STEM VISION

FOR MEXICO

STEM VISION FOR MEXICO

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SUMMARY

In this document, the Private Initiative, through its Business Chambers, in collaboration with civil society organizations that are dedicated to encourage education in Science, Technology, Engineering and Mathematics (STEM), recognize the importance of generating a culture that favors the successful transition of Mexico towards the Fourth Industrial Revolution, which is characterized by automation, analytics, robotics, social collaboration and the convergence of the physical, digital and biological spheres, all this leading to the transformation of the systems that shape our society.

The participants of this proposal, consider fundamental to consolidate a STEM culture with an inclusive vision that has the ultimate purpose of guaranteeing a sustainable and equitable development for our country. This requires as a first step, to build and share a common vision about the importance of STEM for the present and future of Mexico, and in turn, to promote a joint and coordinated effort between the public and private sectors, allowing such vision to become a reality in the different fields and contexts of our national life.

With that intention, this document suggests some key ideas to generate this shared vision, as well as the aspects to be considered in order to have the components and supplies that will allow us to provide high quality STEM education in our country, which will set the ground to successfully address the challenges that can detonate a more equitable economic growth, based on a high quality education that energizes our citizens in the search for solutions to the local and global context problems with an informed, analytical, critical and collaborative participation, that provides adequately trained human capital for the demands of today's labor markets and those to come. But, above all, these new STEM-educated generations will inject our country with innovation, a fundamental condition to become architects of our own economic dynamism and to take advantage of employment opportunities that truly provide well-being to Mexican men and women.

The Alianza para la Promoción de STEM (Alliance for the Promotion of STEM) is an initiative led by the Business Coordinating Council (abbreviated as CCE), by the Executive Council of Global Enterprises (abbreviated as CEEG), by the American Chamber Mexico (ACM), and the Chamber of Commerce of Canada in Mexico, in partnership with The Software Alliance (BSA), with the strategic coordination of Movimiento STEM, A.C., who in turn, leads the Ecosistema STEM (STEM Ecosystem) efforts. This alliance is made up by representatives of private initiative, business organizations, civil society organizations, national and international non-governmental bodies, research, entrepreneurship and innovation centers, as well as specialists in the field, with the purpose of promoting public policies and concrete actions to consolidate the STEM Education in Mexico.

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PARTICIPATING INSTITUTIONS

ALLIANCE FOR THE PROMOTION OF STEM (KNOWN IN SPANISH AS AP STEM)

LEADERSHIP TEAM

TECHNICAL COMMITTEE

A group of experts in Science Education, Technology, Engineering and/or Mathematics who collaborate closely with the design, execution, and monitoring of the objective and actions of AP STEM.

DONORS FOR VISIÓN STEM PARA MÉXICO

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ACKNOWLEDGEMENTS

STEM Vision for Mexico is a document that arises from a real and urgent concern that needs to be solved: What is the social and labor outlook to which our boys, girls, adolescents and young people are confronted? Are we preparing them to be competent in that future?

The corporate bodies, civil society and the educational institutions (those dedicated to other education fields and those dedicated to STEM initiatives) make a profound analysis and reflect on the best ways to guide education towards agile and flexible methodologies that generate a useful competencies for the future of the students.

As collaborators of this document, we appreciate the backing and leadership of Business Coordinating Council (abbreviated as CCE), Executive Council of Global Enterprises (abbreviated as CEEG), American Chamber Mexico (ACM), Chamber of Commerce of Canada in Mexico, and The Software Alliance (BSA), as well as the Strategic Coordinator Movimiento STEM for providing us with the strategic view and making us participants in the progress that will be achieved from the Ecosistema STEM and the private initiative, in the promotion of public policies and concrete actions to consolidate STEM Education in Mexico.

We also thank the institutions that in a spirit of genuine collaboration, consolidate the present document through their work within the Technical Committee of the AP STEM: Mexican Academy of Sciences, artEDU, EDACOM/LEGO© Education, Educando by Worldfund, Impact Asesores, INNOVEC (Innovation in Science Teaching A.C.), Movimiento STEM, Persiste A.C., RobotiX, Tamsa A.C. and Territorium / DELL EMC. The synergy that has characterized this workgroup, has enabled us to generate important consensus from diverse and complementary perspectives.

A particular gratitude goes to the Technical Editor, Marlene Gras (Educational Consultant), and to the Technical Advisers Juan Carlos Andrade (INNOVEC) and Carmen Villavicencio (Academia Mexicana de Ciencias, translated as Mexican Academy of Sciences) for their contributions as experts on STEM Education, whose hard work resulted in this document.

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LETTER FROM THE PRESIDENT OF THE BUSINESS COORDINATING COUNCIL

STEM EDUCATION: OPPORTUNITY FOR DEVELOPMENT AND EQUITY

As new digital technologies come up and progress, new industries and sources of employment have been established in our economy. Some years ago, we didn't know nor produced the goods that we do today, and the productive processes are completely different now: in addition to the manufacturing progresses, the digital transformation has been added to give way to the Fourth Industrial Revolution.

This reality demands more professionals who are able to create and start up efficient, fast and flexible operating processes, in which technology is indispensable. The future of our country depends on our capacity to develop new skills, especially in science, technology, engineering and mathematics areas (STEM). These are the areas that will provide new jobs in the future, will build a stronger growth and trigger social innovation.

Nowadays, countries are not more competitive because of their natural resources, but for the talent of their people. Mexico is a nation of young people who have all the potential to place us at the vanguard. To get there, it's indispensable that we join the global tendencies and strengthen the study of STEM as a motor to detonate productivity and competitiveness through our children and adolescents' talent.

From the private sector, we are convinced that employment is the only sustainable way to reduce the levels of margination and social deprivation in the population. And the only way to generate this, is by linking the needs of companies with the workers' training. Today, more than 30% of Mexican employers have faced difficulties finding workers in STEM areas. Even worse, 78% of young people are not interested in working in something related to science. That is our main challenge.

After all the benefits that science and technology have brought, the challenge that we share is to promote the study of STEM among our boys, girls and adolescents. What we would win is evident: according to the National Survey on Occupation and Employment (known in Spanish as ENOE), 8 out of every 10 highest paid jobs are related to these careers. That is why we as business sector, are committed to a change in our educational model.

We want to see young people, especially young women, working in these areas. According to the OECD, only 8% of the women choose this kind of career, in contrast to 27% of men. It's time to break stereotypes and promote a higher and more equitable participation.

To the Business Coordinating Council, STEM education represents a change in the way we see education and the way we will build the future of Mexico. The 4.0 Revolution, demands from us to look ahead, rather than cutting our view to only see the present. Today, Mexicans have to be able to solve more complex problems: transforming information into knowledge, creating new solutions to old problems of our own societies, and transforming technology into a development tool.

We are convinced that teaching our children and young people to have analytical thinking focused on problem-solving, with skills and competencies for innovation, leadership and entrepreneurship, can generate a substantial change in our society.

Mexico has the potential and the human capital to become the cradle of entrepreneurship, innovation, technological development and social well-being. It is urgent that we act, and together take Mexico to a successful, prosperous and modern future.

Juan Pablo Castañón Castañón

President of the Business Coordinating Council

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5E	Learning cycle based on the model of the 5E: Engage, Explore, Explain, Elaborate and Evaluate
PBL	Project Based Learning
CBL	Challenge Based Learning, also known as Problem Based Learning
AP STEM	Alianza para la Promoción de STEM (translated as Alliance for the Promotion of STEM)
CASEL	Collaborative for Academic, Social, and Emotional Learning
CCE	Consejo Coordinador Empresarial (translated as Business Coordinating Council)
CONACYT	Consejo Nacional de Ciencia y Tecnología (translated as National Council for Science and Technology)
INEE	Instituto Nacional para la Evaluación de la Educación (translated as National Institute for Education Assessment)
OECD	Organisation for Economic Cooperation and Development
UN	United Nations
SDG	Sustainable Development Goals
PISA	Programme for International Student Assessment
STEM	Science, Technology, Engineering and Mathematics
UNESCO	United Nations Educational, Scientific and Cultural Organization
WEF	World Economic Forum

INTRODUCTION

The acronym STEM, emerged in The United States of America, as a strategy to reduce the backwardness of that Nation in the training of human capital with talent in the application and use of science, technologies, engineering and mathematics. The concept has progressed, from being a fusion of subjects to becoming a transdisciplinary and comprehensive educational approach that combines the factual learning with the application of knowledge to real life and to the resolution of problems.

From a STEM vision for Mexico, we believe in Mexican citizens, with a rich identity slowly embroidered through centuries of cultures and through the syncretism that came with the conquest. We believe that there are many aspects that make Mexico a unique country with a leading role in today's world, as well as in STEM careers and STEM Education in the world.

Mexico is a country with great biological and sociocultural variety. Its location, complicated relief, weather and its evolutionary history have favored a variety of environments and has permitted the development of knowledge, traditions and languages that reflect our natural and cultural wealth.

The knowledge of science, technology, engineering, and mathematics has been present since our millenary cultures and we have many evidences of it. The observation and record of the stars, the use of medicinal plants, the development of the chinampas, the nixtamalization process which increases the protein value of corn (Nixtamalization, prehispanic technology, 2016), the use of zero as a number (ONCETV-IPN, 2018) and the accuracy of the Mayan and Aztec calendars (The Astronomy of the ancient Mayans: religious and practical uses, 2018), as well as the great pyramidal architectural constructions and other important hydraulic works in the basin of Mexico. All of the above illustrate the level of scientific knowledge that our pre-Hispanic cultures used to have about science, technology, engineering, physics and mathematics.

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Remarkable images remain captured on the walls of our ancient cities, many of them still buried under the vegetation, the ground or concrete, those images take us back to the richness of our ancient environment: flowers, plants, animals... we can even observe the relationship that our ancestors had with them. Our currency was once the Quetzal feathers! And currently, are there any Mexicans who are not proud of the beauty of our landscapes? We preserve rainforests, beaches, forests, deserts and semi deserts; each one of them with a diversity of flora and fauna of extraordinary beauty, that have been a source of progress for the country and especially of vital importance for our future and well-being. This great natural diversity has offered and still offers us an enormous development potential, which in turn, requires that an informed and participatory citizenry be co-responsible in its preservation and exploitation from perspectives that are complementary and enriching.

Later in our history, with the arrival of the Spanish conquerors and population, innovations were meant to adapt European technology to the needs of the so-called Nueva España (New Spain), as an example, we have the mill for sugar cane extraction; then, in the 17th century, there were some innovations and inventions, both scientific and technological, such as the aqueducts in ten convents of Mexico City. There was great interest in the "creative sciences", that is, innovation, and talented people served as teachers to the new generations.

The 18th century was characterized by the cultivation, development and diffusion of exact sciences (Llanas y Segura, 2011), and in our modern Mexico, we have important figures like Mario Molina, winner in 1995 of the Nobel Prize in Chemistry for the elucidation of the threat to Earth's ozone layer; Cristina Mittermeier, Marine Biologist, photographer and conservationist; Susana López Charretón, rotavirus specialist; Ali Guarneros, specializing in suborbital and satellite rockets of lower orbit, just to mention some examples. Thus, our scientific and technological DNA goes back centuries, and has remained with us.

Because of the strong syncretism that Mexico lived, it became an intricate and deeply interesting country, full of visual, auditory and sensory narratives; a country with many shades inside; and also a country of colors, emotions and stimulus to all our senses. Mexicans tend to be warm people and our culture has deeply rooted values, like sharing and helping. An evidence of this, is the response that we have when facing merciless natural phenomena as the ones we have lived in the last years.

We also know that Mexico is a country of big contrasts, where many people live in situations of vulnerability and inequality, where we still cannot eradicate social practices of discrimination and exclusion. And we can add that these challenges are inserted in a global context that is more changeable and dramatic than ever.

We Mexicans are all born with a strong cultural legacy that can also be observed in the ability to find creative solutions to the challenges and adversities faced. We can see that every day in Mexican workers, who are seeking to provide their families with better living conditions and well-being.

We want to promote a STEM culture with its own specific characteristics. A culture where each of us can open opportunities with the creativity that characterizes us, with well-consolidated knowledge and skills acquired from our training, that are adequate to the changes we face today. We want to intentionally promote educational strategies that help our population acquire those tools that will solve the problems of the local environment and the global community, as well as change paradigms with responsibility.

Mexico has an exceptional natural wealth. It is one of the five countries with the highest variety of terrestrial and marine ecosystems that exist on the planet. It is considered a megadiverse country because it is part of the group of nations that have the largest quantity and diversity of animals, plants and fungi, almost 70% of the world's diversity of species. Such diversity in Mexico is constituted by 19,150 endemic species, it means that they only live in our country and they distribute in a restricted way in a certain territory. Examples of these species are: the Cuatro Ciénegas Turtle, which lives in the states of Coahuila, Nuevo León and Tamaulipas; Cozumel's raccoon, the Vaquita Marina in Sonora and Baja California; the axolotl of Mexico City or the pine of Jalisco, just to mention a few (CONABIO, 2018). Our country also has 44 Biosphere Reserves inhabited by representative species of the national biodiversity, these areas are preserved, enjoyed and used sustainably; among the best known are: Sian Ka'an Reefs, the Alto Golfo de California, Calakmul, Mariposa Monarca, Montes Azules and the great Desert of Altar, just to mention a few (SEMARNAT, 2018).

Mexico is a rich country and we have exploited it as if it could never end, and because of this, nowadays, Mexico faces serious problems of environmental instability that are caused by habitats loss, introducing invading species, overuse, pollution and the effects of climate change; however, Mexico has a big potential to become, for example, an ecotourism world power. To reach this, we require people formed in different fields and ready to interact; some dedicated to research work, some others need to know how to manage STEM projects, and together understand what it means to work in the intersection between the development of a community and the environment impact it involves; they need to always be thinking of the importance of being inclusive and be able to propose the change from the status quo to a situation that benefits all of us, including the fauna, the flora and the environment that we call our country.

The characteristics of modern life, the concentration of the population in big cities, how accelerated life has become, poverty and inequality situations, are some of the motivations that encourage a STEM Education that contributes to an appropriate and quality training for Mexicans. Our girls, boys, adolescents and young people, require great dynamism at their school classrooms and outside of them so they can learn how to learn, how to question, and thus, they can return to identifying themselves with that rich identity that characterizes us. Among us, there are people who already work to make STEM a reality for everyone, some devoted scientists are in the laboratories, some others in field research, and entrepreneurs who incorporate innovation to knowledge and connect with labor markets or with the current social needs.

When STEM emerged as we understand it today, it did it in a global context: a world that has started going deep into the Fourth Industrial Revolution and how it will change the way we work, and consequently, the way we learn. A world that has increased the actions of collaboration, on the one hand, because technology has made it easier and on the other hand, because of the sociopolitical events that have shaped us in recent stages of our historical development. STEM also arose in a moment in which there is so much information that it exceeds our ability to analyze and assimilate it, blurring the clarity about its good use at the precise moment.

STEM also emerged in a moment in which we are required to move closer with sensitivity and empathy to the cultures and the environment, a conjuncture that urges us to detect the local and global challenges, and also the opportunities that lead to a collective benefit in the shape of sustainable development, elimination of poverty and well-being for all of us. It is a historical moment that has led to interdisciplinarity and transdisciplinarity, partly out of necessity and partly because of technological developments that have facilitated communication, and also as a nod to the always curious and participatory spirit that permeates STEM.

STEM, just like the arts, is enjoyed and admired, but if nobody brings us closer to them, if we can't live them, if no one teaches us techniques to appreciate them, if we only attend one class once a month, we will hardly be more than spectators of the works and admirers of their exponent, if we can even get to appreciate them. To participate of Science, Technology, Engineer and Mathematics and really be capable of studying and of using them to our favor and that of our communities, it is necessary to grow up in environments that provide girls, boys, adolescents and young people with maximum quality STEM experiences, which will lead them to a real acquisition of skills and a deep understanding of concepts, both in formal and informal environments. Therefore, STEM Education is integrative and inclusive, it strengthens people's capacities, favors a richer and more complete interaction with their environment and allows the practice of citizenship in a more informed and conscious way.

Shortly before closing the 20th century, we asked each other again as a global community: what are the purposes of education? And we reached this century, which is coming to its first quarter, with a deeper and more integral knowledge of the development of boys, girls, adolescents and young people; more integral indeed, but also with greater demands on educational systems. STEM is not exempt from this challenge: that of reaching a comprehensive development, based on knowledge and on psychosocial abilities such as the promotion of tolerance, resilience and collaborative work. A well-executed STEM Education contributes to the achievement of the purposes mentioned above.

AP STEM arises with the conviction to motivate STEM from this vision: a comprehensive education. We believe that STEM, along with ethic and social commitment, represents a seedbed of innovation for sustainability. We believe that STEM Education also represents an opportunity for equity, where we can propose actions that impact the lives of all Mexicans and with gender perspective. STEM Education, also represents the possibility to awaken the spirit of innovation in Mexico in a collective way, from the rural school classrooms to learning spaces of higher education or the technical training in large cities of the Mexican Republic. STEM also represents the opportunity to connect our communitary, environmental and innovation challenges all throughout the formative trajectory of every person and in a collective way.

Therefore, this document represents the joint effort of individuals, organizations and business that are committed to this vision and want to contribute in cooperation with Mexican society including the educational system, for it to grow and add more actors with whom to deepen and integrate STEM into the formal, non-formal and informal training spaces that exist in the country, doing it with quality and, why not? with the vision of expanding it to other latitudes.

If STEM is integrated in an inclusive way, it offers elements for society to participate by becoming a dynamic agent of change.

Finally, but not less important, we return to the relevance of STEM to have a well-formed human capital that meets the demands of the labor markets of today and those to come. But, especially, to inject our country with innovation and thus be able to become architects of our own economic dynamism and have the jobs that truly bring well-being to Mexicans.

Chart 1. What is STEM Education?

STEM Education is a worldwide trend related to formal, non-formal and informal learning. In the formal and informal education, it implies the inclusion of practices and projects that approach the **Science, Technology, Engineering** and **Mathematics** curriculum in an interdisciplinary, transdisciplinary and integrated way, with an experiential approach and the application of knowledge to solve problems. This perspective seeks to form in the individuals the key skills that allow them to manage successfully in the 21st century, as well as creative thinking, how to collect evidences and make effective use of the information and collaborative work. All of these are essential aspects for innovation, sustainable development and social well-being.

Complex problems are solved by making use of higher-order skills and knowledge and skills from various disciplines combined. When teaching and learning take place in an integrated way in formal, non-formal and informal environments, STEM Education prepares boys, girls, adolescents and young people for real and complex problems and how to solve them. It prepares them to use the knowledge, skills, and ways of thinking and solving problems that are specific to each discipline, in different contexts and situations.

As Aran Glancy and Tamara Moore explain (2013), to better understand how an integrated STEM Education exponentiates learning, let's consider that the logical, causal and deductive reasoning in Mathematics, the design and optimization of processes in Engineering, the inquiry in Science, as well as computational thinking in Technology fields, are all strategies to solve problems. Each one has its strengths and weaknesses; each one can be more adequate to solve some kind of problem than the other one. The intention of STEM Education is to learn how to use the various learnings, learning to choose when to use one of them to solve specific problems, and learning to mix them to solve more complex problems.

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CHAPTER 1. ORIGIN AND EVOLUTION OF STEM AND STEM EDUCATION

1.1. STEM IN THE GLOBAL LANDSCAPE

The World Economic Forum in its publication "The Future of jobs and skills", explains which are the trends of change and in what way: the interaction of fields that were isolated before, like biotechnology and manufacturing, among others, keep improving and increasing. Technological changes as the internet, artificial intelligence, new ways of processing Big data, robotics, the shared economy or crowdsourcing, are becoming more common. Furthermore in a wide context, there are economic and demographic conditions that have an impact on jobs, such as the middle class and young people in emerging markets, flexible jobs, women's aspirations and their incorporation to labor force, longevity, geopolitical changes, among others. New employments are being generated, but at the same time, some others are disappearing and others are changing completely; all of this very quickly. Nowadays we are living some effects of these changes but other changes are coming up in the next years. Thus, skills like flexibility, adaptability, critical thinking and creativity are now more valuable than others that used to be more appreciated. To an individual level, these changes can be felt at a higher speed. Being able to change a group of learnt skills or make them evolve is more urgent.

Currently, when studying or using Science, Technology, Engineering, and Mathematics in an interdisciplinary and transdisciplinary way, keeping the richness and singularity of every field of study while enriching and expanding them, is closely related to innovation because when these fields expand, we discover convergent aspects that were unknown or we form new interactions. For example, from the interaction between biology, technology and medicine, we have stem cells transplant, or we have the possibility of trying to save an endangered species like the northern white rhino, from a laboratory that is not in Africa but in Germany, and with funds raised collectively. In that way, the economy is also driven by ideas and not only by products.

According to the OECD, innovation, patents, research and development are related to the economic development of nations (OECD 2012).

Public and private investment in research and development is considered in many countries to be largely responsible for the progress in both the economic sphere and the social welfare of the population.

A key historical moment of the emergence or the recognition of STEM, was the time when the world pursued the conquest of space. The launch of Sputnik in 1957 by the Russians, and a few years later, the conquest of the moon by the Americans in 1961. Going to space was a feat that required a deeply scientific and technological approach, of colossal engineering and pure Mathematics, coexisting and generating a shared space, all of this in pursuit of a common goal.

And so, the world kept on turning and the computers, cellphones and smartphones appeared, and so did extraordinary advances in scientific fields of medicine which were combined with biotechnology, genetics, nanotechnology and more. Recently, probes and robots built by humans arrived in Mars, they are exploring it through technology and we are observing it through a high definition TV, and at the same time, scientists are proposing the presence of life in that distant planet and searching for water. Despite these vertiginous advances, humans have not been able to include everyone in this development we have called prosperity.

Sometimes, STEM has taken a heavy toll, because it has not always been linked with universal values and aspirations, such as equity, social inclusion and social justice. It has also been stripped of some attitudes that should always come with it, such as the respect for human rights and individual guarantees, as well as its focus on contributing to community development, promoting inclusion and respecting the environment. Thus, the potential of STEM has been overshadowed by a circular and self-referenced notion, which seeks innovation, technology, engineering and science by and for itself. But now, more and more people recognize that STEM has an extraordinary potential to solve social, local, global and environmental problems, if applied from a comprehensive and communal vision of the human being.

Manpower Group (2018), insists in its various reports, that we are in the midst of a revolution of skills, and at the same time, living the digitalization phenomena to which no country is immune. As industries migrate to automatized and more advanced processes, the employers need more people to inspire this transformation, especially people with Information and Communication Technologies skills (TICs), so most of the companies hope to grow instead of reducing their labor force as a result of digitalization.

People are required to learn to think differently. In this digital world, success doesn't always come with a university degree, but it depends largely on the will to get a continuous development of skills. Feeding curiosity and skills is essential so people learn how to learn, and so remain employable during long periods in their professional careers. The world faces the definitive challenge of helping people excel and prepare for the future in record time. New technologies could be expensive and may require people with special skills, so employers are still hesitant to implement automation and manage without workers (Manpower Group 2018).

From a total of 18,000 companies in 43 countries, 62% do not expect that automation or digital technology will affect their workforce in the next two years, and 20% have the expectation that it will help them increase recruitment levels. However, companies are anticipating change: about two thirds are investing in internal training to maintain skills up to date, 42% are recruiting people with additional skills instead of replacing them and more than a third are facilitating transformation when hiring external experts to transfer skills to current employees (Manpower Group 2018).

With the outlook before mentioned, a common vision that originates concrete actions is required. Mexico is not alone in this challenge. Some countries in the European Union, Israel, the United States, Canada, all of them have launched initiatives to encourage a robust STEM Education culture nationwide, with expectation to form citizens with knowledge, skills and attitudes that are necessary to compete in the current labor market, and so create jobs that require more advanced skills. In Finland, for example, a network named Luma[1], integrates the efforts of universities and public sector as an ecosystem to move forward on STEM and make it a reality for Finnish students, by encouraging research, national and international participations, and collaboration between educational institutions, from preschool to higher education, along with the education sector, the media, the business sector, teachers associations, museums and other relevant organizations in the country.

Another example is the United States, where we find initiatives that emerge from the workforce development, with education linked to the local businesses, such as *STEM Learning Ecosystems*,[2] which from civil society seek the inclusion of women in scientific careers, and non-formal education oriented to STEM. Likewise, efforts are made from public agencies, such as The National Science and Technology Council, which recently published the document *Charting a Court for Success: American Strategy for STEM Education.*[3] As additional examples, in 1986 in France, the Union of Teachers of Science, Technology and Industry was created. In The Netherlands, *The National Platform Science&Technology,* and in England, STEM Learning is a network specialized in bringing quality STEM Education to young people. Ukraine, Turkey, Australia and many others, have intentionally set up a network that encourages quality STEM Education and its relationship with the labor sector. In Latin America, the German Foundation Siemens Stiftung, encourages a network to learn about practices and achievements around STEM.

Mexico, and other OECD countries, discuss actions to generate a strategy of skills development[4] which encourages lifelong learning; it is based on the sustainable development of countries and includes concrete studies on their specific national needs, according to priority economic sectors and the search for equity and inclusion. In this sense,

> The countries that are more successful in mobilizing the potential of their people's skills, share a number of characteristics, as they: provide high quality opportunities to learn throughout life, both in and out of school and the workplace; develop education and training programs that are relevant for students and the working market; create incentives and eliminate the lack of incentives for the provision of skills in the workplace; recognize and make maximum use of the available skills at workplaces; they seek to anticipate future needs for skills and they make it easier for population to locate and use information about the labor and learning markets. (OECD, 2017).

1. EU STEM Coalition http://www.stemcoalition.eu/members/luma
2. STEM Learning Ecosystems http://stemecosystems.org
3. https://www.whitehouse.gov/wp-content/uploads/2018/12/STEM-Education-Strategic-Plan-2018.pdf
4. OECD Skills Strategy Diagnostic Report-Mexico

The acronym STEM (from the words Science, Technology, Engineering and Mathematics, started being used in the educational community in the 90's. Since then, its use has been expanded continuously nearly covering everything related to these areas. "The term is very popular and there is no single nor universal definition for it." (Vilorio, 2014, cited in Andrade, 2018). Experts generally agree to define STEM as a field of human activity where Science, Technology, Engineering, and Mathematics converge to try to understand how the natural and social worlds wok or to solve a common goal (Andrade, 2018).

Since all knowledge that has served humanity to improve transport, communication, agricultural production, medicine, and health, fundamentally comes from the development of Science, Technology, Engineering, and Mathematics, it is essential that in educational spaces, teachers and students understand the nature of the knowledge that is being generated from these disciplines, their scope, interactions, limitations and values. It is important that STEM practices are carried out from childhood and keep complexing their competencies throughout their academic and professional training.

Likewise, it is equally useful to know how such knowledge can be used to find practical solutions to present problems. Integrating these disciplines on STEM practices is a contribution from education to create a critical mass of people prepared to find solutions to everyday problems that afflict us, such as climate change, food demand, the cure of some diseases like cancer, among many others (Andrade, 2018).

Since the emergence of the idea of STEM as an interdisciplinary, transdisciplinary and integrated concept and its impulse through education, initiatives have emerged to add other letters that emphasize other relevant and key areas of human development, such as "L" for Languages, "H" for Health, "S" and "E" for socio-emotional learning, and especially the "A" for Art or Arts, becoming STEAM.

However, in this document, we keep the STEM concept without adding any other field like arts, not because we consider the contribution of other disciplines and fields of knowledge is not relevant, but because talking about art is talking about fine arts. Art in essence is the refined and free capacity of individuals to create, even within the limits of the impossible. STEM, just like art does, develops with the creative potential of ideas, however, we doubt that when promoting STEM, we are training in the arts, which are free, subjective and valuable, even in the absence of consensus or collective validation.

Adding disciplinary fields to the concept of STEM, has changed the emphasis that we need to print on STEM Education, which is the Fourth Industrial Revolution, the need for technicians, engineers, scientists, and professionals from STEM fields, all of them, formed and specialized to respond to all demands of the new economic paradigm, as well as the need for citizens with STEM skills that allow them to insert into the emerging labor markets.

That is why we chose to keep the acronym STEM (see figure 1), recognizing at all times, that the education that we provide to our children and young people should be comprehensive and consider all aspects of the human being (see section 4.5). Also recognizing that the Arts (which include Music, Dance, Theater, Painting, Sculpture, Cinema, Visual Arts, etc...) and Language, all of them are vast fields and so rich that they deserve their own spaces. We should understand that they have their own teaching strategies and they deserve a specific training; that doesn't mean that they cannot converge in some spaces and in a transversal way. So, if we say STEM or STEAM to emphasize the aspect of creative thinking, which is so central for STEM or to underline the importance of including aesthetic elements, we do not find any inconvenient, as long as the focus is on STEM and the Arts are provided with their own space, keeping all their richness.

Chart 2 specifies the fields of study that make up STEM.

Chart 2. STEM components

Science allows us to develop our interest and comprehension of the living, material and physical world and to develop collaboration skills, experimental and critical research, exploration and discovery.

Engineering is the method of applying scientific and mathematical knowledge to human activity, and **Technology** is what is produced through the application of scientific knowledge to the solution of a need. Both of them, cover a wide range of fields that includes business, computer science, chemical products, food, textiles, craft, design, engineering, graphics and applied technologies, including those related to construction, transportation, built environment, biomedical, microbiological, and food technology.

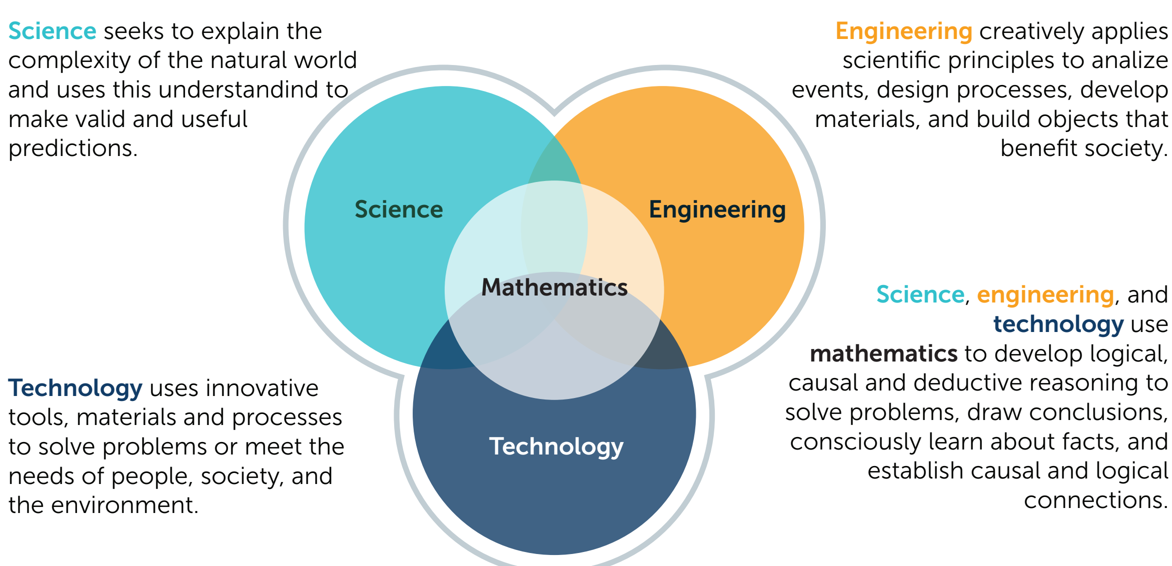
All STEM strategies are based on **Mathematics**, which include numerical ability, and provide us with the skills and the approaches we need to interpret and analyze information, simplify and solve problems, evaluate risks and take informed decisions. Mathematics and arithmetic develop skills and capacities that are essential for life, participation in society and for all jobs, careers and occupations. In addition to providing the basis for STEM, the study and application of mathematics, is a vast and critical discipline in itself with wide ranging implications and values.

Digital Skills also play an important role in society and in the economy, and act as an enabler for other STEM disciplines. Just like mathematics, digital skills and digital literacy are essential for the participation in society and in the labor market. Digital skills cover a spectrum of skills in the use and creation of digital material, from digital literacy, data management and quantitative reasoning, problem solving and computational thinking, up to the application of more specialized computer science knowledge and skills, that are needed in data science, cybersecurity and coding. Within the digital skills, as we mentioned before, computer science is a different discipline and subject.

Source: Science, Technology, Engineering and Mathematics (STEM) Evidence Base, 2017.

The study fields that compound STEM converge with each other. When it happens, they enrich each other.

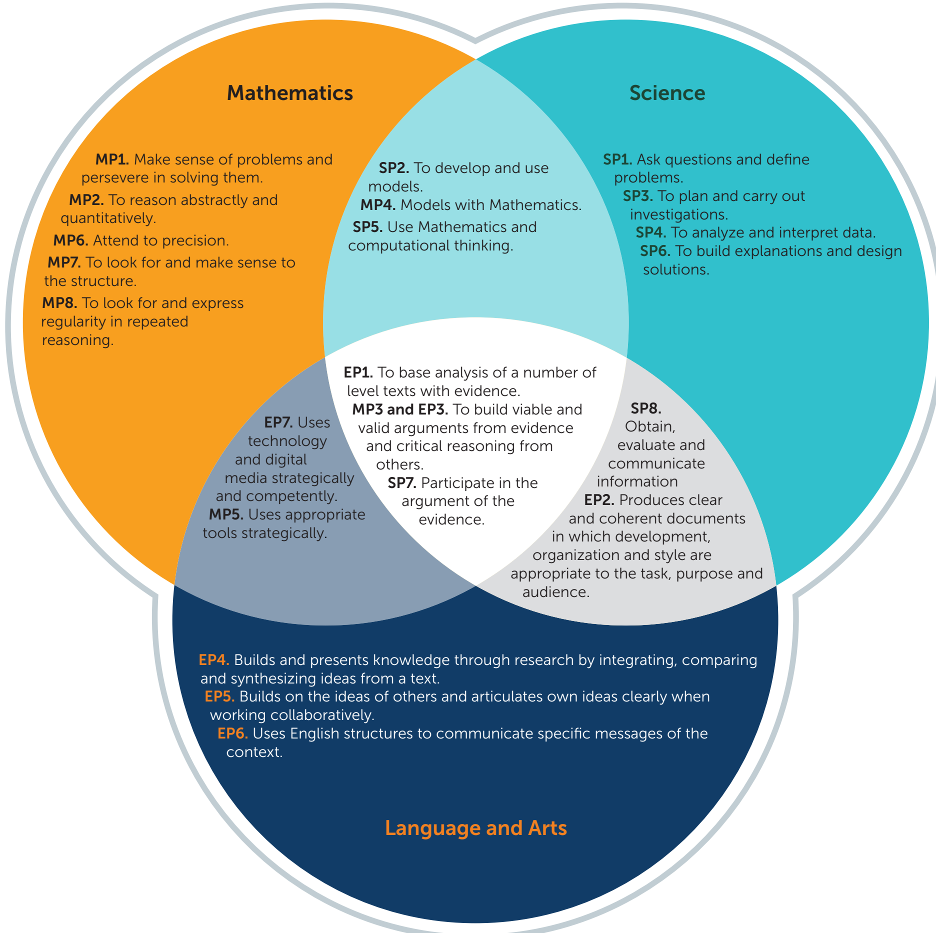
Figure 1. Convergence of disciplines that make up STEM



Source: Massachusetts Department of Elementary and Secondary Education, 2016.

On the other hand, and as we can see in figure 2, it should be noted that Science and Mathematics converge abundantly in key competencies for the 21st century and the Fourth Industrial Revolution, but clearly, there are reading and arts skills that are necessary for the practice of STEM.

Figure 2. Convergence of Science and Mathematics Competencies, with Language and Arts[5]



Source: NGSS&NSTA, 2017.

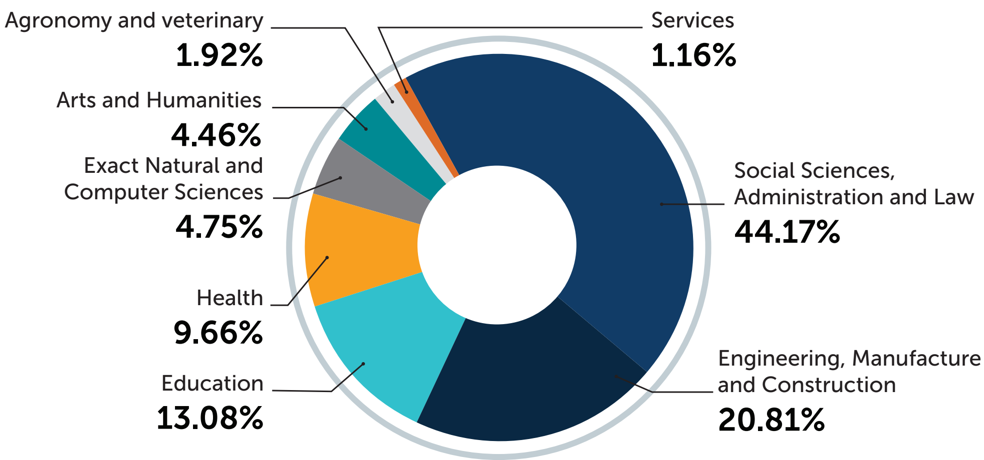
In the same way, socio-emotional skills, although not specified in this figure, can be found with an analytical reading of it. For example, in order to elaborate on the ideas of another person, it will be necessary to be able to listen to points of view with tolerance and wait for one's turn to participate in a self-regulated and cordial way. To be able to express our own ideas, it is required we know ourselves. We can also clearly see the convergence of many other cognitive skills which must be formed through the educational path, not only through STEM subjects.

1.2. STEM IN MÉXICO

Today, Mexico faces the Fourth Industrial Revolution, and so does the rest of the world, and in a special way, we know that Latin-American countries have not yet effectively integrated STEM Education and that young people prefer Social Sciences. To learn about this, we can clearly see in figures 3, 4, 5 and 6, the stronger inclination towards the study of social science in bachelors' degrees, specializations, masters and doctorates in Mexico. The number of graduates of specialties, degrees, masters and doctorates in the science field, is in all cases much higher for social sciences than for STEM careers.

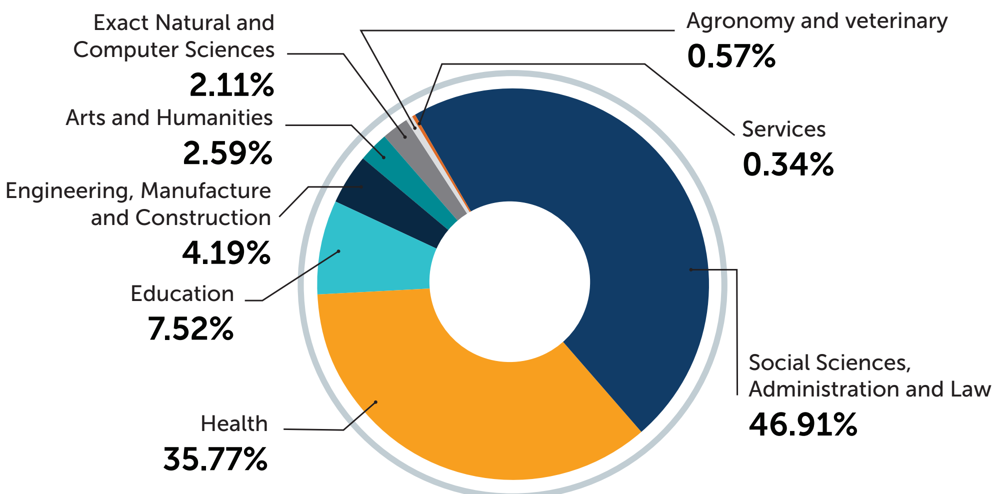
5. English Language Arts (ELA)

Figure 3 . Percentage Distribution divided into fields of Science: Bachelors degree, 2016.



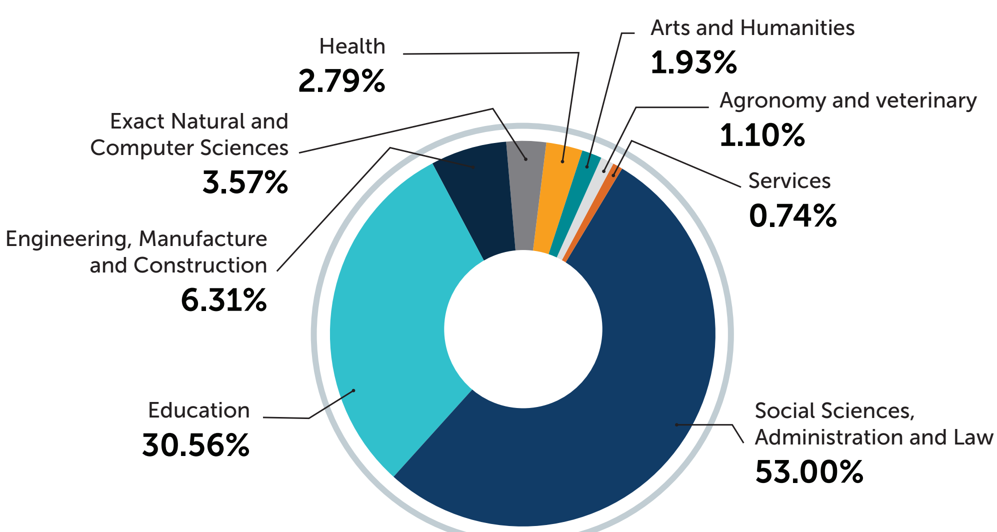
Source: CONACYT, 2016

Figure 4. Percentage Distribution of graduates divided into fields of science: Specialization, 2016



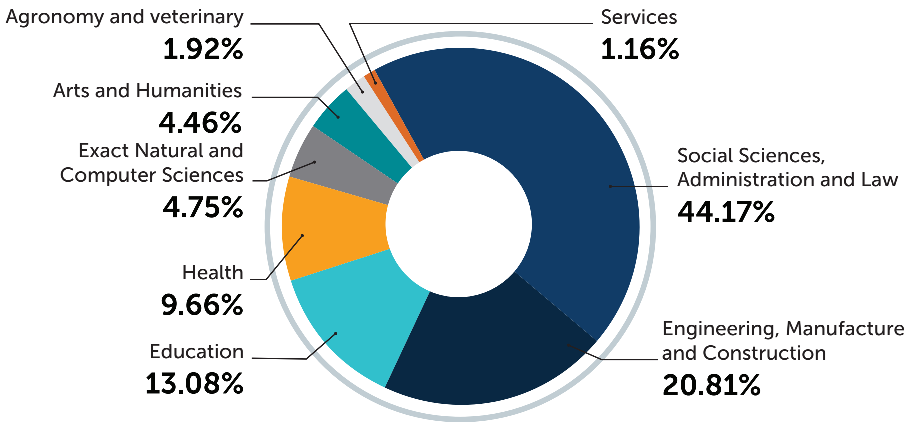
Source: (CONACYT, 2016)

Figure 5. Percentage Distribution of graduates divided into fields of Science: Masters degree, 2016



Source: (CONACYT, 2016)

Figure 6. Percentage Distribution of graduates divided into fields of Science: Doctorate degree, 2016



Source: (CONACYT, 2016)

Although it is true that in our society we need profiles with deep education and knowledge of the Social Sciences, the global context demands from us an urgent push to STEM careers. It is essential to stimulate curiosity and provide inquiry tools to Mexicans from a young age. It also means creating educational and strategic trajectories and generate information about the employability conditions offered by diverse careers, so young people can make informed decisions about their future in order to manage their aspirations based on evidence.

Furthermore, Mexico requires to encourage the election of STEM careers, and also the inclusion of more women in them. According to the Statistical Annuals of Higher Education (ANUIES, 2016-2017), the percentage of men in STEM careers, was about 54%, while for women it was about 38%. This also affects the salary gap between Mexican women and men, because according to the Labor Observatory of the Ministry of Labor and Social Welfare, we observe that engineering careers pay 32% more than careers in the educational area, and the careers in physics and mathematics pay 19% more than the national average (Gómez, 2018).

A statement from the Senate of the Republic (2017) mentions that: *"According to the Statistical Annual of the National Association of Universities and Institutes of Higher Education, during the decade of 1990's, the percentage of women studying Mathematics went from 17.3% to 32.9%, engineering from 15.7% to 23.6%, biology from 20.8% to 49.7%, and chemistry from 42.6% to 52.3%"*. Nevertheless, the distribution within the same disciplines still determines the participation of men over women more strongly, and in general, men are assigned much more technical social roles than women. (Robotix, 2018).

The Gender Equality Observatory of Latin America and the Caribbean, states that *"although this numbers seem very promising for our region, women focus on disciplines related to roles culturally assigned for women and are under-represented in engineering and exact sciences, as well as in leadership positions"*. (Robotix 2018).

According to Valero et. (2017), there are several studies that show that *"students begin to lose interest in science in the last years of elementary school or in the first years of secondary school, and when they get to high school, they select itineraries of social and legal sciences to the detriment of the experimental sciences and engineering (Murphy and Beggs 2003; Fesham 2004; Vázquez and Manassero 2005; 2008; 2012; Chen and Weko 2009; BØE 2012; Jeampierre-Hallett-Njuguna 2014). There are other determining factors in the choice of degrees that are not experimental sciences, such as teacher motivation, proper planning of content in science or secondary and high school studies curriculum"*.

And precisely, the challenge does not start when choosing a career, but during the first years of mandatory education. According to the results of PISA 2015, "Mexico's performance is below the OECD average in science (416 points), reading (423 points) and math (408 points). In these three areas, less than 1% of students in Mexico achieve competence levels of excellence (levels 5 and 6) (OCDE, 2015, p. 1).

On the other hand, *"on average, Mexican boys get higher results than girls, in the evaluation of science, but there is a similar percentage of boys and girls with low and high performance. Around 45% of the boys and 36% of the girls have the expectation of working in an occupation related to science when they turn 30; in both cases, these results are significantly above of the OECD average"* (OECD, 2015, p.1).

It draws attention, and it could be an opportunity that *"students in Mexico show high levels of interest in science compared to students of the same ages of other OECD countries, either measured through their expectations of having a professional career related to science, or on their beliefs of the importance of scientific investigation or on their motivation to learn about science. However, these positive attitudes are weakly associated with the achievement of students in the area of Mathematics"* (OECD, 2015, p.1).

When the results are seen from equity: *"in Mexico, 11% of the variation in performance in science is attributable to differences in the socio-economic status of students; students with socio-economic disadvantage are more than two times more likely to not reach the basic competence in science than others with socio-economic advantage. In both cases, the relation between socio-economic status and the academic performance is weaker in Mexico than the rest of the OECD countries, on average"* (OECD, 2015, p.1).

If we think about the possibility of generating innovation, PISA 2015 shows us that *"around 8% of students from OECD countries reach levels of competence; this means that these students can apply their scientific knowledge and skills in a creative and autonomous way in a great variety of situations, even in instances that are not familiar to them. The proportion of Mexican students who reach those levels (0.1%) has not significantly changed since 2006"* (OECD, 2015, p.2).

Clearly, this data sets off alerts about the future we want for Mexico.

On the other hand, we reflect on the importance we have placed in the summative and standardized evaluation, and even though it has been very positive in many ways, teachers and schools have put all their efforts in aspects that are very far from innovation and inquiry. But we have to focus on "how to" and not only on "what to". "How to" are the teaching methodologies, that need to be dynamic, active and based on meaningful learning. The World Economic Forum emphasizes some integrating methodologies that truly lead to competences acquisition, such as active learning, learning by challenges and Project Based Learning. When these pedagogical methodologies are applied, it is also possible to make sure that knowledge is obtained, because carrying out a project in an accurate way, requires the acquisition of knowledge and the use of skills that are obtained when dealing with a specific issue or problem. It is not about answering a test. As these methodologies are integrative, they contribute in a substantial way to the socio-emotional skills. And finally, they help break the walls that divide schools from the real world, one that is waiting for our girls, boys and young people we are preparing.

Innovation and productivity of the Mexican economy will depend largely, on people with the necessary skills and knowledge to face markets that are more demanding, with more information and complexity. For this reason, it is necessary that men and women have a correct educational background from an early age and through their lives. This education should include skills developed in science, technology, engineering and mathematics, all this on equal conditions. (Gómez, 2018).

Regarding innovation, we need to reach an intersection and connection between the academic, entrepreneurial and the market sectors. Mexico still has a long way to go in this subject: from the public sector (see table 1), considering investments in research and development in universities, published research works and lifelong development strategies throughout life; and also the private sector requires to put greater emphasis on the promotion of patents, investigation and development (OECD, 2016). To achieve this, it is necessary to have people with STEM competencies developed from the Educational System, such as critical thinking, creativity, problem solving, data literacy, communication, collaboration, digital literacy and computer sciences.

When comparing the expenditure of Mexico with other countries, some of them with a similar GDP, our commercial partners and others of the same region, we realize it is necessary to reconsider priorities to encourage the development of our country and be really competitive.

Table 1. Percentage of the GDP in research expenditure in Science and Technology

Country	Percentage of the GDP
South Korea	4.3%
Israel	4.1%
Japan	3.6%
Germany	2.93%
Switzerland	2.9%
The United States	2.7%
France	2.22%
Australia	2.11%
China	2%
Canada	1.71%
United Kingdom	1.70%
Italy	1.33%
Brazil	1.2%
Russia	1.10%
Turkey	0.88%
South Africa	0.73%
Morocco	0.7%
Colombia	0.67%
Argentina	0.63%
Mexico	**0.53%**
Chile	0.36%

Own elaboration based on data from The countries that invest the most in research and innovation, 2018; UNESCO, 2016; Colombia, far from reaching the goal of investment in science, 2018.

The number of patents postulated by Mexico in a comparative perspective, is not encouraging: Intellectual Property Office in China, received 1.3 million applications in 2016, more than the combined sum of the patents presented in the office of The United States of America (605,571), Japan (318,381), Korea (208,830), and Europe (159,358); the sum of all of them represents the 84% of the requested patents in 2016 all over the world. According to CONACYT data, in 2016, the patents applied for in Mexico totaled 17,413, of which 16,103 were carried out by foreigners and 1,310 by nationals (CONACYT, 2016).

Technological, social, geopolitical and economic disruptions, will become important challenges to recruit, train, and manage the talent (Schwab, 2016). For this reason and with the data mentioned before, we are convinced it is a priority to have high-quality STEM Education that is aligned to the national strategies of innovation, development, and investigation, and all of them need major attention.

1.3 WHY SHOULD WE HAVE A STEM TEACHING/LEARNING PROCESS?

The key to achieving these competencies, is to generate active and creative learners interested in learning; which implies putting pedagogical principles into practice in classrooms and schools to promote the renovation of learning environments and to provide an active, situated, self-regulated, goal directed, collaborative learning that facilitates the social processes of knowledge and those of the construction of significance. (Villavicencio, 2018).

There are several challenges to achieve the integration of STEM practices in the classroom (Andrade, 2018):

- Teacher's profile and preparation in elementary education.
- The pedagogical approach.
- The use of technology.

To face the integration challenges of the STEM practices in classrooms, the AP STEM proposes the 5E Model, which is an effective tool to give pedagogical certainty to STEM practices and make them compatible with the pedagogical theory, validated by educational research.

There have been discussions about the importance of creating an intersection between the academy, the business sector and the market to generate innovation.

According to Valero et al. (2017):

> "The importance of encouraging and changing teaching models in schools is fundamental if students are to be guided in these scientific and technological studies. Active learning, interactive science programs, scientific games of reflective training by age groups and many techniques that help students, teachers and science interact. It is important that teachers in charge of science programs and subjects present the corresponding qualification or at least have a scientific training, otherwise they will hardly be able to teach science. Finally, in this sense, motivation and the academic background of teachers is very important, otherwise, it will seem like just another job position, and education is more than that".

For this, it is important to introduce methodologies such as inquiry and Challenge or Problem Based Learning and Project Based Learning (PBL)[6], in the education experience, adding design thinking to these methodologies, as a technique to generate innovative ideas that focus their effectiveness in understanding and giving solutions to real situations with a focus on users.

When these strategies are integrated to STEM Education, the work becomes easier and so does the acquisition of STEM competencies in an integrated way, allowing students to become more participative, proponent and creative, instead of just being receivers. Furthermore, developing socio-emotional skills turns easier. According to the World Economic Forum, strategies as Project Based Learning, are especially useful for the acquisition of competencies of 21st century, so relevant to face the labor demands of the current world and those yet to come (Arteaga y Gras, 2018).

For a young or an adult person to be able to propose changes of paradigm, they need to live them. Classrooms and schools are propitious spaces for this, because they allow the person to build their learnings by gestating and managing projects to make them a reality. In this sense, teacher training becomes indispensable.

We know that acquiring competencies is a progressive and organic process, covering all the curricula that brings us closer to knowledge, skills and attitudes, but it is only reached if they are combined and used to solve complex problems. We also know that it can be hard to evaluate the acquisition of competencies, because we can only observe and measure their manifestations (actions, behaviors and choices). Because of that, Wienert and Oates suggest three practical strategies to bring the evaluation as close as possible to the demands of real life (Wienert, 2001 and Oates, mentioned in Rychen and Salganik, 2001, p.55):

1. Using a wide range of materials of real life.
2. Validating evaluation results to show that they predict successful performance outside the evaluations.
3. Design evaluations that include different contexts and situations that require individuals to adapt themselves to the demands or requirements of life that are similar to the context of the evaluation.

Therefore, the execution of a project, the resolution of a problem and inquiry, allow students to crystallize their competencies, and also teachers and students are able to evaluate that these competencies were acquired. This thrusts a more genuine educational experience, triggering concrete elements for its evaluation.

Experiential learning, and especially the one regarding a problem or a project, is a natural enabler of socio-emotional skills, since it favors the reflection, election and resolution of problems, self-regulation, team work, detection of proper tools and support inside and outside schools, as well as the respect for own opinions and those of others, among many other.

Chart 3. Essential factors to make STEM Education a reality in the Mexican School

Considering all the above, for the implementation of the STEM approach in education, it is essential to:

- Transform the pedagogy that takes place in classrooms.
- Work systematically in training teachers giving them better pedagogical tools that allow them to improve the educational labor and enable them in their professional skills for the implementation of a STEM approach in teaching.

STEM practices contribute favorably to transform the way teaching and learning take place in schools.

6. Both Challenge or Problem Based Learning and Project Based Learning (PBL), work towards the construction of learning through the resolution of a problem. Both follow specific steps, but the first one stands out for being more prescriptive and it reduces to a problem situation. The second one is usually more complex and requires the resolution of many problems, as well as an extensive investigation, as well as iterations that are shaping the final product or project. In addition, Project Based Learning is usually performed during longer periods of time, although the solution of a problematic situation can also be extended over time. PBL usually requires a more interdisciplinary approach. It usually starts with a detonating question and authentic and real situations, whereas Challenge or Problem Based Learning can start from real, hypothetical or imaginary situations. Both approaches promote active learning and the development of skills and competencies of the 21st century and are focused on students. (Cambpell, 2014; Lamer, 2015).

1.4 STEM IS INTERDISCIPLINARY AND TRANSDISCIPLINARY, CONNECTION OF SCHOOLS WITH THE COMMUNITY/ BUSINESS SECTOR

According to Zamorano, García and Reyes (2018):

> The 21st century is characterized for being a world full of dramatic changes, all of them linked to hyper connectivity, development of artificial intelligence, robotics and automation.
>
> This context progressively leads to the development of a dynamic, connected and instantaneous lifestyle, with existence models, jobs and challenges that will probably be different in the future, compared with the present scheme. While these changes are produced, so is the generation of specific pedagogical configurations that allow to attend to the development of prepared individuals (Leong 2017, mentioned by the authors) prioritizing the development of skills that favor lifelong learning and communication with others (Trilling and Fadel, 2009, WEF, 2015), rather than the accumulation of vast contents.

In that way, the treatment of a STEM approach in the classroom has to do with school organization, learning environments, pedagogical model and the interdisciplinary and transdisciplinary collaboration. For the STEM approach to be a reality in schools, the education policy should promote improvement in these intervention areas.

Regarding the scholar intervention, STEM approach and practices, demand a school that is open to community, where teaching is linked to real day-to-day problems and challenges for students. On a STEM learning context there must be a greater interaction with the productive sectors of investigation and recreation. This demands openness from the educational authorities at all levels of hierarchy and above all, from school management and supervision. In an environment where everything is open, school cannot remain closed.

In this way, learning environments have to be motivating for students and the content that is taught has to be significant and interesting. This connects to the pedagogical model, which in the case of STEM, must be active, constructivist in its most intimate essence and teachers have to fully understand that the pedagogical principles must rule in each learning stage, and in consequence, they should reconsider the function of the formative evaluation to assess his or her students' performance under criteria that really help them identify the flaws and the opportunity areas.

If teaching is taking place under a different approach, it cannot continue to be evaluated the same way. Achievements, competencies, results, designs, communication and creativity have to be taken into account. All of that goes beyond a simple conceptual examination. To get there, a good disciplinary formation for teachers is essential. A STEM practice cannot be introduced if the knowledge involved with these disciplines is not clear, if what is taught or what is expected from a practice or project is not well understood. Therefore, a disciplinary formation in all levels is fundamental.

Another challenge is collaboration. Generally, Mexican teachers are used to working only with the information they studied, imparting educational contents of the subjects without linking what they teach with the rest of the curricula. STEM practices demand an educational planning articulated with the rest of the disciplines. This forces teachers to be open to a joint creation, collaboration, constructive criticism and not being afraid of failure of their attempts and experiences. This makes emotional education necessary not only for students, but for teachers. This is a critical aspect to consider, and so are collaborative spaces within the scholar schedule and through digital media, and the collaboration culture among teachers.

Being the nature of STEM a transdisciplinary and interdisciplinary education, it is important to remember that in schools, subjects are taught with specificity in preschool, Exploration and Understanding of the Natural and Social World; in elementary school, Knowledge of the Environment and Natural Sciences; and in secondary and in higher education: Biology, Chemistry, and Physics. While it would be desirable to have more non-formal training spaces where boys and girls could incorporate more skills, such as robotics or science workshops, the reality of the Mexican school is still far from that. This is not about proposing the inclusion of 5 subjects in each grade. It is about finding and providing teachers with practical ways of continuously creating interactions at the same time they acquire and delve into concepts of each discipline in particular. Here we might have room to focus choices collectively by school or teacher specializations, for example: a Biology teacher might be interested in Robotics and he or she could include topics of it in the form of challenges or problems related to biotechnology. But in high school and especially in tertiary levels, the key will be the flexibility of the system for the acquisition of skills, so these interactions and STEM trajectories can be generated in a more spontaneous way and like us, adapt to the needs of the market.

There is a still a lot that needs to be explored and encouraged about linking Companies-Industries-Work Centers-Museums-Public Spaces to schools, in order to allow the development of skills, but also, to inspire and guide through mentoring, visits, internships, etc. In short, for each educational level there are practices with evidence that will guide the initiatives that we promote.

STEM VISION FOR MEXICO

CHAPTER 2. THE HISTORIC MOMENT OF STEM

2.1 STEM AS LEVER FOR DEVELOPMENT

We are facing a complete transformation on a global scale. According to UN, the generations between 9 and 19 years old could be the first ones that are able to end extreme poverty and the last ones that can end climate change (Ki-moon, 2015), that is, if we cannot influence these generations, we will simply as humanity, not have achieved it.

2.2 SUSTAINABLE DEVELOPMENT GOALS OF THE UN 2030 AGENDA

As a global community, we face great challenges. Just to mention some[7]: *13 million hectares of forest disappear every year and the persistent degradation of arid zones is also causing desertification of 3.600 million hectares. Although 15% of the Earth is currently under protection, biodiversity is still at risk. Deforestation and desertification, caused by human activities and climate change, pose big challenges for sustainable development and have affected life and livelihoods of millions of people who are fighting poverty.*

Furthermore, *"carbon dioxide emissions (CO2) have increased almost 50% since 1990; energy is the main contributor to climate change and represents about 60% of all global greenhouse emissions"*. In addition, *"3.000 million people, 50% of them from Sub-Saharan Africa, still cook with highly polluting fuels and poorly efficient technologies"*.

The rapid decline of biodiversity, has left millions of people without access to vital food and plants they depend on to produce medicines, and the overexploitation of the seas will soon result in a shortage of protein for millions of people.

Many of these challenges we face as humanity, promise to find a solution through multidisciplinarity. When STEM and community development strategies combine, solutions from a small to a large scale can be found to really complex problems. For example, the Sustainable Development Goals, (SDG) indicate that *"if a wide range of technological actions and changes in behavior are adopted, it is still possible to limit the increase in world average temperature at 2 Celcius degrees above pre-industrial levels"*. SDG also indicate that *"thanks to the great institutional and technological changes, there will be a greater opportunity than ever, for global warming not to exceed this threshold"*. So, it is clear that STEM education is a strategic decision to work towards the sustainable Development Goals of the UN's 2030 Agenda.

2.3 THE FOURTH INDUSTRIAL REVOLUTION

The diverse revolutions that have existed all around the world, have had an impact in society, jobs and people. Although it is not recognized as the first one, we could say that the precursor of these revolutions was the use of fire by humans. The first revolution started with the development of steam engines, resulting in the shift from manual to mechanize production between 1760 and 1830; the second, brought electricity and mass manufacturing around 1850. For the third one, we had to wait until the middle of the 20th century; and it brought electronics, information technology and telecommunications. And finally, the one that concerns us, the fourth, brings the trend of total automation of manufacturing. Each one has brought a profound economic, social and geopolitical transformation.

7. Relevant information from The United Nations Sustainable Development Goals

Chart 4. What is the Fourth Industrial Revolution?

According to Schwab (2016), Executive Director of the World Economic Forum, "The Fourth Industrial Revolution is not defined by a group of emerging technologies, but by the transition towards new systems that are built over the infrastructure of the digital revolution (Third Revolution)".

The Fourth Industrial Revolution permeates all systems of our society, including the work centers, industries and the lives of people with the following elements:

- Analytics and Big data
- Physical, digital and biological spheres
- Artificial intelligence
- Internet of Things (IoT)
- Robotics and automation
- Mobile Technology
- Social Collaboration

The velocity, reach and impact in the systems, are the three aspects that prove that we are talking about a new industrial revolution, and not about a previous one.

Of course, this Fourth Industrial Revolution brings along benefits such as reducing production costs and processes, the possibility to further personalize products and services, and the remote monitoring of many processes. This will also generate big challenges as it substitutes labor force with robots. Therefore, some job positions will disappear and completely new positions will emerge. This revolution will also imply a robust capacity for adaptation to change and the ability to continue to learn throughout life.

Its effects are already tangible in our country: more than 50% of Mexican employers have faced difficulties in finding the necessary profiles to occupy vacancies in STEM areas, according to the Survey of Talent Shortage of Manpower Group, 2018.

According to the INEGI Occupation and Employment Survey, 8 of the 10 best-paid jobs are STEM careers (Clark and Molano, 2018), however, 50% of graduates choose only between 9 careers and only one of them is STEM. This phenomenon becomes more critical when analyzed under the gender perspective, as according to the OECD, in Mexico only 8% of women choose this type of careers, compared to 27% of men who choose them.

Chart 5. STEM competencies for the Fourth Industrial Revolution

In the presence of the Fourth Industrial - Technological Revolution, Mexico requires to promote and channel the competitive talent of boys, girls, adolescents and young people so they can develop and own STEM competencies:

- Problem resolution
- Creativity
- Critical Thinking
- Communication
- Collaboration
- Data management and analysis
- Computing and IT

CHAPTER 3. AP STEM IS BORN

3.1 OUR HISTORY

In 2018, AP STEM was born as an initiative of CCE, which through diverse documents had been emphasizing the importance of encouraging STEM Education and of linking these efforts to a vision of workforce development.

Meanwhile, diverse organizations of the civil society, but also public and private universities, had been working for many years in STEM Education, mainly in specific higher education programs or in elementary schools, especially in Science, Robotics, Engineering and Mathematics fields. But little by little, these institutions and organizations began to migrate towards an educational approach with a perspective on STEM. As a country, we need much greater efforts, but even more, we require greater linkage and strategic collaboration, as this is what we seek to denote.

AP STEM was born as an initiative of the industrial chambers, with the impulse and commitment of the Commission of Education of the Business Sector, which decided to bring together key actors to generate a joint view on the subject, and support, link and encourage STEM Education in the workforce development of the country. From the first steps, Movimiento STEM has strategically coordinated the organization and linkage efforts of the actors from the civil society, as from its own mission, it was already seeking to encourage the STEM Ecosystem and detonate its exponential growth in our country. And so, in October 2018, AP STEM signed an intention to collaborate, consolidating the interests arising from the collective discussion.

AP STEM, from the Private Initiative, will encourage, support and lead, as appropriate, synergies and initiatives between Companies-Industry-Work Centers-Museums-Public Spaces-Schools and Organizations of the civil society, all of them with the aim of:

- Offering society a positive image of STEM, its benefits and impacts in different areas of society.
- Creating STEM Education quality opportunities for everyone, seeking equity and inclusion.
- Improving the quality of STEM Education in formal, non-formal and informal education. This includes schools, extracurricular programs, museums, universities, public spaces, among others.
- Increasing students' interest in STEM, and so increasing the number of students pursuing a STEM career, emphatically promoting the participation of women and excluded groups.
- Having a prepared workforce for the current requirements of the industry and the pressing needs of the labor market.

3.2 ACTIONS TO BE ENCOURAGED BY THE PRIVATE INITIATIVE THROUGH THE AP STEM

From the Private Initiative we consider that the 4 immediate actions to encourage STEM Education in Mexico are:

- Promoting the development of values and relevant skills for life in boys, girls, adolescents and young people facing the challenges of the 21st century, and to this effect, it will be important to support initiatives that promote it, as well as some directed to teacher's formation.
- Encouraging among the national public opinion a continuous dialogue where STEM is positioned as a crucial factor for national development and also, position STEM Education as a fundamental way to reach such development with a social and inclusive vision in which gender stereotypes are questioned and battled.
- Consolidating permanent linking mechanisms among the key social actors and the experts in the implementation of STEM programs and methodologies to ensure the advances and the achievement of goals in this subject.
- Defining, analysing and monitoring (i) macroeconomic indicators that allow to punctually follow up on STEM progress in the country and (ii) indicators, standards and assessments of common impact among the experts and the key social actors who develop STEM actions and programs at the national level, to ensure the quality and improvement mechanisms in the emergence and evolution of STEM Education in Mexico and comply with international standards, always taking the national context as the first reference.

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CHAPTER 4. STEM EDUCATION PUT IN INTO PRACTICE

STEM EDUCATION:

- Is based on giving solutions to real social problems, thereby fulfilling the 2030 Agenda established by the UN.
- Proposes collaborative work within inclusive teams, providing a favorable environment for the development of socio-emotional skills.
- Works in the fields of Science, Technology, Engineering and Mathematics in an interdisciplinary and transdisciplinary way, as well as the associated disciplines, especially inquiry.
- Applies the engineering design process (research, imagine, plan, create a prototype, practice and evaluate, improve, iterate and finally, question).
- Rigorously uses sciences and mathematics, and proposes the use of technology.
- Develops language and communication skills, encouraging to propose solutions with a fast, agile and effective communication.
- It prepares boys, girls, adolescents and young people to have strong foundations on STEM, helping them discover their talents in these areas, and so laying the foundations to guide them through the election of careers related to STEM and/or positively impact the achievements of their personal and professional life plan.

4.1 PHILOSOPHICAL FOUNDATION

In a globalized, plural and unpredictable world, teaching and learning must make the most out of the advances in research and seek for a balance between the universal values and the diversity of national, local and personal identities. This connection between the global and local is key for learning activities to contribute to insert every person in different communities in which they can belong, build and transform[8]. For that to happen, it is necessary to prepare people who are conscious about their own individuality within the community, the country and the world.

Today, we understand the world as a complex system in constant movement and development. From technological progress and globalization, the generation of knowledge has accelerated vertiginously; the sources of information and the paths to socialization have multiplied in the same way. The promptness with which information flows thanks to internet and smart devices, is increasingly present in all contexts and age groups; this was unimaginable a decade ago[9]. In turn, these transformations in the construction, transition and socialization of knowledge have modified people's ways of thinking and interacting. It is essential to educate boys, girls, adolescents and young people in their own ability to adapt to the changeable environments so they are able to manage information from diverse digital and physical sources, as well as develop complex, critical, thoughtful and flexible thinking, and solve problems in an innovative way[10]. STEM Education gives a specific response to face these challenges.

Pedagogical STEM practices are framed within the socio-constructivist approach, which gives relevance to the social interaction of the learner, raises the need to explore new strategies to achieve learning and considers learning to be a context in which social and situational processes are important. The strategies that promote inquiry, creativity, collaboration and motivation belong to this way of looking at teaching and learning. In particular, inquiry, problem and project based learning models[11] stand out, as they consider the students' interests and encourage them through their appropriation and research. This method allows students to build and organize knowledge, consider alternatives, apply disciplinary processes to disciplinary content and present results.

8. See Reimers, Fernando, Empowering global citizens: a word course, South Carolina, Create Space Independent Publishing Platform, 2016.
9. Brunner, José Joaquín and Juan Carlos Tedesco (eds.), The new technologies and the future of education, Buenos Aires, September Editor Group, 2003. Consulted Jan 7, 2019 in: http://unesdoc.unesco.org/images/0014/001423/142329so.pdf
10. SEP. (2017). Key Learnings for an integrative education. CDMX: SEP
11. Barron, Brigitt y Linda Darling Hammond. "Perspectives and challenges of inquiry-based approaches" in Aguerrondo, Inés (coord) pp. 160-183

In order to provide a quality STEM Education, it is crucial to recognize that Mexicans must be able to access quality education, which considers students and their integrity as essential.

From a pedagogical perspective, it was John Dewey who, since the beginning of the 20th century, in a speech delivered before the American Association for the Advancement of Science, underlined that "the teaching of science has placed too much emphasis on the accumulation of information, neglecting the fact that science is also a way of thinking and a mental attitude. Science is more than a body of knowledge to learn, there is also a decisive importance in the process or in the method of learning (Dewey, 1910, cited in NRC, 2002).

Later on, other researchers such as Joseph Schwab (1960, 1966) stated the importance of argumentation, contrast and the value of inquiry for students to recreate by themselves the knowledge already validated by science. Schawb proposed the bases of three models of inquiry that give the student more and more freedom to solve their own doubts and gather evidence from their own research.

Thus, the Science Standards of the United States (2000) defined the characteristics of an inquiry-based learning and defined its essential elements:

1. Students engage in learning from scientifically oriented questions.
2. Students prioritize evidence, allowing them to develop and evaluate alternative explanations to the questions asked.
3. Students formulate explanations from the evidence.
4. Students evaluate their explanations with the explanations obtained by students of the same age, reflecting scientific learning of the facts or phenomena studied.
5. Students communicate and justify their knowledge based on the procedures used, and on the conclusions they have validated.

Based on the above, those standards defined inquiry-based learning as:

> A multifaceted activity, which involves making observations, asking questions, examining books and other sources of consultation to learn what is already known, plan investigations, review what experimental evidence has been validated, use tools to collect, analyze and interpret data; to propose answers, explanations and predictions and communicate the results. Inquiry requires the identification of assumptions, the use of logical and critical thinking, and the consideration of alternative explanations (NRC, 2002).

Chart 6. Inquiry and STEM

> Inquiry is the basis of STEM because all knowledge must emerge from the students' interest, and for this, it is essential to ask good questions and have the ability to seek for answers, interpret information and collaborate with others in the recreation of a validated knowledge or in the application of the new one within different contexts.

4.2 ACQUIRED COMPETENCIES AND HOW THEY ARE FOSTERED.

There are eight basic competencies generated in students from practices in science, technology, engineering and mathematics education, and they were homologated with the seven proposed by Global STEM Alliance, considering the characteristics of the Egress Profile of the Elementary Education of the National Educational System. They are expressed in "desirable traits" and their achievement is the result of progressive learning throughout previous educational levels. The key factor to achieve these competencies is to generate active, creative and interested learners; which implies putting pedagogical principles into practice in classrooms and schools that favor the renewal of learning environments, promote active, situated, self-regulated, goal-directed, collaborative learning that facilitates the social processes of knowledge and construction of meaning[12]. (SEP, 2018).

Achieving the "desirable traits" is a multi-factor issue and is achieved by the interaction of: the student as the responsible for his or her own learning; the social and family contexts in which the student performs, as well as all the teachers who accompany him or her on the educational journey promoting the expected learning outcomes. However, the work of teachers at each educational level is essential and therefore their training, either initial or continuous, becomes a priority (SEP, 2018).

12. SEP. (2017). Aprendizajes clave para la educación integral. CDMX: SEP.

To evaluate the degrees of mastery of the Global STEM Alliance competencies homologated with the Educational Model of Mexico, a rubric is used that takes up the characteristics of the graduation profile of each educational level, in the understanding that the learning achieved by a student in a level will be the foundation of the learning achieved in the following . To assess to what extent a student has achieved "desirable traits", it is proposed to use the following scale: Expert, Advanced, Good, Basic.

Table 2. STEM Competencies of Global STEM Alliance

1. Critical Thinking / Creativity / Problem Solving: Develops Critical Thinking and solves problems with creativity.	Formulates questions to solve problems of different types. Informs him/herself, analyses and argues the solutions proposed and presents evidence to support the conclusions drawn. Thinks about own thought processes, uses graphic organizers to represent them and evaluates their effectiveness.
2. Problem solving: Strengthens mathematical thinking.	Extends his/her knowledge of mathematical techniques and concepts to pose and solve problems with different degrees of complexity, as well as to model and analyze situations. Assess the qualities of mathematical thinking.
3. Data Literacy: Enjoys exploring and understanding the social and natural world / shows responsibility for the environment / takes care of his/her body and avoids risk behaviors.	a) Enjoys exploring and understanding the social and natural world. Identifies a variety of phenomena of the natural and social world, reads about them, informs him/herself about them, inquires by applying principles of informed skepticism, asks complex questions, analyzes and does experiments. Systematizes his/her discoveries, builds answers to own questions and shows models to represent the phenomena. Understands the relevance of the Natural and Social Sciences. b) Shows responsibility for the environment. Promotes environmental care in an active way. Identifies problems related to the care of ecosystems and the solutions that involve the use of natural resources with responsibility and rationality. He/she is committed to applying sustainable actions in his/her environment. c) Takes care of own body and avoids risk behaviors. He/she activates body skills and adapts them to different situations that will be faced in games and school sports. Takes a preventive approach by identifying the benefits of taking care of his/her body, having a balanced diet, and practicing physical activity regularly.
4. Communication: Communicates with confidence and efficiency	He/she uses mother tongue to communicate effectively, respectfully and safely in different contexts with multiple purposes and interlocutors. If he/she speaks an indigenous language, he/she also does so in Spanish. Describes experiences, events, wishes, aspirations, opinions and plans in English.

5. Collaboration: Has initiative and encourages collaboration.	Recognizes, respects and appreciates the capabilities and different points of view when working collaboratively. He/she has initiative and entrepreneur characteristics, and pushes his/herself to achieve personal and collective projects.
6. Digital Literacy and Computer Science	a) Compares and chooses the technological resources within reach and makes good use of them. Learns different ways to communicate and obtains information, then selects, analyzes, evaluates, discriminates it and builds knowledge. b) Compares and chooses the technological resources within reach and makes good use of them. Searches, selects, evaluates, classifies and interprets information, presents multimedia information, communicates, interacts with others, represents information, explores information, explores and experiments, manipulates dynamic representations of concepts and phenomena and creates products. He/she favors the development of critical, creative thinking, information management, communication, collaboration in the use of technology, digital citizenship, computational thinking.

Adapted by (Villavicencio, 2018)

4.3 TEACHING/LEARNING PROCESS

Encouraging problem solving, developing projects, working on analytical ability or learning how to work in teams, requires a teaching/learning process which allows students to make use of their knowledge in an integrated way and connects concepts of different disciplines. It also requires the use of technology not only as a tool to have access to information, but to enhance the development of creativity and the ability to innovate.

A STEM lesson hardly occurs in a common classroom; it requires a space in which autonomous learning is encouraged, as well as learning how to learn and learning by doing. These characteristics seek that students become the focus of their own learning, in this way, students will understand the reality through multidisciplinary activities and the teacher will only be a guide who helps students in an indirect way with continuous feedback (Fernández, 2006). In this sense, there is not a unique teaching methodology in which to insert the teaching/learning process, but methodologies as inquiry, challenge-based learning and project-based learning, that focus their effectiveness on understanding and solving real situations that are relevant because they are focused on the student, and favor the construction of knowledge through their own experiences and enhance interaction with reality beyond the classroom.

Chart 7. Learning Cycle for STEM Education

In STEM practices, it is essential that teachers consider a learning cycle with well-defined stages for students, which must consider at least the following phases (adapted from NRC, 2000):

- **Phase 1.** Working collaboratively, students actively engage in a question, event or phenomena of their community. They connect with what they already know about it; different ideas create discordance and motivate them to learn more.
- **Phase 2.** Students put their ideas to the test through the design of research or experiential activities; they formulate and test their hypothesis and generate an initial explanation from what they observe.
- **Phase 3.** Students analyze and interpret data, synthesize their ideas, build models to clarify concepts and explanations with their teachers and other reliable sources of scientific and technical knowledge.
- **Phase 4.** Students apply their learning and new skills to new situations or problems.
- **Phase 5.** Students together with their teachers evaluate what they have learned and how they have learned it, favoring a metacognitive reflection.

4.4 TEACHERS AND STEM EDUCATION: WHAT IS EXPECTED FROM TEACHERS? WHAT WOULD THEY NEED TO IMPLEMENT STEM IN THE CLASSROOMS? WHAT RESULTS WILL THIS IMPLEMENTATION HAVE?

Putting STEM into practice in the classroom requires teachers to consider the curriculum as a flexible platform, where each topic is addressed based on the students' previous knowledge, interests and doubts, where there are opportunities for interaction with materials, audiovisuals, virtual learning objects, where information technologies are used. All this in a well-planned and argued sequence by the teacher.

Under this perspective, in various countries there are initiatives where high school students select their subjects based on their motivations and interests, or where the subjects of the curriculum are addressed according to the priority that the students themselves give to them. In a context like ours, where there is a centralized curriculum, it is desirable to seek opportunities so that the topics to be addressed respond to the interest of the students and for this, they must be linked in a more explicit way with their reality and context.

For this, Maker spaces are also being implemented in many schools and spaces such as museums, allowing students to design and assemble prototypes, use different technological and mechanical tools, build models or plan a business or service.

STEM requires teachers who are innovative in their practice, updated in their knowledge and open to collaboration with their students. Those times where the teacher possessed the information and knowledge are long gone. Today, trained teachers are required to lead their students with knowledge but also with creativity and a deep respect for differences, encouraging tolerance and helping their students be resilient to rapid and sudden changes in short periods of time.

Chart 8. Required characteristics of the professional training to make STEM Education a reality for the Mexican school.

To achieve these changes that are required for teaching through a STEM approach, it is necessary to consider a teacher training aligned with these purposes. Such teacher training and professional development should have at least the following characteristics (adapted from Loucks-Horsley et. a. 2010):

1. It should focus on the content of the curriculum. Know the curriculum, the nature of science, engineering, technology and mathematics. It must focus on effective teaching strategies and formative assessment.
2. It must incorporate active and meaningful learning for students. Professional development should shape the type of teaching we want to have in classrooms.
3. Encourage collaboration. Teachers' didactic capacities should be strengthened both individually and in academic bodies and their collaboration at intra-school level or even between different schools or regions.
4. Use effective training models. Trainers must earn the interest of teachers in learning experiences that are relevant and useful so they can be better at teaching their students.
5. Give advice, mentorship and monitoring. The most experienced should support and motivate their peers to innovate in their practice and facilitate the learning of their students.
6. Include opportunities for feedback and reflection on what has been learned.

Working with an approach like the one described, will result in forming a professional capital with the capacity for entrepreneurship, self-employment or to be creative and productive anywhere and in any context.

4.5. THE LEARNING ENVIRONMENT

Comprehensive development approach

To develop STEM competencies in formal and non-formal environments, it is necessary to have a comprehensive view of the development of boys, girls, young people and even adults, because what we seek is lifelong learning. It is essential to create a learning environment that favors learning, and that allows children to be actively involved in the construction of their own learning. Spaces where questions, inquiry, curiosity, healthy personality development, and socio-emotional skills are encouraged. A place where there are positive relationships with adults, and with other colleagues.

To support student achievement, performance, and positive development, research suggests that educational settings should address four main domains (Darling-Hammond, L., and Cook-Harvey, CM, 2018), shown in the figure below and described here:

1. Creation of a positive learning environment, both in face-to-face or virtual classrooms and in school in general.
2. Shaping positive student's behavior through socio-emotional learning.
3. Development of productive instructional strategies that support motivation, competency, and self-directed learning.
4. Creation of individualized supports that address the needs of students, including the effects of trauma and adversity.

STEM Education will take these domains into consideration, recognizing the integral development of children and young people. Figure 7 depicts the aspects for comprehensive development.

Figure 7. Framework for an education focused on the comprehensive development of boys, girls and youth.

Taken from Darling-Hammond and Cook-Harvey, 2018

Promoting gender equity and perspective

It will also be key to generate learning spaces that promote gender equality, where adults in charge have the ability to detect, confront and prevent risky situations in the classroom, preventing that girls, boys and young people are exposed to attitudes, behaviors and expressions that promote gender-based discrimination. These situations are expressed implicitly or explicitly, and the role of the teacher is essential to promote environments that are free of stereotypes and guarantee equal educational opportunities for all. (Robotix, 2018).

In the case of STEM teaching, it is necessary to ensure that from the first encounter that girls and boys have with STEM activities, there is a guarantee that they find a real, useful and interesting meaning related to everyday life. In addition to the mastery of the contents that must be taught, the knowledge of pedagogical approaches and suitable didactic strategies, including the gender perspective demands from teachers the encouragement of the interactions that occur in the classroom to promote equal opportunities through educational practices that are based on gender equity logics. (Villavicencio, 2017).

The key to change are teachers; they are the central figure for the implementation of any didactic proposal, as well as for promoting a change in behaviors and gender stereotypes. The strategy is to design initial and continuous training courses that allow them to live the experience of analyzing behaviors, attitudes and stereotypes that come from their own gender socialization. (Villavicencio, 2017).

With elements of a 21st Century classroom

As mentioned before, the learning space is not limited only to the classroom, ideally it will seek to have collaborative spaces in corridors, classrooms that allow teamwork, makerspaces, messages and visual stimuli that invite to create, spaces to share and exhibit ideas, challenges and projects; interactions and visits to museums, companies, scientists and technicians, as far as possible, to get to know their work and have the opportunity to carry out consultations related to their learning. In brief, it is about energizing and connecting the school and social spaces that already exist and promoting invention and collaboration. (Gras, 2018b).

UNESCO (2017) explains that the 21st century requires us to conform new Smart Learning Environments (SLE). These spaces are characterized by: the use of technologies and elements that allow greater flexibility, effectiveness, adaptation, involvement, motivation and feedback for the learner. Leaders on the subject assure that this approach improves the skills to become lifelong learners. It also exponentiates the ways to create, sustain, and access learning communities.

Spaces for STEM Education have the elements of a positive environment described above, and they are also spaces that (Glancy and Moore, 2013):

- Integrate the contents, skills and ways of thinking of each discipline of STEM subjects, and encourage them to interact and enrich each other.
- Allow work on solving real problems and authentic situations.
- Promote collaboration.
- Encourage that every student gets a personal learning experience that leads to reflection.
- Include feedback as part of their practice and culture.
- Implement experiential learning, but with such a design that students go from manipulation to exploration of variables, that they discover the different manifestations of concepts and the relationships between different concepts, and thus achieve the abstraction of concepts effectively.

4.6 TRANSVERSAL AXES AND FOCUS AREAS IN STEM EDUCATION

Transversal Axes in STEM Education: development of socio-emotional skills and gender perspective

There are many transverse axes and focus areas that could be mentioned here, but as it has been explained throughout the document, we believe that socio-emotional skills, can and should be worked on transversally, but we also believe that it is worth emphasizing the equality aspect and gender perspective in a transversal way as well.

Transversal Axis 1: The development of socio-emotional skills

According to CASEL (2017) "socio-emotional skills are life tools that allow us to identify and regulate our emotions, understand those of others, show empathy, develop and maintain positive relationships, establish positive goals and make responsible decisions.

Contrary to what might be thought, the skills required in fields such as science, technology, engineering and mathematics are not exclusively those related to the field of abstract or logical-mathematical thinking in particular, but also those skills that allow harmonious interaction between the people that carry out science and technology activities. (Gras, 2018a).

Most authors agree in grouping the most significant socio-emotional skills for pedagogical and educational development, as follows:

1. Sense of self
2. Self-management
3. Social and interpersonal conscience and collaboration
4. Relationship skills

The years of compulsory schooling, will pursue the next three socio-emotional learning objectives:

Chart 9: Socio-emotional Learning Goals for Elementary Education

1. Develops self-management and self-consciousness skills and achieves success in school and in life.
1-A. Identifies and manages own emotions and behaviors.
1-B. Recognizes personal qualities and external supports.
1-C. Demonstrates skills related to the achievement of personal and academic goals.
2. Uses social consciousness and personal skills to establish and maintain positive relationships.
2-A. Recognizes others' feelings and points of view.
2-B. Recognizes individual and group similarities and differences.
2-C. Uses communication and social skills to relate effectively to others.
2-D. Demonstrates the ability to prevent, manage and resolve interpersonal conflicts constructively.
3. Demonstrates responsible behavior and skills in personal, in school and common contexts and in decision-making.
3-A. Considers ethics, safety and social factors in decision-making.
3-B. Applies decision-making skills to deal responsibly with academic work and social situations.
3-C. Contributes to the well-being of school and the community.

Source: (CASEL, 2016 en Gras, 2018a

Over several years and in different countries, the implementation of STEM Education has shown the idea that teaching STEM content is not enough, but, as the researcher Melina Masnatta mentions, "... it is... considering a basic set of teaching practices that support students (regardless of their prior knowledge) to delve into scientific ideas, participate in the activities of the discipline and solve problems that have anchors with reality." (Gras, 2018a).

Socio-emotional learning objectives can be perfectly integrated in a transversal way to STEM Education, as stated above, in fact, the environment generated by STEM Education is ideal for intentional and integrated work on socio-emotional skills, obviously without being exclusive of STEM.

Thus, STEM competencies such as problem solving, creativity, critical thinking, communication, collaboration, data management and analysis, computing and informatics, are accompanied by the skills required in the 21st century, like communication and negotiation between peers, skills to relate to others and to find shared solutions and common problems through responsible decision-making. Self-concept or self-awareness and self-management become fundamental skills of collaboration and communication with others. (Gras, 2018a)

Transversal axis 2: Gender equity and perspective understood as inclusion in access to STEM programs, in the management of information and in the design of learning opportunities, so that girls and young women experience STEM as something possible and appropriate for their gender. The above, also implies the participation on STEM of indigenous peoples and communities to favor their technological capacities and the use of natural resources.

As mentioned in the previous section, creating an adequate environment and the role of the teacher will be key, as it will be the teacher's job to carry out specific actions and design appropriate learning experiences to achieve it.

Three focus areas: Community Development, Environment and Sustainability, Innovation

Regarding the focus areas, we are convinced that students should have the opportunity to work, test and continue developing their STEM competencies, using STEM practices in three major areas, in order to strengthen them and open their horizons regarding how they can use their knowledge and skills in local and global life: Community Development, Environment and Sustainability, and Innovation.

Chart 10. Focus Areas of STEM implementation

1. Community Development
A community development project has as its objective the social development and the development of the community, improving the daily life of society as a whole, satisfying the basic needs of people, guaranteeing the respect and exercise of human rights. Community development "Are processes through which the efforts of a population join those of their government to improve the economic, social and cultural conditions of the communities, integrating them into the life of the country and allowing them to fully contribute to national progress" (UN, 1956). Social development refers to the development of human capital and social capital in a society. It implies a positive evolution or change in the relationships of individuals, groups and institutions in a society, generating economic and human development, and its objective is social welfare.
2. Environment and Sustainability
An environmental and sustainability project is one that aims to improve, promote and / or implement practices of care, protection or recovery of the environment that hosts and conditions the livelihoods and behavior of living beings. It also aims to prevent, avoid and repair environmental damage that individuals (citizens or companies), or natural phenomena may cause in the environment, remembering that it encompasses nature and society. It also covers the processes that allow preservation, such as research, fundraising, security, the management of environmental projects, the declaration of protected areas, the implementation of National Parks, among others.
3. Scientific and / or Technological Innovation
A scientific and / or technological innovation project is one that applies new ideas, concepts, products, services and practices, through the transformation of knowledge or improving existing products, thus giving continuous response to changing situations with the intention of being useful for an increase in productivity and competitiveness. It is essential that it has a successful application in the commercial sector and that its continuous improvement is possible.

Source: (Arteaga y Gras, 2018).

CONCLUSIONS

For the Alliance for the Promotion of STEM, STEM Education can strategically add to the construction of citizenship that is capable, not only of knowledge, finding reliable information, collecting data, systematizing and analyzing it, but even more so, a citizenship capable of proposing and improving the status quo. A citizenship that aspires to inclusion, that acts with ethical considerations, from a deep and authentic social commitment with a genuine respect for the environment and innovative spirit.

STEM Education has the ability to train STEM-skilled citizens and also scientific citizens. (Gras, 2018b).

Therefore, the work from the private initiative will continue to implement specific actions through links and collaborations, so we can move towards the objectives indicated in section 3.2.

In addition to this, we have identified 5 major areas of work that need to be promoted in Mexico, as a society and from the private but especially the public sphere:

1. Strategically increase the expense on Science and Technology, aligned to the strategy of innovation, workforce development and STEM Education.
2. Progress in a quality STEM Education in all mandatory educational levels and higher education, as well as throughout life in the form of professionalizing trajectories.
3. Achieve an effective strategy of Continuous Teacher Development on STEM, in the form of training trajectories, that enables a quality STEM Education for all.
4. Strengthen and normalize the links between Companies-Industry-Work Centers-Museums-Public Spaces and Schools that lead to a training that is more experiential and close to the real world that our young people will later face, including stays, internships, tutorials, research, etc., in the fields of formal, non-formal and informal education.
5. Establish Indicators that allow the monitoring of the progress of STEM in the country, including indicators on: innovation, the participation of women in scientific and engineering careers, the relevance of the supply of technical careers according to priority economic sectors, the type of employment and income expectations by career area, STEM attitudes and interests in primary, secondary and high school ages, Mexican STEM patents, teachers and STEM, among others, always keeping the strategic focus.

We believe that the approach of this document is ambitious, but viable if a social consensus is achieved and each of us immediately put ourselves to work from our corresponding field, working with a joint vision.

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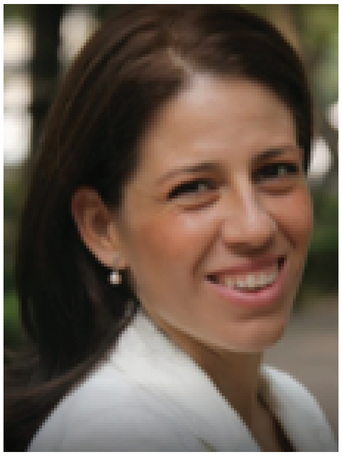

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She is a consultant in the field of Education and collaborates in projects with companies, research centers, international organizations and civil society in Mexico and other countries. Throughout her career, Marlene has designed and advised educational programs that are currently being implemented in various countries. She has participated in several publications with the OECD, on topics such as school improvement, teaching career, reform of educational policies and analysis of the results of the PISA test. In addition, she has collaborated with UNICEF in projects of school inclusion and reintegration. Marlene has designed courses and workshops for teachers and recently, with PIPE-CIDE, she designed elements for training and materials for the acquisition of socio-emotional skills and for the work of the Jóvenes Construyendo el Futuro (Youth Building the Future) Program. In addition, she currently participates in the design and implementation of the Educational Model of a Network of Technical Schools.

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She is a teacher of elementary education with a specialty in didactics of natural sciences and inquiry teaching in basic education. She has dedicated herself to teaching in elementary education, teacher training and Research-Action. She has participated in science dissemination projects for children at Dirección General de Divulgación de la Ciencia (General Directorate for the Dissemination of Science) at UNAM, and in natural sciences technological development projects in different institutions such as ILCE, SINED and SEP. She is Coordinator of the program "La Ciencia en tu Escuela" (Science in your School) in the remote modality, at Academia Mexicana de Ciencias (Mexican Academy of Sciences), and author of educational materials for teaching and learning natural sciences in elementary and secondary school. Since 2016, she coordinates the academic team of biology in the curricular redesign of the study Plans and Programs of the bachelor's degrees for the initial teacher training of secondary school education, that is being carried out by the General Directorate of Higher Education for Education Professionals (DGESPE-SEP), which for the first time, is being implemented in the country alongside the Basic Education educational reform.

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