Higher Education, Science, Technology, and Academics in México: At a Crossroads

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Chapter 20
Higher Education, Science, Technology, and Academics in México: At a Crossroads

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Abstract Mexico's systems of higher education and science, technology, and innovation (STI) are characterized by relatively late development and weak performance within the global context. The federal government has recently sought to strengthen the role of higher education institutions as they have historically been at the center of research and innovation. The efforts made have proceeded despite receiving very few financial resources in a country that allocates expenditure on research and development below 0.5% of gross domestic product (GDP). The goal of this chapter was to analyze elements of the current situation in higher education and science, technology, and innovation in Mexico. We underline the recent developments in the production of Mexican scholars: the advancement of the academic profession, reflected in the increment of scientific productivity. However, despite efforts made to reverse underperformance in research and innovation, Mexican competitiveness and innovation are still ranked in a modest position compared with most of its international peers from the Organisation for Economic Co-operation and Development. We conclude that STI, higher education, and academics work as part of a cross-linking of conditions, characteristic of the crossroads where the country is in relation with international tendencies and social dynamics based on knowledge and innovation.

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Introduction

Mexico's systems of higher education (HE), science, and technology are characterized by their relatively late development and weak performance within the context of the global knowledge and innovation society. Investment in science and technology (S&T) has largely remained fluctuating around 0.4% of GDP for the past two decades. According to the Special Science, Technology, and Innovation Program (PECiTI by its Spanish acronym), despite the low levels of financing, science and technology activities have increased in terms of the number of indexed publications and the number of PhDs awarded in the natural sciences (e.g., healthcare, agricultural sciences, engineering, and technology) and in the social sciences and humanities (Kent, 2014).

In 2019, Mexico had 30,548 scientists affiliated to the National System of Researchers (SNI by its Spanish acronym) (National Council for Science and Technology [CONACYT, for its Spanish acronym], 2019). This membership implies government recognition of people who are dedicated to producing scientific knowledge and technology, for the high quality of their work. The SNI has contributed to research in Mexico that complies with international standards; in this sense, researchers recognized by the SNI have been said to be the "core of scientific research" in the country (CONACYT, 2014). The number of people dedicated to research activities exceeds the number of researchers recognized by the SNI. According to the CONACYT, in 2012, Mexico had a total of 46,066 researchers: 32.3% worked in the industrial sector, 20.6% in the government, 44.4% in higher education institutions (HEIs), and the remaining 2.7% in the private, nonprofit sector. There were 0.9 researchers per 1000 members of the economically active population (EAP) in 2012; this proportion is far below that of developed countries such as Germany (7.9) or the United Kingdom (8.2) and some Latin American countries. It is estimated that Mexico may not achieve the current proportion of researchers in countries such as Argentina or Turkey, which are predicted to have roughly 2.5 researchers per 1000 EAP for another 20 years (CONACYT, 2014). By 2018, the number of researchers per 1000 members of the economically active population (EAP) had decreased to 0.8 (National Autonomous University of México [UNAM, for its Spanish acronym], 2018).

Unlike most developed countries around the globe, Mexican higher education institutions (HEI) and publicly research centers (PRC) are at the heart of national research and development (R&D) in Mexico. Since 1984, through the establishment of the SNI, the Mexican government has strived to strengthen both HEI and PRC to make them capable of fueling the innovation that the country needs to achieve economic progress. Although the Mexican government promotes national prosperity by supporting new technologies through research development carried out by HEIs

and PRCs, it also attempts to convert these institutions to engines of economic growth in their regions. This development, however, has led universities to lose their monopoly on knowledge production as they are increasingly responsive to economic, technological, and industrial needs. As a result, a close interdependency between university, industry-business, and the government has been emphasized. In other words, Mexican government acknowledges that prosperity depends upon the knowledge produced at HEIs; however, scientific production also depends upon both industry needs and the interest of the Mexican government to support scientific research and technological development. The transition toward a knowledge economy has required a profound transformation of HEIs, including a significant economic investment made by the government during the last decade.

This chapter takes stock of the efforts made by Mexico to strengthen R&D as a means to bring prosperity and enhance the quality of life of its citizens. We offer data regarding R&D expenditure over the last two decades, a trend line in R&D expenditure as a percentage of GDP, a trend line in the rate of growth in R&D expenditure, and the expenditure on R&D by sector (government, higher education, industry-business, private/nonprofit). The chapter also presents the structure of the Mexican higher education system and its struggles to advance the knowledge economy. Moreover, in order to understand the efforts made by the country to transit toward a knowledge economy, we briefly explore the effects of a knowledge society on R&D in the country as well as its impact on political participation, societal health, employment, and incomes rates.

Mexico's system of science, technology, and innovation (STI) is constrained by two factors: first, the lack of demand on the part of the industrial sector, which may be partly due to the country's proximity to the United States, and second, to insufficient investment in science, technology, and higher education in general. Unsurprisingly, the Mexican economy is largely based on low-technology companies, which are limited to producing products and services designed and developed abroad. This condition demands little added value in terms of innovation (Scientific and Technological Advisory Forum [FCCyT, for its Spanish acronym], 2006, 2013, 2019).

However, beyond exploiting knowledge competitively for purely economic development, Mexico needs to more broadly diffuse knowledge as a principal strategy for social development and well-being (Gómez-Merino et al., 2017). The Knowledge-Base Society (KBS) should not be only centered on technological advancement but rather must function as a driver of social change (Khan, 2003). Due to its relevance, KBS is a current topic of discussion, especially among social scientists and higher education policymakers across the globe.

The goal of this chapter is to analyze the current state of STI and HE. This text is organized into four sections. First, it analyzes both global trends in higher education and their impact on Mexico. Second, it reflects on the Mexican government's response to these challenges. Third, it leads the reader through the higher education system in Mexico and its transformation over the past two decades. Finally, some suggestions and conclusions are offered as a result of the analysis presented.

Major Drivers and Global Influences on Mexican Higher Education

Over the past few decades, HEIs have undergone major transformations, fueled by the twin forces of neoliberalism and globalization. As a result, a major reduction in government funding and a general decline of the public sphere have promoted the so-called *academic capitalism* (Jessop, 2017; Pusser, 2011). In Mexico, global trends are reflected in an explosion in private-sector providers. Prior to the 1980s, higher education was predominantly provided by the state. However, the growing influence of neoliberal policies around the world, as well as the explosion in demand for tertiary degrees, spurred many governments, including Mexico, to open the door to the private sector.

In Latin America, private higher education institutions recorded an average of 47% of tertiary enrollments, and in several countries, the private share is far larger, namely, Brazil, Chile, Costa Rica, El Salvador, and Peru (Bjarnason et al., 2009). On the contrary, Mexican enrollment in private HE has remained stagnated at 33% over the last decade (Mendoza, 2018). However, the country is a key player in the new phase of private higher education: the for-profit sector. The for-profit market is a big business that made $282 million in 2013 through tuition from its HEIs in Mexico (Millán, 2014).

In addition to the explosion in private-sector providers, public universities are increasingly turning to private sources of funding to make up for the shortfall in government subsidies. In fact, the line between public and private has been blurred in many countries as tuition fees make up an ever-larger share of university budgets. This is particularly true in the United States and Chile. However, even countries with long traditions of public higher education, such as United Kingdom and Canada, have raised tuition fees significantly over the past decade. As a result, students and their families are increasingly relying on public or private loans to pay for college, leading to record levels of student debt. In the United States, the volume of outstanding student loan debt has grown by a factor of 4.5 since 1999 (Quintero, 2012). Mexico is a relative newcomer to student loan market partly because public universities, most of which charge only nominal fees, continue to account for most of tertiary enrollments.

The Competitive Pressure of University Rankings

Another global trend impacting HEIs are international rankings. Governments have seized on the rankings to justify existing higher education reforms or to promote new ones in countries such as France, Spain, Russia, and Malaysia (Ordorika & Lloyd, 2013). Today, governments rely on the rankings to determine where to send scholarship holders abroad (Ordorika & Lloyd, 2013). The most notable of these programs is Brazil's Science without Borders program, which sought to send more

than 200,000 students abroad between 2012 and 2017. Other countries with large study abroad programs relying on international rankings are Russia, China, Chile, Ecuador, and Peru.

In Mexico, CONACYT has dramatically increased the number of scholarships for graduate studies in recent years, from a few thousand in the early nineties to 53,225 in 2018. However, a 2.8% decrease in students of was seen in 2017, and only 8% were scholarships abroad (CONACYT, 2018). The Mexican government gives preference to students accepted at highly ranked universities, preferably in Europe, Canada, and the United States. In fact, CONACYT has only signed collaboration agreements with Brazil and Costa Rica for student mobility in Latin America (CONACYT, 2015a). The mobility program, however, gives priority to students studying in the STEM fields as part of the Special Program for Science, Technology, and Innovation (PECiTI).

The Focus on Investment in Science and Technology

The new enthusiasm among policymakers for the science, technology, engineering, and mathematics (STEM) fields has been fueled by the recommendations of international agencies such as the World Bank and the Organisation for Economic Co-operation and Development (OECD). In the past, the OECD has repeatedly underlined the low investment of Mexico in science and technology, which has remained one of the lowest among OECD countries. In response, the Mexican government created dozens of new technological institutes across the country. In 2012, former president Felipe Calderon announced his government had created 140 new universities in 6 years; 120 of those were institutions devoted to the STEM fields: 45 technological institutes, 42 technological universities, and 33 polytechnic universities (Rodríguez-Gómez, 2012). Although further laws established 1% of GDP must be invested in science and technology, the level has hovered at about 0.40% over the past decade.

Trends in Science and Technology Expenditures

Mexico spends less than 1% of its GDP on research and technological development (World Bank, 2018). According to the National Association of Universities and Higher Education Institutions ([ANUIES by its Spanish acronym], 2012), science and technology policies in the country have not been managed efficiently with national development strategies. The association argues that budgets are systematically assigned with a low priority to the sector compared to 2.3% OECD average. Between 1990 and 2017, the average proportion of the GDP allocated to research and development was 0.38%, with a minimum of 0.25% in 1996 and a

Table 20.1 Trends in Mexico's overall R&D investment, 1995–2018

Year	% of GDP
1995	
1996	0.25
1997	0.28
1998	0.31
1999	0.34
2000	0.31
2001	0.32
2002	0.37
2003	0.38
2004	0.39
2005	0.40
2006	0.37
2007	0.43
2008	0.48
2009	0.52
2010	0.53
2011	0.51
2012	0.49
2013	0.43
2014	0.44
2015	0.43
2016	0.39
2017	0.33
2018	0.31

Source: Authors' own elaboration based on information from World Bank (2018) and OECD (2020)

maximum of 0.53% in 2010. Table 20.1 shows the trend line in R&D expenditure as percent of GDP over the last 20 years.

The indicator for gross domestic expenditure on research and experimental development (GERD) captures all spending on R&D carried out within an economy in a year. Amid OECD countries, Mexico had the lowest level of GERD as a percentage of GDP (0.31%) in 2018 between OCDE countries (OECD, 2020). In North America, the United States and Canada spent 2.8% and 1.6% of GDP on R&D, respectively. However, of all the Latin American countries, Mexico spends the most on R&D; over two-thirds of GERD financing comes from the public sector and one-fifth from the private sector. Unsurprisingly, federal universities, along with CONACYT, conduct most of the scientific research in Mexico (Mendoza, 2018). In this regard, in 2016, CONACYT and public education were the sectors which contributed the most to GERD spending, contributing 50% and 25%, respectively.

Expenditure on R&D by Sector (Government, HEIs, Business, Private/Nonprofit)

Since Mexico's R&D intensity was one of the lowest among OECD country members, its government significantly increased its expenditures between 2013 and 2015 (Table 20.2). Although the promotion and development of scientific research in Mexico is a shared responsibility between the Secretary of Public Education (SEP, by its Spanish acronym) and CONACYT, the expenditure from private and nonprofit sources remains insufficient. Unlike most of the countries, in Mexico, R&D mostly depends on the efforts of universities and public research centers. That is, the active economic participation of different sectors (business/industry, private, nonprofit) remains limited. For example, business contributions to research and development stood at just 20% of the total contribution to R&D compared to 40% in Brazil and and 70% in South Korea (Oxford Business Group, 2019). While domestic S&T development continues relying upon governmental efforts, domestic development cannot be raised unless participation from private companies increases. A balance between private and governmental participation must be achieved within the coming years. As a result, the academic community in Mexico has suggested a tax reform aimed at stimulating private investment in S&T (UNAM, 2018). Public institutions and universities continue to play an important role in R&D. Unlike American universities, Mexican universities' investment in R&D comes from the government itself. That is, the state allocates universities a budget that must be spent in S&T development; therefore, this investment is part of what the column "Government" includes as seen in Table 20.2, while the "Higher Education" column reflects the investment of private HEIs and the private sector associated with public HEIs. Expenditures are presented in millions of dollars and include the expenditures by sector (government, higher education, including research institutes, business/industry, private, nonprofit) over the last two decades (Table 20.2).

The ups and downs that are perceived over time in public and private investment has been explained by various specialists on the subject to be the result of the discontinuities of public policies, which have not made it possible to take advantage of existing talent and to take root in S&T in the business sector (Scientific and Technological Advisory Forum, 2019).

Higher Education Institutions and Academic Staff in Mexico

In recent years, the Mexican academic sector increased the number of scientists conducting research activities. This is a result of the unprecedented growth experienced by the HEIs, concerning such aspects as its diversification, the increased number of professors and research areas, the number of students, and the number of study programs offering a scientific training (see Table 20.3).

Table 20.2 Investment on research and development by sector from 1995 to 2015, presented in millions USD (the sum of the breakdowns may be inaccurate due to the unrevised amounts provided by the OECD)

Year	Total	Business enterprise		Government		Higher education		Private nonprofit	
		Total expenditure	%	Total expenditure	%	Total expenditure	%	Total expenditure	%
1995	1941.486	341.379	17.5	1284.937	66.1	130.862	6.7	22.067	11.3
1996	2081.424	404.677	19.4	1390.274	66.8	168.693	8.1	45.517	2.2
1997	2514.179	425.290	16.9	1786.663	71.0	216.194	8.6	22.123	0.9
1998	2923.546	689.367	23.6	1776.320	60.8	234.807	8.0	3.297	0.1
1999	3505.009	826.438	23.6	2147.237	61.3	340.522	9.7	3.776	0.1
2000	3362.821	992.598	29.5	2119.156	63.0	200.850	5.9	19.217	0.6
2001	3634.889	1084.622	29.8	2146.531	59.1	329.158	9.1	28.518	0.8
2002	4171.255	1447.070	34.7	2313.656	55.5	343.529	8.2	34.913	0.8
2003	4401.937	1527.307	34.7	2469.844	56.1	337.128	7.7	34.384	0.8
2004	4778.963	1845.462	38.6	2405.837	50.3	355.816	7.4	37.239	0.8
2005	5346.151	2219.192	41.5	2629.406	49.2	389.850	7.3	49.853	0.9
2006	5462.068	2469.986	45.2	2717.686	49.8	177.333	3.2	7.683	0.1
2007	6670.852	2590.618	38.8	3636.888	54.5	254.224	3.8	110.576	1.7
2008	7785.429	2579.243	33.1	4522.236	58.1	440.953	5.7	124.315	1.6
2009	8459.543	2860.735	33.8	4764.589	56.3	511.930	6.0	199.566	2.4
2010	9291.092	3052.229	32.9	5792.283	62.3	256.381	2.8	146.991	1.6
2011	9775.282	3159.827	32.3	6159.020	63.0	249.170	2.5	151.466	1.5
2012	9798.989	2399.446	24.5	6645.212	67.8	313.671	3.2	405.167	4.1
2013	10296.712	2158.338	20.9	7278.769	70.7	362.546	3.5	456.866	4.4
2014	11586.595	2339.272	20.2	8315.656	71.8	392.938	3.5	495.166	4.3
2015	11901.398	2450.078	20.6	8475.523	71.2	411.551	3.5	518.62	4.4

Adapted from "Gross domestic expenditure on R-D by sector of performance and source of fund" by the OECD (2019)

Table 20.3 Chronological expansion of higher education in Mexico

	Year						
	1970	1985	1990	2000	2008	2013	2018
HEIs	115	271	372	1416	2397	3017	3291
Enrollment students	225,000	840,000	1,206,100	1,206,100	2,705,190	3,419,391	3,864,995
Academics	25,000	95,799	113,238	220,000	283,818	349,193	397,971

Adapted from Gil-Antón (2009) and Secretary of Public Education (2019)

The Mexican higher education system is complex. It is comprised of seven subsystems: federal, state, research centers, technological and polytechnic, teachers' colleges, private, and other public HEIs which vary by government dependence, source of funding, and specialization in fields of study. Table 20.4 shows the total number of HEIs together with the academics by type of hiring.

Table 20.4 Higher education in Mexico at 2017: Academics by institution type

Type	Total HEIs	Academics			
		Total	Full-time	Part-time	Per hours
Federal universities[a]	142	65,088	25,513	6214	33,361
State universities	56	92,609	34,310	3378	54,921
Technological and polytechnical[b]	309	31,270	8739	509	22,022
Normales (teachers' colleges)	239	11,627	4521	2627	4479
Research centers	24	2110	1928	133	49
Other public HEIs[c]	235	13,050	5463	1603	5984
Private institutions[d]	2140	150,463	12,041	7441	130,981
Total	3145	366,217	92,515	21,905	251,797

Adapted from Mendoza (2018)

[a]Federal, state universities, teachers' college, and research centers depend on public funding. Federal and state universities have autonomy to make most of their decisions regarding institutional governance, faculty or program design, and delivery

[b]Technological and polytechnic institutes depend on government. The government decide on some aspects of their operation

[c]Other public HEIs are funded and managed by other government agencies, such as secretary of justice, agriculture, defense, or health

[d]Private institutions are privately funded; however, their operations require governmental accreditations and authorization

Every subsystem has had a different impact on scientific and technological development in the country. The federal universities are at the center of the higher education research enterprise as they gather 72% of postgraduate programs related to STEM (Cruz & Cruz, 2008). Among the most productive institutions in knowledge transmission and the creation of human resources are the National Autonomous University of México (UNAM), the National Polytechnic Institute (IPN), and the Autonomous University of Mexico (UAM). In fact, these institutions, along with public research centers, manage to concentrate more than 75% of established researchers in the country (Santelices, 2010). Though state public universities have the largest number of full-time professors, the private system has the largest number of academics hired by the hour (Estévez-Nenninger et al., 2020; Gil-Antón, 2009). One-third of students (33%) are enrolled in private institutions, which are part of the largest subsystem. According to the OECD (2019), the 2140 private institutions represent 72% of HEIs in Mexico. Generally, these institutions focus in the field of engineering sciences, biology, and chemistry, as well as medicine and health sciences.

Current Government Policies to Enhance Scholarly Productivity

Over the last decade, Mexico has entrusted its scientific and technologic progress to two main federal programs: CONACYT and SNI. Peña Nieto's administration kept up the oldest instruments of CONACYT, the scholarship program for postgraduate

studies. The program absorbed a third of the financing of CONACYT, which makes it the largest program in the country. From 1971 to 2016, CONACYT awarded more than 328,176 scholarships of which 268,112 were granted in domestic universities and 60,064 in international ones. CONACYT, however, acknowledges there is not an established and clear strategy to grant scholarships in strategic areas (CONACYT, 2017).

On the other hand, the SNI has been operating for more than three decades as a device to recognize and certify Mexican scientists who carry out cutting-edge research, publish in specialized journals, and train human resources. The SNI has been effective in attracting new professionals and containing the emigration of Mexican academics to foreign countries. In 1984, it recognized 1396 members, and by 2019, this figure reached 30,549 (CONACYT, 2019). The areas with the highest number of researchers are social sciences and economics, biology, and chemistry; the areas with fewer researchers are biotechnology, agriculture, medicine, and health. The significant increase in number of researchers is reflected on the amount of indexed publications in recent years. From 2008 to 2015, the production of scientific articles in Mexico experienced an average growth rate of 4.92% in relation to the member countries of the OECD. Currently, the country ranks 33rd of the 34 OECD member countries in terms of the Impact Relative to World (IRW), with 0.98 citation impact of the set of publications as a ratio of world average (CONACYT, 2015a).

Moreover, an increment in the number of patent applications by Mexicans during the 2000–2015 period was observed. In the year 2000, of all patents requested, 431 (3.2%) belonged to nationals, a number that climbed to 951 (6.1%) by 2010 and 1364 by 2015 (CONACYT, 2015b). Another indicator of scientific development in the country is that, in 2012, the Global Innovation Index located Mexico in 79th place out of 143 countries and in 72nd place in 2018 (Cornell University et al., 2018).

Researchers and support for research tend to be distributed unequally; of the 28,635 SNI researchers, 31.67% reside in Mexico City, whereas 68.33% reside in different states of the country (CONACYT, 2017). However, the financing of research projects and infrastructure continue to favor institutions with greater scientific maturity and better management and investment capabilities, thus perpetuating territorial differences. A recent initiative is the so-called *Chair Program*, consisting of public positions of an academic nature for young researchers, whose objective is to incorporate more than 3000 doctors in HEIs, centers, and research institutes located in the 32 states of the country (CONACYT, 2014).

The expansion of human resources is essential for the development of the country; CONACYT and SNI allow the formation of human capital and the creation of a base of science and technology activities. These programs allow the acceleration of innovation, as a strategy to achieve competitive advantages within the framework of knowledge-based societies, as it is generated from new products, designs, and services. Further, the federal government is promoting Innovation Incentives Programs (IIP) which aim to link higher education institutes and research centers with the productive sector for the creation, transfer, and exploitation of knowledge. Although these programs have strengthened the exchange and cooperation between the

academic, scientific, and corporate sectors (Dutrénit & Arza, 2010), the interaction between these agents is still limited, weak, and irregular, to consolidate a real system of innovation (OECD, 2014). CONACYT acknowledges this condition is the result of both the absence of policies that recognizes the types of companies; the phases of innovation; the link between science, technology, and innovation agents; and the lack of support for innovative technology companies (CONACYT, 2014).

Increasing Fragmentation and Stratification of Academic Workforce

While an increasing contingent of productive scholars and researchers continues to grow, especially at the federal universities and public research centers, the vast majority of academic staff, including those in the private sector and in the technological-oriented institutions, continue to work in a more precarious and less supportive situation. In Mexico, only 36% of professors in public and private sectors hold tenured positions, and the rest are part-time or hourly contracted (ANUIES, 2014). However, public institutions have maintained higher percentages of tenured professors, especially in the research centers, and federal and state universities, in comparison with private HEIs.

There is also a marked segmentation between teachers and researchers, with the latter group deemed as more valuable in its contribution to the knowledge society. In Mexico, the financial difference between both academic groups is particularly extreme. Starting in 1984, with the creation of the SNI, the government linked the salaries of top researchers to their scientific production, measured primarily in terms of the number of publications in peer-reviewed journals. Members of the SNI receive substantial bonuses depending on their levels of production; the system has four levels, with bonuses (extra salaries actually) ranging from $350 to $1600 USD a month in 2019. However, researchers are evaluated accordingly to their production in scholarly journals, with internationally indexed journals in English (of which there are far more in the STEM fields) receiving the highest points. Furthermore, members of the SNI in universities (the program also has members from research institutes and private companies) represent a privileged and tiny minority of university professors.

Mexican Higher Education and Social Improvement

Mexican universities have a broader contribution to the knowledge society by promoting social betterment and civic participation. Historically, universities have been responsible for educating thoughtful citizens who fight against human pandemics like poverty, unemployment, and educational lags. The knowledge society fostered

from HEIs has been the imaginary space where intellectual debates take place to encourage societal improvement and social justice in Mexican society. Overall, HEIs have contributed to improving society to the extent that social aspects like political participation, societal health, and employment are improved.

Due to the global economic circumstances, social demands are rising; hence, a more politically active and engaged society must be educated in a knowledge society to serve in a knowledge economy. The interaction in a global economy has led Mexican HEIs to embrace a knowledge society that fosters individuals to interact in civilized life. However, the promotion of a more participative society remains as a pending issue in the political agendas of HEIs. In that regard, data from National Survey on Political Culture and Citizen Practices (ENCUP) (Governing Secretary, 2005) underlines two main reasons. First, Mexico is still immersed in an "inevitably of elites"—in fact, the most critical decision-making process is still dominated by a small stratum of economic and political decision-makers. Second, it seems that politics are less complicated to those who study in private institutions. As a result, the level of interest in politics is also higher among individuals educated in those institution. Figure 20.1 displays the levels of interest in politics in people who have not attended higher education and on those who have attended higher education in public and private institution (Fig. 20.1).

The efforts made in campuses across the country seem to be more fruitful in terms of societal health and quality of life. According to the OECD (2019), Mexico has made important progress over the last decade in terms of quality of life of Mexicans. Among the most significant signs of improvement are in indicators such as income, education, jobs, and health. The better life report (OECD, 2017)

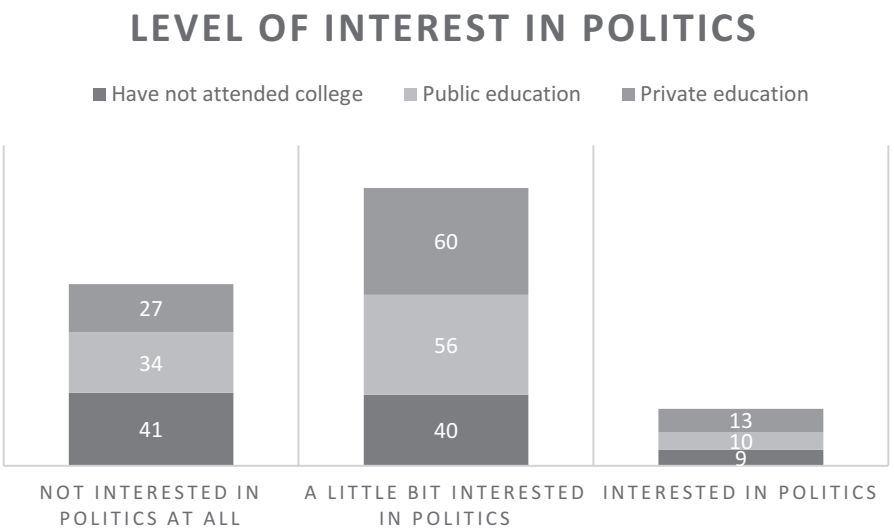

Fig. 20.1 Graphic shows the level of interest in politics of Mexican citizens. The graphic distinguishes the level of interest among those who have not attend college at all and those who have attended public and private universities. (ENCUP, 2005)

indicates college attendance has exponentially grown in Mexico. Between 2007 and 2017, graduation rates increased from 16% to 23%, which is still below the OECD average of 44%. The average household net-adjusted income per capita remain at 13,891 USD per year, which is considerably lower than the OECD average (30,563 USD). In Mexico, 37% of adults age 25–64 have completed upper secondary education, much lower than the OECD average (74%). In terms of employment, about 61% of people aged 15–64 in Mexico have a paid job, lower than OECD employment average (77%). Regarding health, life expectancy at birth in Mexico is 75 years, 5 years lower than the OECD average (80 years). In general, Mexicans are satisfied with their lives. In a scale from 0 to 10, Mexicans gave it a 6.6 on average, quite similar to the OECD average (6.5).

Conclusions

In recent years, Mexican science and technology policies induced sustained yet not spectacular growth. This is reflected in the increase of highly qualified personnel dedicated to science and the increase of Mexican scientific production. Despite these undeniable accomplishments, it is necessary to urgently address the factors that hinder scientific development to give greater dynamism and strengthen the role of science in the economic and social development of the country.

Former President Enrique Peña Nieto's administration promised to strengthen national science and technology development. In fact, there was a commitment for 1% of the GDP expenditure in science and technology at the end of the administration. Nevertheless, multiple factors like the fall of oil prices, the limited investment in science by the private sector, and the contraction of economic growth complicated the accomplishment of that goal. This condition might have hindered the advancements of the fragile Mexican science and technology system.

Nowadays, Mexico faces several dilemmas, none of them new, of course. The biggest one is to update a system that has historically regulated, financed, and assessed the science and technology activities to align it to "the emerging tendencies toward collaboration, internationalization, bonding, and the opening of new fields" (Kent, 2014, p. 347). Although current policies are no longer favorable for the expected results regarding quality, change would mean to increase current tensions in higher education, given the competitive allocation of resources. A change of policy aligned to the support of STEM would signify more and major resources to federal institutions. This condition would increase annoyance among the remaining institutions for the gaps in funding and governmental support. In this regard, De Vries and Alvarez (2014) explained that "at the beginning of the nineteen-nineties, the question was whether governmental policies could change the workings of the system in Mexico. Nowadays, the key question is whether policies can be changed, as policies themselves have turned resilient to change" (p. 33). Another dilemma is to both explain and justify why currently implemented national policies are decreasing their impact on the improvement of higher education in Mexico (Galaz

et al., 2012). Therefore, in the future, policymakers, scholars, and administrators are required to look at different options to face the weaknesses of public policies in terms of higher education, science, and technology.

Mexican scholars generate knowledge and innovation in alignment with the role assigned to their universities, which is not necessarily aligned with scientific and technological development. Within each institution, it is possible to distinguish disciplines growing in both size and diversity, which generates new research directions. There is a tendency for science growth to occur in aggregate and diversified forms, from which new scientific areas emerge, assuming the legitimate coexistence of diverse theories about the same phenomenon (Bonaccorsi & Vargas, 2010). This triggers the development of new disciplines and emergent fields of study (e.g., environmental sustainability, renewable energies, aerospace, biodiversity, cold technology, energetic sustainability, sustainable agricultural innovation, food innovation) that can offer a view toward more dynamic environments in relation to the intensive use and innovative application of knowledge. From the HEIs, these new disciplines and sciences aim to respond to priority areas of attention reported by the CONACYT (such as information and communication technologies, biotechnology, advanced materials, manufacture design and processes, infrastructure, and urban and rural development) regarding strategic knowledge for the solving of problems.

Mexican academics have a distinctive feature as they have increased their productivity in recent decades despite receiving very few resources in a country that has been allocating an expenditure on research and development. If this stagnation continues, scientific competitiveness and productivity in the country would hardly approach the pace of developed countries or even emerging ones. There are pending inquiries on the details of this distinctive feature and a pending analysis of the limit to which academics will maintain these tendencies in their scientific production rates before they are replaced by a new generation.

It is clear that the new circumstances in the national and international contexts require deep changes in higher education for further STI development. In the face of paradoxes deriving from knowledge-based social dynamics and innovation, it is for HEIs and academics to further progress through the complex path of developing and perfecting their scientific and technological processes.

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