Article **Journal-International Economy**
December 2018 Vol.2 No.3 19-29

STEM disciplines: Detonating for national and regional economic development

Disciplinas STEM: detonantes para el desarrollo económico nacional y regional

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Received June 30, 2018; Accepted September 30, 2018

Abstract

The Importance of scientific, technological and innovation progress has-been a subject of interest for MOST of the country clubs; the leading economic powers Have Shown The Importance of Establishing the Public Policies That Encourage STEM disciplines (Science, Technology, Enginnering and Mathematics) as triggers for economic development. In This qualitative and descriptive documentary study, the state of the art of the STEM education policy in Mexico is Analyzed, with emphasis on the state of Tabasco, the federal Describing, Local and state actions in esta area. It describe the relationship Between science, technology and economic development, STEM education, and public policies developed in the field. It is Observed That the advances are Insufficient, to adequately compete in a knowledge-based economy, THEREFORE Governments, national and state,

STEM, Public Policies, Economic Development

Resumen

La importancia del progreso científico, tecnológico y de innovación ha sido tema de interés para la mayoría de los países; las grandes potencias económicas han evidenciado la importancia de instaurar políticas públicas que fomenten las disciplinas STEM (Science, Technology, Enginnering and Mathematics) como detonantes para el desarrollo económico. En este estudio documental, cualitativo y descriptivo, se analiza el estado del arte de la política educativa STEM en México, con énfasis en el estado de Tabasco, describiendo las acciones federales, estatales y locales en este rubro. Se describe la relación entre la ciencia, tecnología y desarrollo económico, el alcance de la alfabetización STEM, y las políticas públicas desarrolladas en la materia. Se observa que los avances son insuficientes, para competir adecuadamente en una economía basada en conocimiento, por ello los gobiernos, nacional y estatal, deben poner especial énfasis en la implementación de políticas públicas que aumenten la inversión en Ciencia, Tecnología e Innovación y fomenten la educación STEM, para mantenerse competitivos en el mundo actual globalizado.

STEM, Políticas Pública, Desarrollo Económico

Citation: HERNÁNDEZ-MENA, Verónica, MAGAÑA, Deneb Elí and AVENDAÑO, Karla C. STEM disciplines: Detonating for national and regional economic development. RINOE Journal- International Economy. 2018.2-3:19-29.

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Introduction

Economic development of a country is closely linked to scientific and technological development of this; a nation that invests in science and technology, has the tools necessary to innovate and position themselves above others(United Nations Economic Commission for Latin America and the Caribbean [ECLAC], 2004b). Developed countries are those that invest in scientific research and technological development, in fact the top five in the standings, in terms of absolute spending on research and development (R & D) are major economic powers: the United States, China, Japan, Germany and the Republic of Korea, so it is important that developing countries working in both public education and financial policies, that affect more scientific investment(Pérez, 2013).

To encourage scientific development is necessary a combination of several factors: investing in infrastructure, training and education of human capital and investment in technological innovations, including efficient industrial organization structures (Lopez and Sandoval, 2007). Highlights the importance of qualified human resources as the main source of scientific and technological activities, since it depends on the generation of new knowledge and its subsequent transformation into technological innovations(National Council of Science and Technology [CONACYT], 2016).

Under such conditions, the developing country require greater efforts in promoting disciplines called STEM (Science, Technology, Enginnering and Mathematics) or CTMI (Science, Technology, Engineering and Mathematics). The*National Science Foundation* (NSF) defines "STEM education" as teaching and learning in the fields of science, technology, engineering and mathematics, which generally include educational activities at all levels, from kindergarten to post-doctorate, both in formal settings and informal (Gonzalez and Kuenzi, 2012). STEM catalog is extensive, and generally includes el study of mathematics, natural sciences (including physical, chemical and biological sciences), engineering and computer sciences and technology (National Center for Education, 2012).

Despite the global importance of scientific and technological development, there is a continuous decrease of students enrolled in studies of such areas, as well as professions related thereto (Solbes, Monserrat and Furio, 2007). This problem occurs globally; for example in the European Union and the United States, despite having the best university infrastructure, R & D, leading technology and innovation companies and major organizations focused on outreach and scientific promotion, new generations they have shown lack of interest in STEM studies(Everis, 2014).

The ***Organization for Economic Cooperation and Development (OECD, 2016)*** It indicates that in the last decade in many European countries, the number of young people entering universities is increasing but they are choosing study fields other than science and therefore the proportion of young people studying science is decreasing. In Latin America the problem is not minor, the lack of students in STEM disciplines as well as the lack of skills of workers in these areas generate uncertainty in economic development related to the production of knowledge (Alburquerque and Cortés, 2004).

The trend toward alienation of youth interest in the study areas related to the exact sciences and engineering, causes concern in the scientific, technological and economic future of Mexico. Studies of this problem in the country are scarce and there is little evidence to explain this phenomenon, however a clear decline in the percentage of workers with postgraduate degrees in STEM disciplines related to highly skilled occupations.

Some studies have shown that pay interest and economic stability are some of the main factors in choosing careers studying STEM (Mitchell, 2016)Though in Mexico the labor market punishes the youngest graduate in STEM areas, and provides unfavorable conditions for women and for those with doctoral studies (Lozano, Gandini and Ramirez-Garcia, 2015), Which discourages the election.

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In the year 2013, the Government of the Republic Mexico established the purpose of the six-year period, achieving an investment of 1% of GDP for science, technology and innovation (STI), pledging to strengthen human resources, increasing the number of postgraduate scholarships and encouraging increase in the workforce of the National System Researchers (SNI), supporting research groups, investing in science and technology infrastructure, but the goal is still far away and scientific production indicators do not reflect significant progress (CONACYT, 2016). Undoubtedly Mexico should place special emphasis on the development of STEM disciplines if you want to stay competitive in various economic sectors. Meanwhile, in the state of Tabasco this problem is even more evident as the scientific production indicators are well below the national average.

The purpose of the study is to analyze the state of the art educational policy STEM in Mexico, with emphasis on the state of Tabasco, describing federal, state and local actions in this area, moving from national plans to regional actions that lead out the institutions responsible for popularizing science, contrasting with the results.

In the first section the relationship between science be analyzed, technology and economic development, then the meaning and scope of STEM education will be addressed in order to make way for the third section, where public policies are described in Mexico and Tabasco aimed at developing STEM showing the main results obtained in the field both at and national and state levels.

Methodology

The study is qualitative descriptive, since the purpose was to make a documentary analysis STEM education policy in Mexico, with emphasis on the state of Tabasco, describing federal, state and local actions in this area. Martinez (2011) He notes that the social sciences require the analysis of written documents, interpreting fragments or oral explanations, under their theoretical explanations are in communicational perspective and language that requires the construction of new concepts from existing ones. A literature review of primary sources, including scientific papers, in English and Spanish, arbitrated and indexed in different databases (EBSCO, Emerald, Scopus, Scielo, CONRICyT, etc.) language was performed.

It also documents major national and international organizations that provide relevant information on scientific and technological issues, such as the OECD, UNESCO and CONACYT, as well as reports, plans and national and state laws in the field were consulted. For proper understanding of the subject, the relationship between science was analyzed first, technology and economic development, then the meaning and scope of the STEM literacy addressed in order to make way for public policies in Mexico and Tabasco aimed at developing STEM.

Results

Science, technology and economic development

Economic and social development of countries is closely related to scientific and technological progress as well as its ability to innovate (Lopez and Sandoval, 2007). In this globalized economy, technology and innovation are key factors for emerging economies overlap their socio-economic problems and strengthen their development (Hair and Ortiz, 2013).

Generating value and wealth are increasingly dependent on the use of knowledge, which makes it a fundamental element (Guzman and Adriano, 2013)It is why the economic progress must seek investment in knowledge, ensuring generation projects that benefit social development (Pérez, 2013).

Notably, the increase in investment in Federal spending on science and technology positively associated directly and indirectly, to the increase of gross domestic product (GDP) and total investment (Olive et al., 2013), why countries have been increasing their interest in implementing STI policies in order to promote growth, development and competitiveness (Kababe and Stubrin, 2011), Likewise have increased lot investment in science, technology and higher education and most of them have developed strategies to formulate and implement policies to stimulate innovation (Organization of Iberoamerican States for Education, Science and Culture (OEI), 2014). Notes that while in developed countries the private sector is the main funder of R & D in Latin America and the Caribbean has traditionally been public sector(Casas, Corona, and Rivera, 2014).

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Economic regions have set increasingly ambitious objectives with regard to spending in this sector: the best known example is that of the European Union, who proposed increase overall investment in R & D to 3% of GDP by 2020 (United Nations Educational Scientific and Cultural Organization [UNESCO], 2016). In the whole world only six countries have overcome the target of 3%, Republic of Korea, Japan, Israel, Denmark, Finland and Sweden, while Latin America and the Caribbean still lag far behind, allocating just 0.5 points of GDP (ECLA, 2004a) being Brazil leader, with 1.2%. For its part, Switzerland is considered a world leader in innovation and devotes 30% of its Gross Expenditure on Research and Development (GERD) to basic research thus ensuring the continuous generation of knowledge and a quality university education(UNESCO, 2015). Evidence shows that if the goal of 1% of GDP as a minimum investment in R & D is reached, the result of growth in per capita GDP would increase, long-term 3.4% annually. This would be enough to finance such an effort in the future as well, employment levels increasing and helping to raise the efficiency and social welfare(Capdevielle et al., 2013).

In Mexico for several years, they have set goals aimed at increasing investment in this area; the objective of the Special Program of Science and Technology (S & T) for 2006 was to try to reach 1% of GDP in S & T and double the percentage to achieve an investment of more than 2% in R & D by 2015, positioning the Mexican economy as one of the top 10 in the world and one of the 20 most developed countries in science and technology But the goals were not achieved, El Government of the Republic (2013) through National Development Plan (PND) 2013-2018 established again in order to reach 1% of GDP for science, technology and innovation in the administration, and increase public spending for these activities, however until the end of 2017 this figure stood at only 0.57%.

For his part, State Government of Tabasco (2013)In its National Development Plan he sets a goal, aligned with national plans, reaching 1% of GDP in investment programs Science, Technology and Development; the goal is still far away, the budget allocated to the Council of Science and Technology of the State of Tabasco (CCYTET) in fiscal 2016 was 0.04% occupied with this figure the twenty national position.

According to the OECD (2016), Specialized human capital is crucial for the development and dissemination of knowledge, constituting the link between economic growth and technological development, as well as between social progress and general welfare component. The combination of scientific and technological resources with specialized human resources, results in a key element to increase competitiveness in the country(CONACYT, 2016).

However, there is concern on the issue, since worldwide from 1996 to 2013 there was a decrease in the number of researchers between 17% and 15% in middle-income countries, resulting in 2013 a world average of 1083 researchers per million inhabitants (UNESCO, 2015) This negative trend could affect sustainable development worldwide.

In Latin America, which account for 8% of the world population, researchers compared the percentage of the world total approximately 3.6% (UNESCO, 2015). In Mexico the numbers show an interesting dynamic, in 1996 there were record 207 researchers per million inhabitants, a figure that rose significantly by 2005 to reach 400, falling back to 242 in 2013(World Bank, 2013).

In Tabasco, the figures are equally worrying, in the SNI, the number of ““tabasqueños”” researchers represent 0.6% of the national total, standing at the national level at position 29 with a ratio of 0.56 researchers per thousand inhabitants, a figure that is far from recommendation indicating the two researchers per thousand inhabitants (CONACYT, 2014). For its part, the State Research System (SEI) recorded in 2012, 446 “tabasqueños”, number, although it has been increasing year after year, has been affected by the decline in resources allocated what has influenced your productivity(State Planning Committee of Tabasco [COPLADET], 2018).

Literacy STEM (Science, Technology, Engineering and Mathematics)

Our knowledge-based economy is driven by constant innovation. The basis of innovation lies in a dynamic workforce, motivated and well educated, equipped with STEM skills.

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The acronym STEM was introduced in 2001 by scientific administrators of the National Science Foundation of the US. UU. (NSF) and its use quickly spread to many countries, with programs developed in places like Australia, China, France, South Korea, Taiwan and the United Kingdom.

In the United States and elsewhere, the absence of a clear definition of STEM contributed to disagreement over what professions they really qualify as STEM careers. Some groups believe that any job that requires skills and knowledge of any STEM field is a STEM job. However, government agencies used different criteria for designating such work. There have even been difficulties in analyzing statistics STEM occupations because there is no commonly agreed definition of a STEM job. Table 1 presents a summary of some of the definitions most used nowadays.

Organism	Definition
European Commission	STEM skills are associated with advanced technical skills, which are considered as strong drivers for technology and growth driven by knowledge and productivity gains in high-tech sectors, including ICT services. (Danish Technological Institute, 2015 p1).
National Science Foundation	The term refers to education STEM teaching and learning in the fields of science, technology, engineering and mathematics. (Gonzalez and Kuenzi, 2012, p.1).
Researchers from Pennsylvania	It is an interdisciplinary approach to learning where concepts rigorous academics combined with real-world lessons as students apply science, technology, engineering and mathematics in contexts that make connections between school, community, work and the global enterprise allow the development of STEM literacy and with it the ability to compete in the new economy (Tsupros, 2009).
international network of national contact points for science and society of the European Union	Education and innovation framework that brings science, technology, engineering and mathematics along with arts / disciplines (STEM + Art = STEAM and STEAM) and types of students in order to be more attractive, creative and naturally successful for all members of any educational system (Network of Science with and for Society, 2016, p.7).
Rodger W. Bybee	STEM true education should increase students' understanding of how things work and improve their use of technology. STEM education should also introduce more engineering for pre-university education. Engineering is directly involved problem solving and innovation, two subjects with high priorities on the agenda of every nation (Bybee, 2010, p. 996).
University of Minnesota	STEM integration is an innovative way of thinking about teaching math and science in K-12 has the potential to impact education in a positive way. This form of learning fosters student learning and student confidence in math and science courses(Wang, Moore, Roehrig and Park, 2011, p.11) .

Table 1 STEM definitions most commonly used.
Note: Prepared

STEM education and literacy implies that an individual operating in a knowledge-based economy, has the ability to adapt and accept changes driven by new technologies (Asunda, 2011). Many contemporary politicians consider the widespread STEM literacy and STEM specific experience, skills and human capital necessary to stay competitive today's economy(Gonzalez and Kuenzi, 2012).

Despite the evidence of the importance of strengthening areas related ECI is not until 2009 that, internationally, it begins to pay special attention to the promotion of disciplines related to this area, when the United States creates an important program to publicize Educate to Innovate, accompanied by substantial public and private investment aimed at strengthening STEM areas above (President's Council of Advisor on Science and Technology, 2010).

Despite the urgent need for trained human resources, there is a global phenomenon that indicates an important number of new researchers decreased. The phenomenon is complex, on one hand the interest in science and technology are increasing, and especially among young people and the need for professionals dedicated to scientific development (Everis, 2014)And on the other, nevertheless there is a continuing decline in students enrolled in the studies of science and technology and related professions in the same (Solbes et al., 2007).

While we have studied some factors that may be related to this remoteness, the literature is still scarce and requires multifactor analysis and targeted to specific regions and populations, to understand and attack (Aschbacher Ing and Tsai, 2014; Eng, 2014; Perera and McIlveen, 2017; Potvin and Hasni, 2014; Vazquez-Alonso and Manassero-Mas, 2015).

Research has addressed the issue of women's inclusion in these areas (Dave et al, 2010;. Sadler, Sonnert, Hazari and Tai, 2012; Wang, Eccles and Kenny, 2013)agreeing on the importance of redoubling efforts inclusion issues of scientific and technological development. Notably occupational segregation by gender is a factor that has important economic implications, and there are now fewer women choosing STEM related careers(Sadler et al., 2012).

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Some analysts say that self-efficacy, institutional culture, discrimination and bias limit women participation in science, other observers found no evidence of spread, contemporary discrimination against women in STEM fields; however, disparities mainly attributed to family formation and child rearing, gender expectations, lifestyle choices, career preferences, and personal choice, among other complex factors(Gonzalez and Kuenzi, 2012).

Moreover, the medium in which the individual (urban or rural) develops appears to be an important factor in access to opportunities for career choices STEM factor, while large cities have appropriate for study spaces and development, rural schools often face challenges that are different from non-rural schools, resource constraints are particularly acute in rural schools, and have difficulties in providing advanced courses and extracurricular programs (Burton et al., 2014).

Public policies focused on developing STEM

Public administration development has become in recent decades in one of the major concerns of governments in both developed countries and emerging economies (Hair and Ortiz, 2013). Currently, Latin American countries agree on the idea that policies of science, technology and innovation are a strategic tool that countries should care for and use in order to achieve sustainable development (OEI, 2014).

In this regard Mexico has legislated and developed various instruments to define targets to enable it achieve scientific and technological development to position themselves within the framework of international competitiveness, calling at different times of history participatory exercises for creating policies on Science, Technology and Innovation, from the 1970s to the present with the development of the Plan 2013-2037 (Casas et al., 2014) called Special Plan for Science and Technology (PECiTI) with a view to 25 years.

The agency nationwide is responsible for developing these public policies is the National Council for Science and Technology (CONACYT), created in 1970 as a public agency, a member of the education sector and serves as principal advisor to the federal executive in the matter.

The main goal of CONACYT, as indicated on their official website, is the consolidation of a National Science and Technology that responds to the priority needs of the country that a solution to specific problems and needs and contribute to raising the level of life and welfare of the population, having among its functions sectoral coordination and management of a budget branch for Science and Technology (CONACYT, 2018). This system bases its legal capacity in the Law on Science and Technology and the Organic Law of CONACYT. Based on the General Council for Scientific Research, Technological Development and Innovation, the National Conference on Science, Technology and Innovation, and the Scientific and Technological Consultative Forum AC (FCCyT) who act as coordinator and consultative part.

For its part, Chamber of Deputies of the Mexican Congress (2009) sets as its main objective the promotion, strengthening, developing and consolidating scientific research, technological development and innovation in general in the country. And has among its main activities, aimed at the topic that interests this study: linking education, productive sectors, services, technological development and innovation; increased scientific capacity and training of researchers and technologists contributing to the development of the country and improve the welfare of the population in all its aspects; and boosting strategic areas of knowledge for development.

At the state level, the CCYTET created in 1999 as a public agency of state government, is responsible for defining and implementing the scientific and technological state policy, planning, coordinating, evaluating and promoting activities related to science and technology in the state; Also encourage the training of highly qualified resources, promote research in science and technology as well as the dissemination and popularization of science(CCYTET, 2018).

However, despite advances in public policy, governance concerns focus on the lack of investment, perceived duplication and lack of coordination in the federal effort; expanding concerns participation tends to highlight achievement gaps among different demographic groups.

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One of the great challenges on the issue is the adequacy of laws to institutional design and implementation and enforcement of the same, because the main problem is how far regulations and those responsible for compliance is met(Casas et al., 2014).

While national policies emphasis on the training of human resources of high quality that enable it to successfully compete with the most advanced countries in science and technology, this is mentioned only in general terms, without specifying the elements necessary for the success of such policies (Lopez and Sandoval, 2007). For proper development of policies in this area and must take into account the basic skills are: reading, science, math and technology, these being evaluated internationally which and that the achievements of students in Latin America are well below those obtained by developed OECD countries (OEI, 2014). Statistics show that while 71% of students in the economies associated with the OECD reached above the first level levels, fewer than 40% of Mexican students reached that level, this should not be forgotten during national public policy planning and regional.

In Mexico the National Development Plan 2013-2018 is the document in which the issue of strengthening human resources is addressed, and lines of action an important link weight is between educational institutions and production centers scientific, with the public, social and private (Government of the Republic, 2013).

Among national efforts to work in training STEM Women program in STEM, Future Leaders, designed by the US-Mexico Foundation (USMF) and the Secretariat of Communications and Transportation in 2005, focused on school youth interested in is pursue careers in the area.

Meanwhile, the Government of the State of Tabasco (2006)through the Special Program of Science and Technology of the State it is committed to strengthening human capital formation that benefits the scientific and technological development of the state, and Promotion Act who emphasizes the creation and strengthening of spaces to promote , promote and disseminate scientific and technological activity, especially among young people and children.

And the creation of policies, tools and approaches to encourage new generations to take an active part in scientific activities in order to create generations of researchers. And it is the Education Sector Program that proposes to increase state educational offer undergraduate and postgraduate level as well as the participation of professionals abroad to raise the scientific and technological performance of Tabasco(COPLADET, 2013).

The CCYTET has launched various programs aimed at bringing the population to scientific and technological culture in both the rural population and marginalized or rural areas (COPLADET, 2018)Among these programs are: the Science project Movement for All and in all parts of Tabasco, the Program of new scientific and technological talents, the State Register of new scientific and technological talents, among others (CCYTET, 2018).

While in the state, an increase of interest of young people in scientific and technological activities, inefficient educational and research infrastructure is observed not paid to the development of their scientific talents; Ninety percent of public institutions of higher education do not conduct research for the purpose of technological development, since they do not have the adequate infrastructure, this situation limits to researchers for integration into national and state systems researchers, which discourages to young people(COPLADET, 2013).

In the state public institutions where there are two master's degrees, doctorates and specialties, belonging to the CONACY PNPC, the Graduate College and the University Juárez Autónoma de Tabasco taught (CONACYT, 2018)who host 75 graduate programs, occupying the 29th position nationally and positioned below states like Oaxaca, Chiapas and Yucatan those in the logares 25, 19 and 14 respectively. As for Tabasco Research Centers it is behind, counting only 9(Scientific and Technological Consultative Forum [FCCyT], 2014).

Conclusions

The importance of scientific, technological and innovation in economic development of societies progress, it has been a topic of interest to most countries, who have generated strategies to promote their growth and development.

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Without a doubt befits economies like Mexico, monitor progress in the field of major economic powers and play the strategies they have found it beneficial, such as increased investment in CTI, promotion of higher education and incentives for innovation. Encourage private investment is perhaps one of the most viable strategies for Mexico to achieve the much needed 1% of GDP investment in CTI, which would enable it to boost the training of specialized STEM human resources, thus generating greater scientific competitiveness and technology in the country.

Investing in human capital is undoubtedly necessary to achieve scientific development of the country, why should turn look to new strategies such as the promotion of literacy STEM, at all educational levels, including educational, economic strategy and social inclusion. Promote women's participation in STEM not only bring benefits in increasing indicators of scientific and technological production, but would increase wage equality in the economy, as wage inequality by gender is higher in races not STEM in the STEM careers(Sadler et al., 2012). Work programs including STEM programs for rural populations should be a subject of interest to governments.

While the country and the state of Tabasco have worked for years to generate policies that benefit the development of scientific activity, when public programs implemented in Mexico are analyzed, their non-selective, short, strong variations in the amounts distinguishes committed and changes in regulations (Olive et al., 2013)This has led to these projects remain on paper only and good intentions, without meeting the goals set and falling behind compared to major world economies.

You cannot deny the advances that have been taken in the matter, but these are insufficient to adequately compete in a globalized economy that currently live in the world, so governments should put particular emphasis on actions that allow to fulfill the goals, otherwise the lag STEM could bring adverse economic consequences.

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