Progress and Factors that Contribute to Closing the STEM Achievement Gap in Mexico

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> […] the term "teaching and learning system" is used advisedly to describe a set of elements that, when well designed and connected, reliably support all students in their learning. These elements ensure that students routinely encounter well-prepared teachers who work in concert around thoughtful, high-quality curriculum, supported by appropriate materials and assessments. These elements also help students, teachers, leaders, and the system as a whole continue to learn and improve.
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Introduction

This paper is based on Mexico's chapter of the book *Closing the Achievement Gap from an International Perspective* (Clark, 2014), "Achievement Gap in Mexico: Present and Outlook" (Sánchez, 2014), and is organized in four parts:

- Achievement gap in Mexico, that begins with a general overview about the country updating students distribution data.
- What has been done in Mexico? Updating 2013 events, especially those related to Educational Reform.
- Successful innovative experiences, including four recently implemented.
- What else is there to do?

Achievement Gap In Mexico

Mexico is the 11th most populated country in the world, with the 14th largest GDP, and ranks 57th on the Human Development Index (HDI). In Mexico, more than 36 million students in 2015 are distributed in preschool (K, with 3 years, 14%), primary (1-6, 41%), secondary (7-9, 18%), middle education (10-12, 13%) –all of these compulsory–, and superior and job training (14%). Further, Mexico has a great diversity, for instance, there are 68 original indigenous languages with more than 300 variants. As a reference of the achievement gap, the original chapter analyzes evaluation results of two National Assessments, ENLACE[2] and EXCALE[3], and PISA, sorted into subjects and education level, and presents a comparison between the best and worst federative entities. In all of these evaluations, almost half of students qualify with an insufficient achievement.

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[2] National Evaluation of Academic Achievement in Schools (Evaluación Nacional del Logro Académico in Spanish).

[3] Exams of Quality and Education Achievement (Exámenes de la Calidad y el Logro Educativos in Spanish).

Mexico is a developing country with enormous inequality, which reflects in education, no matter the Government efforts, which are summarized in the next section. For example, information related to marginalization, with indicators such as potable water, electricity, telephone and other kind of services, is generalized in the next table that presents percentage distribution of secondary schools according to the degree of local marginalization. This table is a reference to understand the later data analysis related to the gap in educational achievement for this level.

Table 1: Percentage distribution of secondary schools according to the marginalization level of the locality where they are situated, school year 2007/2008

Degree of Marginalization	Public Secondary				
	General*	Technical	Tele-secondary[4]	Communitaria	Private secondary
Very high	0.4	2.1	8.5	38	0.1
High	8.3	14.5	52.3	45	0.9
Medium	8.7	11.2	18.1	5.7	2.6
Low	19.9	21	14.2	3.2	10.2
Very low	62.1	50.7	5.8	0.9	85.1
Lost[1]	0.6	0.5	1.1	7.2	1.2

*Includes the secondary schools for workers

[1] Corresponds to the schools where it was not possible to identify the marginalization level of the locality in which they are located.

Source: INEE (2009). Learning in Mexico in the third year of secondary. *Report about the results of EXCALE09, 2008 application. Spanish, Mathematics, Biology, and Civical and Ethical Training.*

Some of the results of EXCALE, one of the two National Assessments, are analyzed with additional information published by the National Institute for the Evaluation of Education (Spanish acronym: INEE), regarding 3rd grade of secondary, to compare the information related to the education gap in places with certain marginalization. Case study information about Chiapas and Mexico City (D.F.) are highlighted because the first one has the lowest Human Development Index (HDI) of the entities (0.7395)[5] (PNUD, 2011), especially with a bigger percentage of young population out of the standard education level (50.3% in 2008) (INEE, 2011, p. 56), with minor results of education achievement and associated with the poorest states in Mexico; whereas the second one has the highest HDI of the country (0.9176) (UNDP, 2011), the lowest percentage out of the standard education level (14.8%) (INEE, 2011, p. 56), the best achievement level, and better opportunities for its inhabitants.

EXCALE exams are applied to a sample of students and have a similar methodology to PISA, with four levels of achievement: under the basic, basic, medium, and advanced. To illustrate the gap of educational achievement in these exams, only the first level of achievement is used because it measures the students who do not reach basic. The next table shows results of EXCALE 2008 in Mathematics[6].

[4] It is a distance-learning system with only one teacher per group or even per school.

[5] This information is from 2008, although the report from Mexico is from 2011.

[6] For those interested, we recommend consulting http://www.inee.edu.mx/explorator (English) or http://www.inee.edu.mx/explorador (Spanish).

Table 2: Percentage of students of the 3rd year of secondary below the basic level for Mathematics of the strata in rural populations, urban of high marginalization (UHM) and urban of low marginalization (ULM)

Education Modality	Mathematics		
	Rural	UHM	ULM
Technical	67	57	47
General	57	56	45
Private	-	-	25

Source: INEE (2009). Learning in Mexico in the third year of Secondary. *Report about the results of EXCALE09, 2008 application. Spanish, Mathematics, Biology, and Civical and Ethical Training.*

On the other hand, the percentage of tele-secondary students under the basic level for Mathematics in EXCALE 2008 was 62%. Data was unavailable to differentiate the achievement of students in rural, urban of high marginalization, and urban of low marginalization tele-secondary schools, but according to Table 1, 60.8 % of its schools are in towns of very high and high marginalization; therefore, 62% is also an indicator of how the gap in the education achievement is larger regarding the less favored students. In the following Table, information focuses on Chiapas and Mexico City (D.F.).

Table 3: Percentage of students from the 3rd year of secondary below the basic level for Chiapas and Mexico City (D.F.) Spanish, Mathematics, and Biology, EXCALE2008

State	Spanish	Mathematics	Biology
Chiapas	48	64*	40
Mexico City (D.F)	26	39	16

Source: INEE (2009). Learning in Mexico in the third year of Secondary. *Report about the results of EXCALE09, 2008 application. Spanish, Mathematics, Biology, and Civical and Ethical Training.*

What has been done in Mexico?

In the first decade of this century, the demographic pressure that kept Mexico in a complicated race to achieve the universal coverage of the primary education during almost all the past century started to decrease. Although an educational reform took place in 1972, it was not until 1993 that a series of changes in primary and secondary plans and programs began: the free text books were updated, secondary (7-9) was declared obligatory, the education services in the federative states were decentralized, and a teaching degree was created as an incentive program based on evaluations to teachers, among others. Additionally, the teacher-training colleges were reformed with infrastructure supports for schools and an aggressive updating program for teachers was encouraged with the creation of more than 600 teaching centers distributed along the country at the end of the last century. Then, various reforms were introduced in all curriculums based on competences starting in 2004 for preschool, 2006 for secondary, and 2008 for middle school and primary. These changes were complemented in 2011 with the articulation of the basic education, where PISA is explicitly considered as referent (SEP, 2011). In the specific case of the Natural Science subjects in secondary, the previous dispersion was diminished because the students had two courses in the first grade, three in second grade and two in third grade. With the 2006 reform, students had one course in each grade (Biology, Physics and Chemistry), each one consisting of six hours per week.

Most of the teachers and directives were not subject to periodic and strict evaluations. In 2012, the Ministry of Education (Secretaría de Educación Pública in Spanish, and SEP as the Spanish acronym) announced the first massive evaluation to 541 thousand teachers of basic education on June 23-24 and July 6-7, and was made law at the beginning of 2013 for all entry and service teachers. With this law, the National Institute for the Evaluation of Education (INEE) obtained autonomy and became the institution in charge of all education evaluation in Mexico (Ramírez, 2013). In 2014 an intensive program to evaluate entry teachers and principals began. This program announced a training program in order to foster teachers and principals' qualifications, but it is a 2013 Reform pending issue; 2015 will follow last programs and will begin a first phase for service teachers and pedagogical advisers.

In July 2013, the INEE decided to cancel the National Assessments ENLACE for basic education, which was a standardized test based on the curriculum, with multiple choice questions and administered by the Ministry of Education. This test was applied yearly since 2006 to all students from third to sixth grade of primary and to the students of the third grade of secondary; in 2008, it will also applied in the first and second years of secondary and in the last year of middle education. The later validity study found that this exam was corrupted because: schools could avoid low achievement if students were absent the day of the exam; many teachers taught focusing on preparing students for the exam; teachers who were supposed to monitor, allowed students to cheat or even told them the answers; and in some places, the exam was stolen and distributed in advanced. In January 2015 the INEE announced the new generation of learning evaluations to be applied during the first semester of this year.

In 2013, the Literacy and Inclusion Digital Federal Program began with free distribution of 240 thousand laptops for 5^{th} and 6^{th} primary grade students in three states, and this year (2015) 709,824 tablets, 664,201 of these will be distributed to students of the same grades and the other 45,623 to teachers, all in six entities instead of three.

At present, the Ministry of Education keeps reviewing the curriculum of all levels that began at the end of 2013 and has planned to renew all textbooks in 2016 and 2017.

However there are three main factors that intervene in the results of the academic achievement with a wide inequality gap:

- The great cultural and socioeconomic diversity of the Mexican population make education efforts insufficient, worsened with an education system completely centralized in the twelve grades of basic education along with bureaucratic practices of excessive control.
- Since the creation of the National Union of Education Workers (Sindicato Nacional de Trabajadores de la Educación in Spanish, and SNTE as the Spanish acronym) in 1943, the government made a pact ceding the control of the teaching positions and those of the directives (sector chiefs, supervisors, school principals and teaching chiefs) to the Union (Arnaut, 1998; Barba & Arnaut, 2010). Although the 2013 Educational Reform established new rules to break this control, there is still some resistance, mainly in the SNTE sections called CNTE (National Coordinator of Education Workers) in the states of the south region of the country: Oaxaca, Guerrero and Michoacán, the three with minor results of education achievement and

associated with the poorest and troubled states in Mexico. By the way, SNTE and CNTE are representatives of the Mexican corporatism political system.

- The national education system is excessively prescriptive with detailed study programs, unique and national textbooks in primary and subject of government authorization in secondary, so there has not been enough space for education innovation and for curricular development to be in teachers' hands.

Successful innovative experiences

The following innovative experiences are a light in the darkness for pointing out some actions taken that can contribute to close the STEM achievement gap in Mexico, as Sagan wrote in his book *The Demon-Haunted World: Science as a Candle in the Dark* (1995). Five experiences from the bottom and then three with the participation of institutions that contribute to improve STEM education, two publics and one private.

Tele-secondary linked to the community, in which 14 schools of Puebla's rural areas participate with a model of productive workshops focus on the competitive strengths of each community (Pieck et al, 2008). All of these schools belong to a poor rural environment, and they have high migration. This is why the workshops try to provide young men with a practical and ecological training to take advantage of the land, community resources, and local productions (e.g., vegetables, edible mushrooms, medicinal plants, or elaboration of processed food). Also, students are taught to acquire technological skills as a possible source of future work. Blacksmith handicrafts' workshops have been organized too. In all the workshops, the students learn financial planning. This experience is an example of a connection between theory and practice, because it relates these workshops to the official curriculum. Also, part of its success has been that many of the new teachers are "graduates" of this education model, which has its foundation in the pedagogy based in projects. Its founder was Gabriel Salom (2009), the tele-secondary school coordinator of the zone; he created the model in 1994 and coordinated it until his death in August 2011. His work was a great example of collective work among teachers, directives, and the community.

Educational Coexistence. (Convivencia Educativa), founded by Gabriel Camara in 1996, is a way of learning based on tutorial networks integrated by students but with the freedom of choosing their subject of interest to prepare themselves as peer tutors. The teachers offer students a menu of contents, which are those the teachers know best[7], and give them personal assistance to master the subject, give them confidence, and let them rehearse as tutors until they are ready to do it independently and are able to give presentations to parents or other schools teachers and principals. This pedagogical model has favored the competence of "Learning to Learn" and help them in expressing themselves in different audiences to teach something since the early ages. It first started in few tele-secondary schools in Chihuahua, Zacatecas, and San Luis Potosi. In 2012, it became the SEP Integral Strategy Program for the Improvement of the Educational Achievement (*Programa de Estrategia Integral para la Mejora del Logro Educativo*), with presence in all federative states and deals primarily with the 9,000 schools of basic education that obtained the lowest results in the Enlace test. The program also trained

[7] Remember that in tele-secondary schools there is only one teacher per grade or even per school.

Spanish and Mathematics teachers of the first grade in all the secondary schools of the country in the first weeks of the school year 2011, to develop a preparatory course about the tutor relationship. Besides, the tutor relationship is giving a new dimension to the secondary education reform. Also, it is helping redefine the technical advisor's functions, and it is already mentioned as part of the educational policy in accordance to the Agreement 592 (SEP, 2011). The schools involved in the program have started to show substantial improvements in the results of the Enlace test (Camara, 2010; Malone, 2011).

Technical Secondary No. 120 (EST 120) won the *Zayed Future Energy Price* (United Arab Emirates) in 2013. This school is located in a rural community in Guarda Parres, Tlalpan Mexico City, with several water problems. The competition involved 88 countries of the five continents. To won this price the schools had to answer how to deal with the climate change and offer sustainable alternatives practices within their schools to achieve this. The project of this technical secondary consisted in a system to collect rainwater with a 50 thousand liters storage capacity to be used on a daily basis. This idea has been replied in other communities and the 100 thousand dollar award was invested in two new projects. In the final round, this technical secondary defeated a New York University team and was named as the America Environmental Best School. This school had won four awards before this one (Hernández, 2013).

Conalep (National College of Professional Studies) won the third national award institution, due to its link enterprises-schools. This College is in Mazapil, a very poor municipality in Zacatecas, has 200 students that belong to 50 communities and offer technical professional options in industrial electro-mechanics and diesel engines. It was distinguished with this award due the participation of the Mine *Peñasquito* that has invested over 2 millions dollars since its construction in 2009. Thanks to this, its graduates can continue its bachelor in the Autonomous University of Zacatecas, a free public institution, and the college offers their students free accommodation with meals and other facilities. If this option did not exist, some students would need to travel eight hours per day to their communities making it impossible for them to continue studying. This college has helped to improve the mining industry in Zacatecas that contributes with 29% of its GDP (Guerra, 2013).

Mexico, First place in the *RobotChallenge* Competition 2015, winning 9 medals in its different categories. RobotChallenge is an international championship for self-made, autonomous, and mobile robots. Each year robots compete in different categories –Robot Sumo, Line Follower, Air Race, Humanoid Sprint, Puck Collect and Freestyle. This competition is the most important of this type in Europe, and this year it took place in Vienna on April 11th and 12th. The challenge was conformed by 150 teams of 40 countries. The Mexico´s teams were from three public institutions (National Polytechnic Institute –IPN–, Autonomous University of Puebla –BUAP– and the Technological Institute of Poza Rica). IPN students made the 1-2-3 in Micro Sumo, 1-2 in Mini Sumo and first place in Nano Sumo (Crónica –anonymous–, 2015).

Previous innovative experiences constructed from the bottom are an alternative proof of how to boost the education achievements of poor communities or public universities. This improvement would be even greater if they were supported resolutely and without concealment. It is not a coincidence that in a centralized, prescriptive and authoritarian educational system like the Mexican one, the innovations are from the base, that is, born in marginalized sectors and at the margin of the system (Barba & Zorrilla, 2010). The

federal and state governments need to support the innovation in these sectors in a more compromised way and with more resources.

Moreover, it is important to consider for future actions the Science and Mathematics programs for basic education developed by the Mexican Academy of Science, such as *Summer in the Scientific Investigation*, *Teaching of Mathematics* and *Science in your School* (AMC, 2010a). For instance, the last one was born in 2002, and links the scientific community with primary and secondary professors via a course focused on improving the teaching of Science and Mathematics. From 2001 to 2013, 7,086 professors were prepared (AMC, 2010b).

However this analysis was made in the basic achievements that are not fulfilled and the inequities between the more and less favored. The need to encourage projects linked to the ICT is unquestionable.[8] As an example, we have in Mexico the proposal of *Classroom of the Future* of the Center of Applied Sciences and Technological Development of the Mexico National Autonomous University (Universidad Nacional Autónoma de México [Spanish acronym: UNAM]) (Gamboa, 2009). The basis of this proposal is an interactive surface "in which several users can collaborate without having to use a mouse or a keyboard; it's enough to put, move, or remove physical elements from the surface to do all the actions that are traditionally done with a simulator" to work business and collaborative strategies, "to support and promote the collaborative work among students" (Gamboa, 2009). In particular, innovative STEM projects should be imposed to transform them in a more effective education programs, as was the case of the teaching of English in the Mexico, with the help of the ICT. For instance, the secondary curriculum contemplates the realization of bimonthly projects. These projects should take into consideration ICT support, with students and teachers collaboration, as the systematization of these projects made by Harland (2011) shows.

In a different context, but not less important, BID Inspiring Innovations in Latin America´s report (2014) recognizes the International System UNO-Santillana (UNOi) as one of the ten inspiring innovative cases in Latin America and the only one in Mexico. UNOi is an integral teaching system, used for pedagogical and consultancy purposes, as a collaborative network and as an evaluation instrument that allows each school to be compared to other 700 schools, with Spanish and English textbooks, and digital resources, available offline or online, to run on mobile devices. The system pretends to improve the school operations with a management platform (LMS). The BID report includes trends on teaching systems, schools and students networks, science renew and technology innovations of the schools that are present at UNOi. Also, the report presents "secrets", and one is the mysticism of contagion that reflects what UNOi has achieved since 2010. Although this case does not contribute directly to closing the STEM achievement gap in Mexico, the program has been so successful that last year it got financial support from the World Bank and could contribute to show how to introduce the past trends in a more general way.

[8] ICT (Information and Communication Technologies) plus LCT (Learning and Knowledge Technologies), and EPT (Empowerment and Participation Technologies); called TIC, TAC, and TEP in Spanish (http://toyoutome.es/blog/tic-tac-tep-las-siglas-del-aprendizaje-aumentado/12734).

What else is there to do?

First of all, it is necessary to develop a national educational policy that only defines the achievements and the general standards so the teachers can develop their curriculum. However, this must be in accordance with the school and community context, which means working in collaboration with the schools of all the education levels. That policy could be gradually favored, for instance, first with open contests for those interested teachers where they could present projects and receive economical supports with the guarantees that the executions will be done in complete freedom. The mechanisms to select the projects that receive economical support should be transparent and strictly based on academic criteria[9]. This will help to make the national curriculum more flexible in order to stop the study programs from being "omnimonopolized" or omnicovered (Cordera et al, 2009, p. 35).

The conclusions are a series of reflections to foster the discussion mainly about the need to innovate and promote the autonomous curricular development, by considering learning achievements as the fundamental educative purpose and viewing school as a learning community in interaction with the neighborhood. The preceding discussion does not deny the need to implement wider state and federal policies:

- Raise the education expense as a percentage of the GDP, mainly with labeled budgets to take care and improve the schools' infrastructure, develop innovation and educational investigation projects, emphasizing the importance of applying this in the poorest communities.
- Set out to a bigger impulse related to the scientific and technological investigation. This should be theoretical and applied, starting with a bigger federal budget bounded to this matter, including the incubation of new companies with favorable cost and feasibility studies.
- Involve the scientific community in more SMET programs for basic and middle education. This should be done with interdisciplinary groups where the participation of specialists in the didactics of sciences, mathematics and technologies, apart from engineers, take place.

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[9] Although this kind of contest has existed since the 1990s, their number needs to be increased.

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