had reached the lower limit of this normal interval, although they were closer in 2018 than in 2013. By contrast, the senior high school moved from the lower limit to the center of the normal value interval, indicating that the distribution of basic education schools was more suitable for meeting the needs of the population distribution. However, the small-size characteristic of basic education in Gansu Province is very typical.

(a) The school district population of both primary and junior high schools was always less than its lower limit, although it increased in the past five years. Senior high schools achieved the normal range of the EDI value but Gansu Province is consistently one of the few provinces with a small value on this index.

(b) Average school size increased in primary schools but decreased in both junior and senior high schools. Although the index achieved its normal threshold in primary schools, junior high schools, and senior high schools, it is always near its lower limit in the primary and junior high schools.

Undoubtedly, small education size was affected by both the policy of “enrollment in the nearest schools” implemented in China and the great disparities in population density in Gansu Province. The statistical data showed that the number of schools, in primary, junior, and senior high schools, reduced at different degrees from 2013 to 2018. Thus, it is unlikely to enlarge school size or school district population by school district consolidation, continually, as has been done in the past decades, especially in remote and mountainous rural areas. Changes in the average school size of primary, and junior high schools reflected the reduction in school-age children. Demographics show that this is caused by a declining fertility rate and its bottom-up effect. Therefore, small school sizes are an unalterable trend in basic education in Gansu Province. Existing research and investigations proved that this will affect the costs [46], performance [47], and quality [48,49] of schools, and hence, is not conducive to the achievement of equitable quality basic education in Gansu Province.

5.1.2. Weaknesses in Resources Allocation

Table 4 shows the remarkable progress in resource allocation ($E_{resource}$), as well as its two components, i.e., teachers ($T$) and funds ($E_f$), between 2013 and 2018. The student-teacher ratio index ($t$) increased from 1.170 to 1.345 in primary schools, from 0.813 to 1.055 in junior high schools, and from 0.745 to 1.002 in senior high schools in Gansu Province. These values in 2018 were greater than the national average and greater than 1, indicating that the policy objective of student-teacher ratio has been well achieved. In other words, the total number of teachers was relatively sufficient compared to the objective determined by current policy. The index of per-student educational appropriations ($E_f$) increased, obviously, and was greater than the national average, ranking in the top ten percent. These findings indicate that Gansu governments have made a great effort to improve school conditions in the past five years.

However, the inner components of both index ($T$) and ($E_f$) demonstrated less optimistic trend:

(a) The proportion of teachers with the required academic qualifications and above in primary schools and senior high schools consistently ranked in the lowest 10 percent among the 31 Chinese provinces. In junior high schools, it ranked 19th in 2013 and 20th in 2018. This was 5–15% below the target value of 100%.
(b) The actual amount of per-student educational appropriations at the three school levels was less than the national average and that of other provinces in Northwest China, such as Qinghai, Ningxia, Shanxi, and Xinjiang. It was only about 40–60% of that in many eastern provinces. This disparity reveals that the underdeveloped economy in Gansu Province has significantly restricted educational investment.

Table 4. Resource allocation indices and the rank of Gansu Province, 2013–2018.

| Indices | Primary School | Junior High School | Senior High School |
|---------|----------------|--------------------|--------------------|
|         | 2013 | 2018 | 2013 | 2018 | 2013 | 2018 |
| \( T \) | The national | 0.990 | 1.080 | 0.792 | 0.910 | 0.809 | 0.939 |
| Gansu Province | 1.170 | 1.345 | 0.813 | 1.055 | 0.745 | 1.002 |
| Rank | 10 | 6 | 18 | 11 | 23 | 12 |
| \( E_f \) | The national | 0.158 | 0.160 | 0.212 | 0.230 | 0.193 | 0.227 |
| Gansu Province | 0.252 | 0.352 | 0.305 | 0.417 | 0.298 | 0.375 |
| Rank | 4 | 2 | 4 | 3 | 6 | 3 |
| \( E_{\text{resource}} \) | The national | 0.574 | 0.620 | 0.502 | 0.570 | 0.501 | 0.583 |
| Gansu Province | 0.711 | 0.849 | 0.599 | 0.736 | 0.521 | 0.689 |
| Rank | 9 | 4 | 13 | 7 | 15 | 8 |

5.1.3. Increase in Inequality of Urban-Rural Areas

Figure 2 presents the index value of urban-rural equality \( (E_{\text{equality}}) \) and its rank at the provincial level. It shows that Gansu Province ranked lower than most of the 31 Chinese provinces in 2013 and 2017. This indicates that Gansu Province has a greater inequality between urban and rural areas than other provinces. The index for rural-urban equality in senior high schools increased from 0.945 to 0.953, but decreased from 0.893 to 0.816 in junior high schools, and decreased from 0.810 to 0.686 in primary schools. In general, this means an increase in urban-rural inequality.

![Figure 2](image-url)
As the most important index of educational quality, the proportion of teachers with the required academic qualifications and above ($t_p$) in Gansu Province was behind most other provinces, and there was a large gap between urban and rural areas. In 2017, the proportion of primary school teachers with college degrees and above in urban areas was 8.34% higher than that of rural areas. The proportion of junior and senior high school teachers, with bachelor’s degrees and above, in urban areas was also 3.59% and 2.59% higher, respectively, than that of rural areas. The differences in teacher allocation, together with the inequality in educational facilities and investment, enhanced the attraction of urban schools, which further enlarged the gap in basic education between urban and rural areas.

5.2. Prefecture Level

There are three reasons for resetting the threshold of policy objectives and the research stage at prefecture and county levels:

(a) Education size, established by Gansu Provincial policies, is much smaller than the national average. Thus, the policy objective of educational size is reset according to “Basic standards for running schools of compulsory education in Gansu Province (trial)” [59], issued by the Educational Department of Gansu Province in 2012. In this standard, the threshold of the school district population is 5000–20,000 in primary schools and 15,000–30,000 in junior high schools. The threshold of average school size is 240–960 students in primary schools and 900–1500 students in junior high schools.

(b) Statistical data obtained from the local government do not distinguish junior high schools and senior high schools. Thus, educational levels can only be divided into primary schools and secondary schools.

(c) The proportion of teachers with the required academic qualifications and above ($t_p$) is only available for 2016–2018. Thus, the EDI can only be calculated for these three years.

Figure 3 shows the distribution of the EDI in 14 prefectures of Gansu Province. The deeper the red color, the higher the development level, while the deeper the blue color, the lower the development level. It shows that the EDIs increased significantly in most prefectures. This means that basic education in the province underwent obvious development from 2016 to 2018, especially in the remote mountainous prefectures. It also shows that overall development in the eastern areas is lower than that of the northwestern areas of Gansu Province. At both primary and secondary school levels, there is a belt area in the east-central region of the province, consisting of a few prefectures whose EDIs are less than 0 in both 2016 and 2018, revealing that spatial inequality remains at the prefecture level and even increases with inequal investment.

5.2.1. Differences in Education Size

As shown in Table 5, the three prefectures with ultra-low-quality inequality (EDI < 0) have small education sizes. The school district population is less than the lower limit preset by the policies ($S_p < 0$). Only two cities belong to, or are near to, the high-quality level of equality based on the EDIs, i.e., Jinchang (0.83) and Jiayuguan (0.79). In these two cities, the average school size in primary schools is larger than the upper limit of the policy objective ($S_s > 1$). This shows that both small and large schools exist at the prefecture level. Small schools are mainly in remote and mountainous areas, such as Qingyang, Pingliang, and Longnan cities, while the large schools are in the central cities with greater urbanization rates, such as Jiayuguan and Jinchang cities. Other prefectures with EDIs in the medium or low equality range usually have a moderate school district population and moderate school size. Therefore, in current policy, education size is probably the most major factor that affects the development of equitable equality basic education because resources in basic education are allocated mainly according to the number of students in schools.
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Table 5. Scores of $E_{DI}$ and its components in the 14 prefectures of Gansu Province in 2018.

| Prefectures       | $S_p$ | $S_s$ | $t_p$ | $E_f$ | $E_{equality}$ | $E_{DI}$ | $S_p$ | $S_s$ | $t_p$ | $E_f$ | $E_{equality}$ | $E_{DI}$ |
|-------------------|-------|-------|-------|-------|----------------|---------|-------|-------|-------|-------|----------------|---------|
| Jinchang          | 0.92  | 1.08  | 0.99  | 0.22  | 0.73           | 0.83    | 0.56  | 0.74  | 0.92  | 0.23  | 1.00           | 0.74    |
| Linxia Hui        | −0.16 | 0.04  | 0.94  | 0.75  | 0.80           | −0.36   | 0.36  | 0.47  | 0.83  | 1.03  | 0.94           | 0.72    |
| Jiayuguan         | 0.72  | 1.12  | 0.99  | 0.09  | 1.00           | 0.79    | 0.53  | 0.81  | 0.96  | 1.14  | 1.00           | 0.72    |
| Gannan Tibetan    | −0.02 | 0.24  | 0.96  | 0.77  | 0.83           | 0.48    | 0.12  | 0.55  | 0.81  | 0.76  | 0.85           | 0.62    |
| Jiuan             | 0.26  | 0.35  | 0.98  | 0.25  | 0.94           | 0.62    | 0.34  | 0.46  | 0.86  | 0.27  | 0.93           | 0.61    |
| Zhangye           | 0.07  | 0.19  | 0.96  | 0.41  | 0.86           | 0.47    | 0.21  | 0.31  | 0.91  | 0.39  | 0.91           | 0.55    |
| Lanzhou           | 0.15  | 0.27  | 0.97  | 0.20  | 0.62           | 0.45    | 0.22  | 0.23  | 0.92  | 0.26  | 0.83           | 0.49    |
| Tianshui          | 0.04  | 0.26  | 0.94  | 0.51  | 0.92           | 0.50    | −0.12 | 0.26  | 0.82  | 0.61  | 0.98           | 0.37    |
| Qingyang          | −0.13 | 0.03  | 0.90  | 0.33  | 0.81           | −0.32   | −0.09 | 0.22  | 0.78  | 0.41  | 0.95           | 0.34    |
| Pingliang          | −0.15 | −0.07 | 0.93  | 0.61  | 0.82           | −0.45   | −0.13 | 0.18  | 0.88  | 0.65  | 0.78           | 0.25    |
| Wuwei             | 0.05  | 0.11  | 0.94  | 0.51  | 0.79           | 0.40    | −0.07 | 0.10  | 0.87  | 0.54  | 0.89           | 0.22    |
| Baiyin            | −0.02 | 0.08  | 0.94  | 0.41  | 0.79           | 0.29    | −0.19 | 0.04  | 0.87  | 0.46  | 0.88           | −0.39   |
| Longnan           | 0.03  | 0.29  | 0.92  | 0.68  | 0.90           | 0.51    | −0.24 | 0.05  | 0.79  | 0.76  | 0.88           | −0.40   |
| Dingxi            | −0.04 | 0.07  | 0.92  | 0.90  | 0.89           | 0.24    | −0.27 | −0.02 | 0.86  | 0.98  | 0.85           | −0.50   |

Figure 3. The distribution of EDIs at the prefecture level in 2016 and 2018.
5.2.2. Resource Allocation and Spatial Equality

To improve equality and the quality of basic education, a program [60] for comprehensively improving the conditions of compulsory education schools has been implemented in Gansu Province since 2014. This has increased the government’s investment greatly in the past few years, especially in the poverty-stricken prefectures, such as Linxia Hui Autonomous Prefecture, Gannan Tibetan Autonomous Prefecture, Dingxi, and Longnan cities. The index of per-student educational appropriations ($E_f$) has greatly increased in these prefectures, and is even larger than 1 in secondary schools in Linxia Hui Autonomous Prefecture. In Dingxi City, famous for “being arduous”, the index is also near to 1. This indicates that per-student educational appropriations are close to, or larger than, the per-capita GDP of these prefectures. In terms of government expenditures, the proportion of total financial expenditures on education in the total financial expenditure reached 15.72% in Gansu Province and was even higher than 20%, in some poor prefectures, in 2018. As the international common index of measuring education investment, the proportion of educational expenditure to GDP was consistently higher than China’s current standard (4%) for many years in Gansu Province. It reached 7.86% in 2018, which is about 3.6% greater than the national average (4.22%). This shows that governments in Gansu Province have made great efforts to invest in basic education.

At the same time, as an important index of educational quality, the proportion of teachers with the required academic qualifications and above ($t_p$) sharply increased in poor areas, remote mountainous areas, and autonomous prefectures of ethnic minorities in recent years. Therefore, the increase in the standard deviation of resource allocation index ($E_{resource}$) does not means that spatial inequality among the prefectures has increased. The effect of improving resource allocation should be reflected in the coming years.

5.2.3. Urban-Rural Equality

Urban-rural equality is an essential objective for achieving equality and equality in basic education. In theory, the closer the equality index ($E_{equality}$) is to 1, the more equitable the development situation. Figure 4 shows the changes in the urban-rural equality index ($E_{equality}$), in 14 prefectures, from 2016 to 2018. The short black lines represent increases or decreases in the urban-rural equality index in 2018 compared to that in 2016. When it is above the histogram, it indicates an increase in the rural-urban equality index, and when it covers the histogram, it indicates a decrease. The length of the short black line indicates the magnitude of the changes. According to Figure 4, the urban-rural equality index has changed differently in the 14 prefectures. In primary schools, the index increased in seven prefectures but decreased in the other seven prefectures. The most significant increases were seen in Jinchang, Tianshui, and Zhangye cities, but the most significant decreases were seen in Dingxi City. In secondary schools, the index increased in six prefectures but decreased in seven prefectures. The most significant increases were seen in Lanzhou, Wuwei, and Qingyang cities, but the most significant decreases were seen in Linxia Hui Autonomous Prefecture. The change was mainly due to the differences of the proportion of teachers with the required qualifications, and above, in urban and rural areas. Inequality also exists among primary and secondary schools in the same prefecture. The largest inequality among urban and rural areas is in primary schools in Lanzhou City. The most significant inequality between primary and secondary schools is in six prefectures: Lanzhou, Jinchang, Baiyin, Wuwei, Qingyang cities, as well as Linxia Hui Autonomous Prefecture.
Secondary schools in 2018

Figure 4. The changes of urban-rural equality index in 14 prefectures from 2016 to 2018.

5.3. County Level

A county is a basic unit of management, and the budgeting of funds, for basic education in China. Thus, it is a base spatial unit for realizing equitable quality development. To strengthen the development capacity of basic education in counties, China has implemented an assessment and accreditation policy [45] since 2012. The purpose of this policy is to improve the resource allocation and decrease inter-school differences through evaluation and assessment. Whether a county has realized equitable development is assessed by the achievement of policy objectives in eight aspects: per-student campus area, per-student teaching facilities, per-student stadium area, the number of computers per hundred students, the number of books per student, student-teacher ratios, the proportion of teachers with the required academic qualifications, and the proportion of teachers with an intermediate technical position and above. Each year, the Ministry of Education in China issues the scores of counties that have achieved equitable development. It includes these eight aspects, and an inter-school difference coefficient, of each county. In Gansu Province, 70 out of 86 counties passed this assessment between 2014 and 2018. Hence, the inter-school difference coefficient, in this assessment, is used as the index of inequality at the county level.

Figure 5 shows the spatial distribution of the EDI in the counties of Gansu Province. Blue, yellow, orange, and red represent counties that fall into different categories, as shown in the legend in Figure 5. However, the colorless areas are counties that have not been assessed because some of the assessment indices have not been achieved. The EDIs in 70 counties, that passed national assessment, showing that the development of basic education at the county level is generally lower than that of the prefecture and provincial levels. Moreover, the difference among counties is obvious, as is the difference between primary and secondary schools. As far as primary schools are concerned, 3, 31, and 5 counties fall into the categories of high-, medium-, and low-quality equality, respectively, representing only 55.7% of the 70 counties that have passed the assessment of equitable development. In secondary schools, only 1, 23, and 16 counties fall into the categories of high-, medium-, and low-quality equality, representing 57.1% of the 70 counties. The EDI revealed that more than 40% of counties fall into the category of ultra-low-quality inequality. The three dimensions are described in the following subsections.
The achievement rate of the policy objectives at county level in 2013 and 2018.

Table 6. The achievement rate of the policy objectives at county level in 2013 and 2018.

| Education Levels | Year | Student-Teacher Ratios | School District Population /× 10,000 People | Average School Size /Number of Students | Achievement Rate of the Inter-School Difference Coefficient in the 70 Counties |
|------------------|------|------------------------|-------------------------------------------|----------------------------------------|---------------------------------------------------------------------|
| Primary schools  | 2013 | ≤ 19                   | <0.5                                      | ≥ 2                                    | 240 – 960 ≥ 960 ≤ 0.5                                               |
|                  |      | Number of counties     | 82                                        | 64                                     | 0                      | 55 31 0  0                                                             |
|                  |      | Proportion              | 94.25                                     | 73.66                                  | 0.00                   | 63.22 35.63 0.00                                                      |
|                  | 2018 | Number of Counties     | 84                                        | 65                                     | 0                      | 22 61 3 41                                                           |
|                  |      | Proportion              | 96.55                                     | 74.71                                  | 0.00                   | 25.58 70.93 3.49                                                      |
| Secondary schools| 2013 | ≤ 13                   | ≤ 1.5                                     | >3                                     | <600 600 – 1500 >1500  | ≤ 0.45                                                              |
|                  |      | Number of counties     | 42                                        | 57                                     | 1                      | 12 69 5 5                                                        |
|                  |      | Proportion              | 48.83                                     | 66.28                                  | 1.16                   | 13.95 80.23 5.81                                                      |
|                  | 2018 | Number of counties     | 86                                        | 57                                     | 3                      | 21 61 4 25                                                          |
|                  |      | Proportion              | 98.85                                     | 65.52                                  | 3.45                   | 24.42 70.93 4.65                                                      |

5.3.1. Education Size

Both the school district population index and average school size index were closer to, or within, the normal interval of 0–1 in most counties in 2018 than in 2013. The correlation between the average school size and the school district population increased significantly. The correlation coefficient of two indices increased from 0.387 to 0.886 in primary schools, and it increased from 0.816 to 0.863 in secondary schools. This change indicates that the spatial distribution of schools is more suitable for meeting the needs of the population distribution. The problem of large schools in both the primary and secondary schools was partially controlled, which is more conducive to achieving equitable quality basic education.

5.3.2. Generally Low-Level of Development

Table 6 presents results regarding the achievement of three major policy objectives in all the 86 counties in Gansu Province. It shows that teacher allocation improved, obviously, from 2013 to 2018, especially in secondary schools. By 2018, almost all counties had met the policy objective of student-teacher ratios, 19 in primary schools and 13 in secondary schools. The proportion of counties with a school district population less than 5000 people decreased by 38%.
However, the proportion of counties with an average secondary school size less than 600 students increased by 11%. A total of 70 out of 86 counties (81.4%) passed the national assessment of basically equitable development, but only 58.57% of these 70 counties achieved the policy objective of inter-school difference coefficient lesser than 0.5 in primary schools. Only 35.71% of these 70 counties achieved the objective of having an inter-school difference coefficient of 0.45 or lower in secondary schools. The raw data shows that meeting these objectives was constrained by many factors, such as limited per-student stadium areas, the proportion of teachers with the required academic qualification and above, and the proportion of teachers with intermediate technical positions and above. This means that small schools, and the lack of well-trained teachers, are the key constrictions on equitable and quality development of basic education.

6. Validation: Comparison with Educational Competitiveness

To validate this evaluation, the results were compared with the educational competitiveness scores issued in “The Blue Book of China’s Provincial Competitiveness” [61] and “The Blue Book of Gansu” [62] in 2018. The two books are used to evaluate the competitiveness of provinces and counties, respectively, based on, at least, nine aspects. The results in the first book show that the educational competitiveness score of Gansu Province was 29.9 in 2017, placing it at “medium level of competitiveness” in 31 provinces in China. However, the results in the second book show that the science educational competitiveness score attained by 77 counties was 67.28 in 2017, placing them at the level of “general disadvantage”.

These are consistent with the result that Gansu Province, and most of its prefectures and counties are at medium- or low-quality levels of equality obtained in this study, which supports the rationality of the analysis in our study. The slight difference should be due to the differences in the indices that we used. In our study, all indices were chosen from policy documents and normalized with the thresholds established by current policies. Therefore, the index system designed in our study is closer to the national assessment requirements.

7. Discussion and Conclusions

This study aimed to systematically analyze basic education in Gansu Province to determine whether its development between 2013 and 2018 met the requirements of equality and quality established by China’s current educational policies. Education size, resource allocation, educational equality, and educational development index (EDI) scores for 2013–2018 were analyzed at three spatial scales: province, prefecture, and county.

Some useful conclusions and suggestions, regarding the equality and quality of basic education in Gansu Province, are as follows.

First, significant improvements have been made in the normalizing of education size. The degree of correlation between school size and school district population increased significantly at each of the three spatial scales and increased gradually from province to prefecture and county. These trends indicate that the distribution of basic education schools is more suitable for meeting the needs of the population distribution, which is helpful for promoting both opportunity and spatial equality of basic education [1,3,16,19]. In fact, the level that school distribution, suited to population distribution, should be higher than what was calculated in this study. To ensure every child has access to an equitable and quality basic education, many small schools, with less than 100 students, are retained in remote mountainous rural areas [37]. However, this study measured achievements in education size using the average values of school size and school district population. Thus, this study can reflect the overall status of the region but not reveal the contribution of these small schools for meeting the needs of the population distribution. Prefectures and counties fall into the level of ultra-low-quality inequality just because they have more small schools than others, which would affect the costs, quality, and performance [46–49] of basic education in these prefectures and counties.
Second, resource allocation, as represented by teachers and educational funds, has improved greatly, leading to better education conditions for the development of equitable quality basic education. The results reveal that objectives regarding student-teacher ratios and proportions of educational funds have been achieved, but the objective regarding teachers’ educational qualifications has not. This finding reflects both the great efforts that were made by local governments [19,38,63] and the restrictions placed on education investment by economic development [4,7,10,26]. Although teachers [1,24,51–53] and funds [10,27,64,65] are the major components of educational resources, the analysis of resource allocation, in this study, may be unable to capture all the progress and weakness because educational facilities data were unavailable. Equitable development assessment data [45], used at the county level in this study, provides more evidence for the weakness of education resources [10,26,29]. Thus, continued investment in basic education is very important [27] in this province.

Third, the results of urban-rural inequality, inter-school inequality, and the gap between primary and secondary schools indicate that the objective of equality has not been achieved to an expected level in Gansu Province. It is reasonable to question the reliability of urban-rural inequality, and the gap between primary and secondary schools, because they were analyzed only using urban-rural difference in teacher allocation in this study. Equitable development assessment data that was issued by the National Ministry of Education [45] provided ample evidence of the inter-school inequality in source allocation at the county level, which may be the underlying cause of education inequality [2,4,8,65]. However, data unavailability of funding and education facilities restricted this study from revealing detailed differences among prefectures, counties, and urban and rural areas.

Finally, based on the above three dimensions, the EDI scores reveal that the development of basic education, in most prefectures and counties, are at medium- or low-quality levels of equality, with remote mountainous prefectures and counties even falling into the ultra-low-quality category of inequality. These findings indicate that, although some policy objectives have been achieved, the overall development level of basic education in Gansu Province is still low, as indicated by education competitiveness of the province and its counties [61,62]. The main restrictive factors are the quality of teachers, educational inequality, and deficiency in educational investments. To achieve the equitable quality basic education, these issues should be addressed [1,8,24,51] in Gansu Province. Certainly, this study has three limitations that need further exploration. First, the concept of equitable quality education was narrowed. To keep the analysis in line with the government’s expectations and requirements for basic education in China, the policy objectives were assumed as equitable quality education. This policy-centered approach narrows equitable quality education into a scope that current policies could have foreseen and cannot represent its full meanings [1–3]. Thus, with the reforming of policy objectives, and the changing of national and local environments [26,38], long-term dynamic analysis of the achievement toward equitable quality basic education will be needed. Second, the indices used may be enriched in future. Limited by the existing statistical data, educational equality and quality was measured only by teacher allocation on average. More indices that are thought to have effects on educational equality and quality were not measured, such as teachers’ professional structure [7,28], teacher’s experience [52,53], educational infrastructures [10], and so on. Therefore, additional research will have to enrich the indices using big data and survey data. Third, the applicability of the approach needs to be explored. The work in this study uses the policies and criteria of China [41–45], the research can guide the basic education of this country, but whether it can be used in other countries needs further investigation.

For achieving equitable quality development, rather than just reducing spatial inequality or meeting the policy objectives, some policy suggestions are as follows. First, decreases in the number and size of small schools in rural areas and the increase in demand for urban education will continue, along with the population urbanization. Therefore, improving educational quality and personalized development [1,2,21,24] in small schools, while simultaneously optimizing the distribution of urban schools, should be the primary goal in
the future. Second, well-trained teachers [1,2,50–53] and education funds are needed in Gansu Province, and resource allocation should give more attention to schools, especially to small schools [37,66], in rural areas. Third, some training or communication programs for teachers, principals, and administrators should be offered to improve educational quality in rural schools. Finally, some training programs for students’ parents [1,4,6,17,18] should also be provided to improve their ability to participate in their children’s education and decrease the number of families who blindly follow the phenomenon of school choice.

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