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Building scientific literacy in China: achievements and prospects

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Scientific literacy is an important part of a population's comprehensive quality. The improvement in citizens' scientific literacy is not only an intrinsic demand in the construction of an innovation-driven country, but also a foundation project to create the innovative environment and to cultivate innovative talents. Citizens' scientific literacy surveys have been carried out in the United States since 1957 [1]. The first survey in China was conducted in 1992, followed by eight consecutive surveys. In 2006, the *Outline of the National Scheme for Scientific Literacy* (2006–2010–2020) was promulgated to guide the construction of citizen scientific literacy. The current essay summarizes main conclusions from the surveys conducted in the past decade. By clarifying the developmental trend of Chinese citizens' scientific literacy, we expect to provide a better understanding of the target in the "Thirteenth Five-Year Plan" period, and offer more information for government decision-making.

1 Improved scientific literacy of Chinese citizen during 2005–2015

According to the most recent data issued by the China Association for Science and Technology in October, 2015, 6.20 % of Chinese citizens demonstrated scientific literacy, with an increase of 4.7 %, comparing with 1.50 % in 2005 (Fig. 1a). This result suggests a significant improvement of the citizens' scientific literacy (Fig. 1a).

2 Variations of citizens' scientific literacy levels in different regions, populations, and genders

Not surprisingly, the citizens' scientific literacy of Shanghai, Beijing, and Tianjin ranked top three in China. The levels of Shanghai and Beijing in 2015 were comparable to that of the United States at the end of the twentieth century (17.3 % in 1999), higher than that of the European Union in 2005 (13.8 %). Meanwhile, the level of citizen scientific literacy in Tianjin in 2015 was similar to that of the United States in 1995 (12.0 %). However, unbalanced development exists within different regions. Besides the provinces mentioned above, four provinces (Jiangsu, Zhejiang, Guangdong, and Shandong) demonstrated a better than average performance in the survey. The levels of citizen scientific literacy in other 13 provinces (including Fujian, Jilin, Anhui, etc., as shown in Fig. S1) were between 5 % and 6.2 %. Meanwhile, 11 provinces were lower than 5 %, some of them even below 2 % (Fig. S1).

We also observed unbalanced development of citizens' scientific literacy among different populations. Those of the leading cadres and civil servants improved from 10.38 % in 2007 to 21.3 % in 2015, ranked top in all of the key populations, maintaining a leading trend of rapid growth. The levels of urban workers improved from 2.97 % in 2007 to 8.2 % in 2015, leading this group to a fast growth channel. The levels of the farming communities improved from 0.97 % in 2007 to 1.7 % in 2015 (Fig. 1b). As viewed from the residence classification, the levels of

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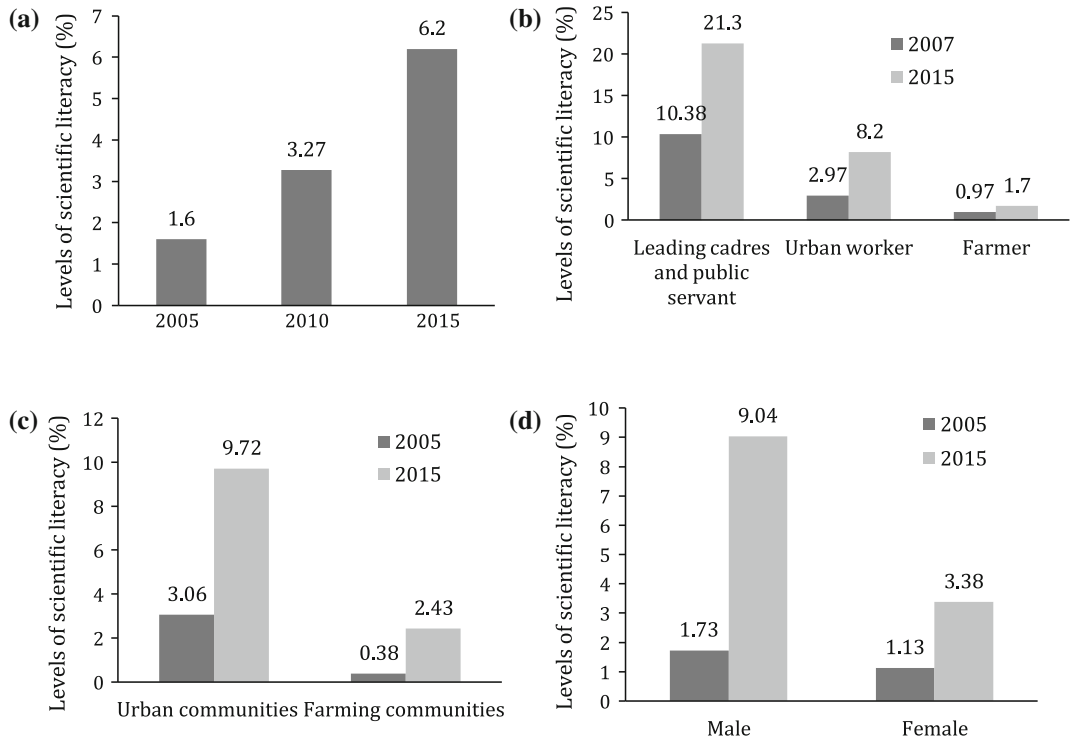

Fig. 1 Improved levels of Chinese citizens' scientific literacy in different years and populations. **a** The overall levels of Chinese citizen scientific literacy in 2005, 2010 and 2015; **b** The levels of citizen scientific literacy for different populations in 2007 and 2015; **c** The levels of urban and rural citizen scientific literacy in 2005 and 2015; **d** The levels of citizen scientific literacy for different genders in 2005 and 2015

the urban residents improved from 3.06 % in 2005, to 9.72 % in 2015 (Fig. 1c). From a gender perspective, the levels of the citizen scientific literacy in males improved from 1.73 % in 2005, to 9.04 % in 2015, and both the amplitude and the rate of growth were significantly higher than those of the female population (Fig. 1d).

While demonstrating a rapid improvement of the citizens' scientific literacy, the above data also reflects great differences existing within the regions, genders, and populations. In particular, the slow improvement of scientific literacy in farmers indicates the necessity to invest more efforts in the future.

3 Significant achievements made in improving citizens' scientific literacy

In 2006, the *Outline of the National Scheme for Scientific Literacy* (2006–2010–2020) was promulgated by the Chinese government in order to comprehensively increase the citizens' scientific literacy, which became an action plan for the Chinese Science Popularization Program. Ten years of implementation made significant achievements.

3.1 Massive themed popular science activities accomplished

To take full advantage of the social publicity platform, the National Science Popularization Day and the Sci-tech (S&T) Week which focuses on the themes of "energy conservation, eco-environment protection, safety-health guarantees, and service innovation" were carried out. Nearly 200 million distinctive S&T activities were conducted across the nation. More than 40,000 key science popularization activities launched for the National Science Popularization Day with over 700 million people participated.

3.2 Significant achievements and rapid improvements in the scientific literacy action

(1) Policies, guidance, and planning documents had been issued to guide and lead the execution of the scientific literacy movement in the key populations. With regards to minority population, the science curriculum standards of compulsory education were revised, and child learning and family education plans were formulated. The *Farmer Scientific Literacy Action*

Plan and the *Decision on Vigorous Development of Vocational Education* were developed for farmers and urban workers, respectively. As for the leading cadres and civil servants, an official document issued requires scientific literacy content to be added to the training, examination, selection, and appointment of involved positions. For community residents, science popularization content was approved to be part of the files, such as the construction of harmonious communities and community service.

(2) Diverse training programs were carried out to enhance the scientific literacy in key populations, including agricultural vocational skill training, entrepreneurship, special technology training, rural labor transfer technology training, worker vocational skill training, with related science and technology training implemented.

(3) Award-subsidy demonstration projects were set up to guarantee the constant improvement of scientific literacy in key populations. Award-subsidy projects, such as the program for "Benefiting Farmers and Revitalizing Countryside by Means of Science Popularization", were created to encourage outstanding science popularization organizations and individuals with awards and subsidies, for further improving the scientific literacy in key populations.

(4) Multiple types of science popularization and S&T competition activities were extensively conducted to improve the scientific literacy in key populations, i.e., "Astronaut Space Science-Popularization Teaching", "Learning by Doing" Projects, and "National Youth S&T Innovation Contest".

(5) The mechanisms and approaches to improve the science literacy of key populations were explored. The activity of a "Science and Technology Museum on Campus" was implemented to explore the science-education combined mechanism of school and out-school programs, as well as in-class and out-of-class programs. An award-subsidy plan was also set up to study the motivation and driving mechanisms for the development of grassroots science popularization programs.

3.3 Steady progress in infrastructure project and significant enhancement of service capacities achieved

(1) The coverage of science popularization and scientific education resources was greatly enlarged. More than 300 types of scientific educational textbooks and multi-ethnic written materials were published. As in 2014, 8,243 types of scientific popularization books were published in China, with a circulation of 88.5998 million copies. Meanwhile, 1,036 scientific popularization journals (with a circulation of 170 million copies), 385 million copies of S&T newspapers and 5,903 types of audio and video science-popularization products were distributed. Furthermore, 223,600 h of science popularization (technology) programs were broadcasted on TV, and 181,100 h of science popularization (technology) programs were aired on radio.

(2) The quantity of the science popularization infrastructure in China grew rapidly. By the end of 2014, there had been 409 S&T museums established in China, of which the construction and exhibition areas increased by 63.8 % and 105.7 % over 2006, respectively. A total of 85,000 stations of science popularization and farmer benefiting service were built across the country, and 1.476 million science popularization activity stations (rooms) opened at the county level.

(3) The capacity of science popularization service increased significantly. From 2011 to 2015, more than 2.5 million "discipline backbone" teachers engaged in scientific education were trained. Moreover, over 800,000 users registered in the Chinese Digital Science and Technology Museum by the end of 2014. These high-quality science popularization resources, 3.5 TB in total, were provided to the public through the network, and were downloaded over one million times.

3.4 The improved supporting conditions were the guarantee of the substantially increased citizens' scientific literacy

(1) The size of the talent working on science popularization was enlarged constantly, and the structure was optimized. As of 2014, the number of science popularization personals in China was 2.0123 million, which exceeded the number in 2006 by 388,800, with an increase of 24 %. The personals with intermediate titles or bachelor degrees and above reached 49.72 % of the total number, which exceeded that of 2006 by 8.52 %.

(2) The expenditure in science popularization continued growing. In 2014, the science popularization fund raised from the whole-society reached 15.003 billion Yuan, with an increase of 10.32 billion Yuan over 2006. In the same year, the national per capita funding for science popularization reached 4.68 Yuan, which increased by 3.50 Yuan compared with that in 2006.

4 The goal of the Chinese citizens' scientific literacy is to reach 10 % by 2020

(1) As viewed from a worldwide perspective, the comprehensive economic and social development level of China has surged to the forefront in regards to human resources and investment in S&T. However, compared with other developed countries, the level of citizens' scientific literacy, as the basis of an innovative human resource, was still low. For example, the level of citizen science literacy in China was only equivalent to that of the United States in late 1980s [2] (Fig. S2). The gap between China and the European Union countries was also large.

(2) Improving the citizens' scientific literacy is the basic requirement of an innovative country. According to the Chinese development strategic plan, China will become an innovative country by 2020. To build an innovation-oriented country, China needs to implement the strategy of innovation-driven development. Structural transformation and economic growth relies on the S&T progress and the improvement of laborer literacy, the foundation and support of which is a general population with basic scientific literacy. Without the general improvement of citizens' scientific literacy, it would be difficult to construct a large high-quality labor force and transfer S&T achievements rapidly into real economic strength [3]. According to the threshold standard of an innovative nation [4], China needs to improve its citizens' scientific literacy level to 10 %. This goal has been the development goal of the *Outline of the National Scheme for Scientific Literacy*, and the 13th Five-Year Plan for Economic and Social Development in China.

Conflict of interest The authors declare that they have no conflict of interest.

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