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RESEARCH

## Innovation Through Education and Research: The Chinese Case

Inovação Através da Educação e Pesquisa: O Caso Chinês

Innovación a Través de la Educación y la Investigación: El Caso Chino

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### How to quote this article:

Sichel DL, Magalhães GRF. Innovation Through Education and Research: The Chinese Case. Rev rop. Intelec. Online. 2019 Mar./Aug.; 2(1):92-97.

### ABSTRACT

The article aims to address the relation between education, research, innovation, and development. The Chinese case will be studied since much of the investment in its national system of education and articulation with the other productive sectors has managed to generate both greater internal and international competitiveness. This work will analyze both Chinese's educational system and Research and Development (R&D) historical evolution, mainly using patent registration and scientific publications numbers as mensurable tools. Finally, this study makes conclusions about the importance of education and research to improve the national innovation system and its consequent development.

**Keywords:** China, innovation, Research and development, Educational system, Intellectual property.

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## RESUMO

O presente artigo busca tratar da relação entre educação, pesquisa, inovação e desenvolvimento. O caso abordado é a China uma vez que grande parte do investimento em seu sistema nacional de educação e articulação com os demais setores produtivos, conseguiu gerar tanto uma maior competitividade interna, como internacional. O trabalho se estrutura na análise da evolução histórica do sistema educacional chinês e de seu setor de P&D, para isso se valendo das patentes e publicações científicas como unidades de mensuração. Por fim, o estudo conclui da importância da educação e da pesquisa para o aperfeiçoamento do sistema nacional de inovação de um país e de seu consequente desenvolvimento.

**Palavras-chave:** China, Inovação, Pesquisa e Desenvolvimento, Propriedade Intelectual, Sistema Educacional.

## RESUMEN

Este artículo busca abordar la relación entre educación, investigación, innovación y desarrollo. El caso abordado es China, ya que gran parte de la inversión en su sistema educativo nacional y la articulación con otros sectores productivos ha logrado generar una mayor competitividad nacional e internacional. El trabajo se estructura en el análisis de la evolución histórica del sistema educativo chino y su sector de Investigación & Desarrollo (I&D), haciendo uso de patentes y publicaciones científicas como unidades de medida. Finalmente, el estudio concluye la importancia de la educación y la investigación para la mejora del sistema nacional de innovación de un país y su consecuente desarrollo.

**Palabras clave:** China, innovación, investigación y desarrollo, propiedad intelectual, sistema educativo.

## INTRODUCTION

With the dawn of the new times, it is clear the role of the evolution of science and new technologies in society for its development in the most diverse sectors. Contemporaneity is constantly demanding changes and new solutions in an increasingly hurried way. In this context, innovation emerges as a fundamental element to meet such needs.

For many scholars, innovation can be thought of as the process of turning an idea or invention into a good or service (INNOVATION, s.d. apud CONSTANTINO *ET AL*; 2018, p. 156). According to Schumpeter, entrepreneurship is an essential tool in society in which value aggregation and the finding of opportunities for profit are used, and therefore, innovation is its core activity (CONSTANTINO *ET AL*; 2018, p. 156).

It can be seen, then, that for a society to develop it is necessary to differentiate itself amid fierce competition between people, companies, and countries. The fact is that we are striding into a period where new forms of production are being organized, the so-called Fourth Industrial Revolution. Along with this, a concept that has been gaining a lot of prominences is the National Innovation System, whose premise emphasizes the need for articulation between the various public and private sectors for the growth of a nation.

It is evident that among these various sectors education stands out as one of the most relevant exponents.

Responsible for the organization and reproduction of the various areas of science and knowledge, it is through educational institutions that knowledge is built, a fundamental tool for innovation. Moreover, it is they who create all the human resources that will leverage the diverse needs of society as a whole, and their integration with the other entities of a country is essential. In short, education is essential for the creation of intangible assets that ultimately become intellectual property.

When we look at emerging countries like Brazil we must have a particular view on the subject. It is the science responsible for the connection of the National System of Innovation, still immature in these types of nation, to international technological and scientific flows, thus allowing an approximation to the accumulated wealth levels of the most developed countries (MOTTA E ALBUQUERQUE; 1998, p. 160). Therefore, the extreme importance of education for the national innovation process is concluded.

A case that exemplifies the report very well is that of China, a country of extreme relevance in the international scenario of innovation and competitiveness. Through a policy of fostering education, the country has been able to create a strong base of intangible assets that can be traced, especially by the high number of patents and scientific publications registered. Not surprisingly, many global players today are trying to understand how the country has achieved such global importance by employing a scholarly effort to analyze the country's various national strategies.

For this reason, the Chinese education system can and should be the target of various analyzes. Considering this perspective, we present a brief account of the historical evolution of the Chinese educational system and its application to scientific and technological discoveries. Sequentially, an analysis is made of recent data from China on the subject, seeking to illustrate and quantify the effects of its policies. Finally, conclusions on the subject are brought to create the appropriate reflections on the relationship between education and innovation.

### The Chinese case

Many Chinese scholars believe that the history of the Chinese educational system can be traced back to the 16<sup>th</sup> century BC, when education was a privilege of the elites and was strongly based on the classical books of Confucianism (CHINA EDUCATION CENTER; 2019). This philosophical system is a cultural mark that continues to this day in virtually every area of Chinese society.

When Deng Xiaoping's reform policy was adopted in 1978 and China opened up to the world, basic education took a turn toward recovery after the serious damage caused by the Cultural Revolution. In 1985 the Communist Party decided to begin a reform of the education system structure, establishing the principle that local governments

were responsible for basic education. This measure would be strengthened by the congressional enactment of China's Compulsory Education Law in 1986, thus creating a legal basis for basic education in the country. From then on, the system of nine years of compulsory education began to this day.

In 1993 the Party established the new guidelines for the development of education in the country, updating them in 1999 for the new century. The assumed strategy was reinvigorating China by science, technology, and education. These measures were accompanied by a growing number of Chinese expatriates to study abroad, as well as a greater reception of exchange students from various countries, aiming at scientific and technical development.

Continuous economic development has fueled educational reform, while the reform itself has stimulated economic development. The objectives of the Chinese education system were clearly and primarily set, with a focus on learning, providing for a multifaceted and diverse curriculum, and preferably investing in young people.

Today we can track the progress of these measures through the series provided by the United Nations Educational, Scientific and Cultural Organization (UNESCO)<sup>1</sup> database and World Bank data<sup>2</sup>. From 2008 to 2017 the gross ratio of pre-primary enrollment increased from almost 50% to 85.96%. In the same period, the ratio of students in secondary and tertiary education, respectively, increased from 79.82% to 95.03% and from 20.67% to 51.01%. From 1985 to 2010, the approximate number of people over the age of 15 with functional illiteracy fell from 220 million to 54 million citizens, an increase from 65% to 95% of the literate population.

Much of this qualification has been used for internal essential activities, promotion of missions abroad, research, search for solutions and innovation in companies and industries. The 2016 National Bureau of Statistics of China Research on Research and Development (R&D) and Patent Activities found that the number of professionals working entirely in the area amounted to 2,702,489, while research spending amounted to about U\$ 15,760,308.00 over 360,997 projects (NATIONAL BUREAU OF STATISTICS OF CHINA; 2017). In the same year the registered number of inventions was 286,987, totaling 769,847 that are being applied. Not coincidentally, China moved from eighth in the world in R&D spending to second in 2015, just behind the US (CHINA POWER, 2016).

Accompanying the process, and based on research by the Chinese statistics office, educational funds rose from approximately U\$ 1,248,551 to over U\$ 52,026,037.00. This culminated in 2016 in 189435 primary schools, 77398

secondary schools, 2596 higher education institutions, 217 research centers and 793 institutions providing postgraduate programs. In higher education there is an average of 1,601,968 full time teachers. There are also 2080 qualified special education schools with 53,213 teachers.

The indices justify a new scenario that is emerging. From a first transition from the agrarian system to manufacturing, China now advances through the scientific field. In research, it is already an imminent risk that China will surpass the United States. With eleven of the top 100 ranked universities in the world, from 2000 to 2016 Chinese scientific publications quadrupled (ORSZAG, 2018). This development goes hand in hand with economic growth and is leveraged by the business initiative that represents 74.1% stake, according to 2015 Organization for Economic Co-operation and Develop (OECD) data (CHINA POWER; 2016). This figure even surpasses the OECD average of 62.2% and the US 64.2%.

This high percentage is largely due to the Party's effort to transfer government research laboratories to state-owned enterprises and to encourage private entities, which have increased their participation by 12% (CHINA POWER, 2016). Higher education institutions alone also contribute to the further development of R&D with a 9.4% share. The challenge is in trying to create a direct channel between universities and companies in this sector, as we can see with the policy of incentives for universities to create and become shareholders of technology companies (BRASIL DEBATE; 2015). For example, University-born Lenovo, which about 42% of the capital, belongs to the Chinese Academy of Sciences, the top-ranked scientific organization ranked first on Nature Index's 2015 list of largest science institutions (O'MEARA; 2016).

In 2006 the Party launched the draft of the *Plano Estratégico Nacional de Médio e Longo Prazo para o Desenvolvimento da Ciência e Tecnologia* (PENCT) [National Medium- and Long-Term Program for Science and Technology Development]. The strategic plan, which covers the period up to 2020, aims at its innovation in areas such as electronics and software, energy exploration, environment, and sustainability. Research priorities were set in three fields: basic research, without specific or immediate application; applied research to solve problems and improve human conditions; and experimental development, the use of the knowledge gained to produce and improve products and processes, that is innovation.

At an international level, China has encouraged its innovation policy not only through academic and professional exchange policies, but also through increased cooperation agreements in science and technology. Accor-

<sup>1</sup> UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION INSTITUTE FOR STATISTICS. *Education and literacy*. Available at: <<http://uis.unesco.org/country/CN>> Accessed on Jun. 14<sup>th</sup>, 2019.

<sup>2</sup> THE WORLD BANK. *Education Statistics*. Available at: <<http://datatopics.worldbank.org/education/>> Accessed on Jun. 14<sup>th</sup>, 2019.

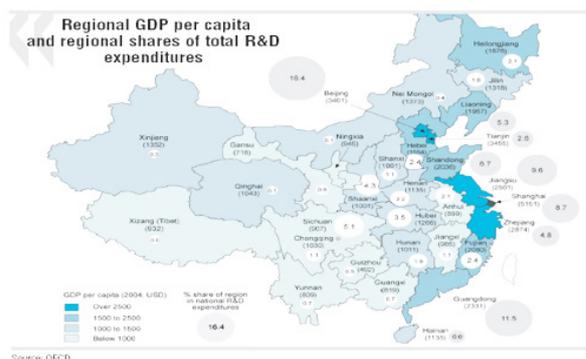
ding to data from the UK embassy in China<sup>3</sup>, there are 135 countries and regions with signed cooperation treaties, as well as agreements with 86 countries in the area of technical and economic cooperation. At the United Nations (UN), it participates in 30 science and technology institutions and, worldwide, 827.

To measure Chinese innovation, one of the best indicators to use is the number of patent filings, as they have strong equivalence to the number of inventions. The US Patent and Trademark Office grants patents worldwide, granting more than 300,000 patents in 2016. From 2000 onwards, the participation of developing countries in this amount increased from 1% to 6%, with China accounting for 4% of the total (WORLD ECONOMIC FORUM; 2018).

The innovation becomes evident as the internet advances in China. The issue goes beyond the limit of mere connectivity, but the functionalities resulting from this insertion, because of the potential that emerges and the breadth of the market to be reached. Digital connectivity, in addition to changing the functioning of markets, contributed to the acceleration of the global development process. In this sense, the use of the world wide web is an indicator to be considered (BARRERA, 2017).



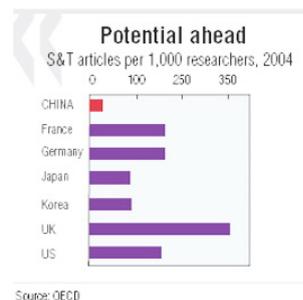
The numbers are impressive for the size they express. Over a 12 years, the number of users has multiplied by 7, highlighting a policy aimed at digital integration as part of an economic development strategy. This tool explains the development of Chinese Gross Domestic Product (GDP) and the investments made in Research and Development (R&D). The choice of strategic regions, aiming to leverage the innovative process. China has had a 19% increase in R&D investments from 1995 to 2005 (OECD, 2007). The map below shows these regions, as well as a comparative table about the people involved with the research.



The transition in the Chinese economic model, with the adoption of more market-oriented policies, ended up creating a favorable environment for the promotion of research and economic and technological development. According to data from the World Intellectual Property Organization (WIPO), China observed the following evolution of requests:

Year	Patent	Trademark	Industrial Design	GDP (Constant 2011 US\$)
2008	204,268	673,522	328,075	10,528.08
2009	241,434	838,071	369,593	11,517.70
2010	308,326	1,113,120	448,121	12,742.74
2011	436,170	1,445,916	563,532	13,957.94
2012	561,408	1,694,024	717,863	15,054.51
2013	734,096	1,940,908	761,027	16,222.39
2014	837,817	2,422,084	673,538	17,406.24
2015	1,010,615	3,100,312	729,551	18,607.31
2016	1,257,409	4,193,624	791,338	19,854.00
2017	1,306,019	6,381,512	857,753	21,223.92

The expressive increase observed in all segments, resulting from the research potential that the table below identifies, makes clear the importance of the Chinese economy in the global market. It is not just a technology importer, but a major player in prospecting for new technologies.



According to reports from the World Intellectual Property Organization<sup>4</sup> (WIPO), China in 2017 was the second largest country with international scientific publications, behind only the United States, reaching 2,444,482 works. Besides, the country has qualified as

<sup>3</sup> EMBASSY OF THE PEOPLE'S REPUBLIC OF CHINA IN THE UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND. *International Science and Technology Exchange and Cooperation*. Available at: <<http://www.chinese-embassy.org.uk/eng/zygx/st/t27120.htm>>. Accessed on Jun. 14<sup>th</sup>, 2019.

<sup>4</sup> BERGQUIST, K; FINK, C; RAFFO, J. *Identifying and ranking the world's largest clusters of inventive activity*. Available at: <<https://www.wipo.int/publications/en/details.jsp?id=4189&plang=EN>>. Accessed on Jun. 14<sup>th</sup> 2019.

the third-largest patent depository through the Patent Cooperation Treaty (PCT) with 305,311 entries.

The report also pointed out that 16 Chinese regions are among the 100 largest science and technology clusters in the world. Still, within more than thirty Chinese clusters, the Shenzhen region of Hong Kong and the capital Beijing ranked respectively as the second and eighth highest levels of global performance for scientific publications and patent filings.

## CONCLUSIONS

It is clear that the exponential increase of Chinese participation in scientific and technological production came from long-term planning that mainly used to foster education and research. Although it alone did not explain the great international phenomenon that has become the country, the fact is that the case draws attention to the need to invest in the educational framework of a country and integrate it with other sectors of society. Through such policies, it is possible to achieve innovation and hence boost the nation's development.

In looking at these facts, Brazil's national innovation strategy can, and should, analyze perceived strengths and try to replicate them in their national context, as well as develop their plans. This requires a strong multidisciplinary study able to identify where to act.

The education system is the main driving force in the development of national knowledge and qualifies as one of the bases of the intangible production process. Through good training, it is possible to allocate knowledge to generate new solutions and technologies that are capable of reducing costs, generating profits and boosting the performance of the most diverse national sectors, in addition to creating exponential international competitiveness.

Ultimately, it is noticeable that creating channels between this knowledge production system and other fields, such as business and government, is a requirement for national development. Therefore, investments in research and innovation should not come in isolation but should seek integration and partnerships with other national agents.

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Received on: 06/2019  
Required Reviews: None  
Approved on: 07/2019  
Published on: 09/2019

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