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The Forecast of Demand and Shortage of China 2015-2025 Primary School Science Teachers

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Abstract
This paper establishes mathematical models of the demands of primary school science teachers, and based on the data of the sixth census, predicts the demands and shortage of China 2015-2025 urban-rural primary school science teachers. For the current stock of primary school science teachers the paper proposes many measures to solve the problem of teacher shortage: Continue to set science classes on primary school grade 1 by phases; increase college and university science education major enrollment targets; broaden college and university specialized science major learning fields; carry out teacher training and position transfer.

Key word: Primary school science; Teacher; Demand; Gap; Forecast

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INTRODUCTION
At present, science and technology play an important role in social development. Countries around the world have stepped up to strengthen science education. *Popularize Science –The USA 2061 Plan* stated that "in the next stage of human development, the human living environment and living conditions will change rapidly. Science, mathematics and technology will be the center of changes. They cause changes, shape changes and react to changes. Therefore, science, mathematics and technology will become the foundation to teach children to face the world in the future." (Liao, 2013, p.3) In 2006, China promulgated the *National Scientific Quality Action Plan (2006-2010-2020)*, which pointed out the important role of school science education, stressed the need to strengthen the construction of teacher group, and to develop a qualified teacher group with rational structures, high-qualities and capabilities for all kinds of scientific education and trainings. The forthcoming *Primary School Science Curriculum Standards (Revised)* stipulates to broaden science courses at primary school from grades 3-6 to grades 1-6 (Liu, 2013). This change will inevitably lead to the increased demands and increased shortage of China primary school science teachers. Thus, in the next decade how much is the demands and gap of China primary school science teachers? How will the authorities and teachers colleges to solve the problem? Thoughts on the above problem are the motivation of this study.

1. MATHEMATICAL MODEL OF THE DEMANDS AND SHORTAGE OF CHINA PRIMARY SCHOOL SCIENCE TEACHERS
The demands for teachers in various subjects are influenced by school-age population, weekly teaching hours, teachers' weekly workload, class size and other factors. According to the relationship between these factors we can establish the following mathematical models to calculate the demands for teachers in various subjects:

$$T_n = \sum_{i=a}^{b} \frac{R_n i * P_n * Z_n}{B_n * G_n}.$$

In the formula: T_n is the demand of teachers in the n-year; $R_n i$ is the school age population (a to b years old) in the n-year; P_n is the enrollment rate of schooling-age population in the n-year; Z_n is the weekly teaching hours in the n-year; B_n is the class size in the n-year; G_n is the teachers' weekly workload in the n-year.

Mathematical model to calculate the shortage of teachers:

$$T''_n = T_n - T'_n.$$

In the formula: T_n'' is the shortage of teachers in the n-year; T_n is the demand of teachers in the n-year; Tn' is the actual teacher number in the n-year.

2. THE VALUE OF EACH FACTOR

2.1 The Number of School-Age Population

People's Republic of China Compulsory Education Law stipulates that: "For each child who has reached six years old, their parents or other legal guardians should send them to school for compulsory education; for children in the areas where the conditions cannot be met, they may be postponed to enter school until seven years old." In reality the school ages of Chinese primary school students differentiate, but since setting the primary school enrollment age as 6 years old does not have much impact on the predicted result of school age population, this study sets the primary school enrollment age as 6 years old, and the school-age population as the 6-11 year old population. This study has adopted CPPS, the Chinese population prediction software developed by The State Family Planning Commission Department of Planning and Finance China Population Information Research Center to conduct population prediction. The software is characterized by easy-to-use, modularity, flexibility, and high quality prediction, etc.. It can not only conduct population prediction according to given parameters of different needs, but also carry out policy analysis and simulation experiments (Liu & Huang, 2011). The model requires to set value on age and sex-disaggregated population, age and gender-disaggregated mortality, birth rate of women at childbearing age, urbanization rate, population mobility rate and other parameters. Take the age and gender-disaggregated population by the *China Sixth Census Data* as the prediction basis; take the age and gender-disaggregated mortality by the *China Sixth Census Data* as the morality; take the age-disaggregated birth rate of the national women at childbearing age by the *China Sixth Census Data* as the birth rate. The United Nations set China's total fertility rate to be between 1.83-1.86 in 2003, and the State Family Planning Commission announced in 2010 the total fertility rate was about 1.80 (Census Office under the State Council, 2012). All factors considered, this study sets the base period total fertility rate to be 1.8, and the urban and rural fertility rates to be 1.6 and 2.0 respectively; some forecasting studies show that from 2009 to 2020, China's urbanization rate will have an average increase of 1.03% annually (Shi, 2004). This study adopts this increase rate. According to the educational statistics released by the Ministry of Education, we can draw the analysis that in 2011 and 2012, children of migrant workers accounted for 9.8% and 10.4% respectively of the total school-age population (China Education Yearbook Editorial Department, 2013). Considering all the factors of social development, this study suggests that the proportion of Chinese migrant workers' children will remain at 11.0% in 2015-2025. We can draw China 2015-2025 school-age populations in the following table:

Table 1
China 2015-2025 School-Age Population (Unit: people)

Year	Total	Urban	Rural
2015	93,594,454	58347,423	35,247,031
2016	95,891,993	59,779,479	36,112,514
2017	95,848,140	59,079,407	35,689,415
2018	95,848,139	59752,145	36,095,994
2019	96,546,591	60,187,490	36,359,101
2020	97,229,531	60,613,167	36,616,364
2021	97,421,144	60,732,599	36,688,545
2022	97,347,158	60,686,484	36,660,674
2023	98,926,125	61,670,653	37,255,471
2024	97,981,485	61,081,859	36,899,625
2025	96,458,670	60,132,682	36,325,977

2.2 The Enrollment Rate of School-Age Population

As per educational statistics released by Ministry of Education in 2012, primary school enrollment rates from 2008 to 2012 were 99.5%, 99.4%, 99.7%, 99.8%, 99.9% respectively (Ibid.) Considering all the factors, this study suggests that in 2015 to 2025, the Chinese primary school enrollment rate will remain at a high level, with a more reasonable enrollment rate of 99.9% in 2015 to 2025.

2.3 Weekly Class Number

In this study, weekly class number refers to the class number of a subject taught within a week. Class number directly determines the demand for the number of teachers, and the weekly class number is mainly impacted by the importance of the subject. At present, China does not have a clear definition on the weekly class number of primary school science course, but there is a more consistent view on the weekly teaching hours of primary school science course. Based on the consultation to the expert group of *Primary School Science Curriculum Standards*, this study

sets the weekly class number of primary school science course as two.

2.4 Class Size

Class size refers to the number of students in a class. In China, teaching is usually conducted in classes. Class size affects the demand for teachers. The former State Educational Commission has stipulated in the *Primary School Management Procedures* which has been formally implemented on April 1st 1996 that class size should be no more than 45 students. According to the analysis of 2008-2012 educational statistics, Chinese primary school class sizes was at an average of 38 students from 2008 to 2012 (Ibid.). This study suggests that in 2015 to 2025, Chinese class size will stabilize at about 38 students, so sets the class size to be 38 students.

2.5 Teachers' Weekly Workload

At present, China has no state-level regulations on teachers' workload, but educational authorities in provinces and autonomous regions have made their regulations relating to the workload of teachers as needed. Referring to the relevant regulations of Shanxi, Hunan and other provinces and after consultation with experts and some teachers, this study sets the weekly workload of a science teacher as 18 classes.

2.6 The Actual Number of Teachers

According to the educational statistics released by Ministry of Education in 2012, China had a total number of 176,931 primary school science teachers in 2012 (Ibid.). Changes in primary school science teachers are mainly affected by teacher increase and teacher reduction. The reduction is mainly due to retirement, transferring and school inner adjustment, etc., and teacher increase includes hiring of graduates, transferring from other systems and school inner adjustment, etc. As per change data of science teachers from 2008 to 2012, we can draw that China's total number of primary school science teachers has grown stably, with an annual average growth rate of about 2%. It can be estimated that in 2015 the actual number will be about 187,760. From 2015 to 2025, because science course will be taught at grade one in primary schools, Chinese primary school science teachers will have a greater change, which is not suitable for the above calculation method, so this study still uses the number of 187,760 primary school science teachers to calculate the teacher shortage.

3. THE PREDICTED RESULTS

According to the mathematical model established in this study as well as the value of each factor in the model, we can predict the demand and shortage of primary school science teachers in 2015 to 2025. The predicted result is shown in below Table 2:

Table 2
2015-2025 Demand and Shortage of China Science Teachers (Unit: people)

Year	Demand			Shortage
	Total	Urban	Rural	Total
2015	273,668	170,606	103,061	85,907
2016	280,385	174,793	105,592	92,626
2017	277,101	172,746	104,355	89,341
2018	280,257	174,713	105,543	92,497
2019	282,299	175,986	106,313	94,539
2020	284,296	177,231	107,065	96,536
2021	284,857	177,580	107,276	97,097
2022	284,640	177,445	107,194	96,880
2023	289,257	180,323	108,934	101,497
2024	286,495	178,601	107,893	98,735
2025	282,042	175,826	106,216	94,282

According to the above prediction, we can suggest that China in 2015 to 2025:

(a) The demand for primary school science teachers shows a wavy upward trend. The total demand will increase from 273,668 teachers in 2015 to 282,042 teachers in 2025, and in 2016 and 2023, there will be two maximum demands of 289,257 teachers and 280,385 teachers respectively, with growth of 6,717 teachers and 15,589 teachers compared to 2015, at growth rate of 2.45% and 5.69% respectively; urban and rural primary school science teacher demand trends are generally consistent with the national total trend, but due to urbanization and the increase of children of migrant workers, the demand for urban primary school science teachers is slightly larger than the demand for rural primary school science teachers.

(b) The shortage of primary school science teachers is large, and the shortage accounts for 31%-35% of the total demand. The shortage of primary school science teachers also shows a wavy upward trend, which is consistent with the trend in total demand. The reason is mainly because this study takes 187,760 primary school science teachers in 2015 as the calculation basis. In 2015 the shortage is 85,907 teachers, 31.4% of the total demand; in 2023 the shortage will reach the maximum of 101,497 teachers, 35% of the demand for teachers at that year.

4. SCIENCE TEACHER STOCK

The above analysis of teacher shortage is based on the hypothesis that in 2015-2025 teacher supplies will not increase. In fact, in 2015-2025 teacher supplies can be adjusted. Just by increasing the number of newly hired teachers to the number of teacher shortage, we can solve the problem of teacher shortage in that year and afterwards. However, as a group of professionals

specialized in science education and teaching, science teachers have to go through a long period of study and training, and can obtain the qualification only after mastering specified knowledge and skills. At present, the task of training Chinese science teachers has been mainly done by colleges and universities. In 1997 Hunan Huaihua College firstly set "integrated science" major. In 2001 Chongqing Normal University was firstly approved to set the undergraduate major of "science education". In 2003 24 colleges and universities were approved to set the undergraduate major of "science education". In 2004 13 colleges and universities were approved to set the undergraduate major of "science education", and afterwards some colleges have also been granted to enroll students. So far China has more than 60 colleges and universities which have been approved to set the majors of "integrated science" or "scientific education" to cultivate science teachers. However, surveys showed that 9 universities have never enrolled undergraduates majored in science education, and 5 universities have stopped enrollment in 2011 (Liao, 2013, p.246). This study makes statistics on the students who have been majored in "comprehensive science" or "science education" and are about to graduate in 2015 to become science teachers (ie enrolled as undergraduates in 2011 and junior college students in 2012), finding that there were altogether 31 colleges and universities which have set up the undergraduate majors of "comprehensive science" or "science education" in 2011 (or junior college major in 2012), with a total of 1,415 student enrollment; which is generally consistent with the plan announced by the designated platform website of Ministry of Education college enrollment sunshine project that 63 colleges opened the majors of "comprehensive science" or "science education" and cultivated 1,500-2,000 graduates nationwide (Ministry of Education, 2014). However in 2014, China had only 29 colleges planned to recruit a total of 1365 students majored in "integrated science" or "scientific education".

CONCLUSION AND SUGGESTIONS

Thus, China's existing training system of colleges and universities and science teacher stock cannot solve the big problem of elementary school science teacher shortage. In order to change this situation and alleviate the large shortage of China primary school science teachers, we can start from the followings:

a) Carry forward in phases to set science class in primary school grade one, reduce the demand for teachers. Based on the above analysis, if China set science class in primary school grade 1-6 in full scale, it will face the problem of a huge shortage of primary school science teachers. However, if this is to be promoted in phases, to make experiments firstly in the areas where condition permits and then gradually spread, the teacher shortage can be alleviated to some extent.

b) Increase the enrollment plan of science education and science comprehensive majors in colleges, cultivate more science teachers. At present, China has less colleges which have set science education and science comprehensive majors and have less enrollment plans. These also show a shrinking trend, which contradicts the large demand of science teachers in China. Therefore, we need to increase the enrollment plan of science education and science comprehensive majors in colleges and train students by signing "orders".

c) Broaden the learning fields of specialized science majors in teachers college so that the graduates can be competent to teach comprehensive science courses. For those students who have already entered colleges and whose enrollment cannot be reduced because of subject development, they should broaden learning fields during the process of study so as to be competent for integrated science teaching tasks in primary schools.

d) Through a variety of transfer trainings, make teachers of other subjects be competent for science teaching. In the short term, to solve the lack of science teachers and surplus of teachers in other subjects the best way is through a variety of trainings to make teachers of other subject's master scientific knowledge and be capable of primary school integrated science teaching.

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