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Siemens Stiftung's international education program

Experimento in Mexico

Learning about natural sciences and technology through experimentation, exploration and discovery

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Experimento in Mexico

In 2015, Siemens Stiftung extended its international education program Experimento to Mexico. Siemens Stiftung is partnering there with the nonprofit organization Innovec (Innovación en la Enseñanza de la Ciencia), an initiative supported by the Mexican education ministry to improve teaching and learning methods for STEM subjects. Currently being piloted in four schools, the project will be subsequently extended to a much larger target group.

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* The Siemens Stiftung has brought its Experimento program to almost all Latin America countries. And in most cases, it's spread to multiple locations across the whole region.

“Technology doesn’t solve all our problems. But it sure helps.”

Nathalie von Siemens is Managing Director of Siemens Stiftung and previously held various posts at Siemens AG.

Dr. von Siemens, you are a small, dedicated team at Siemens Stiftung in Munich. How do you tackle your tasks?

We’ve been active on an international scale from the outset, since the company also operates in more than 190 countries. We look for the right local partners and try to network them with each other, even beyond national borders. We’re primarily engaged in Latin America and sub-Saharan Africa. And, of course, in Germany. At the heart of our involvement is the conviction that technology doesn’t solve all our problems, but sure helps. Most of the world’s problems have a technical component. In turn, technical solutions bring about social innovations.

What specifically does Siemens Stiftung do?

We have three working areas. One of them is Basic Needs, which includes clean drinking water for African and Latin American countries. We work together with social entrepreneurs, businesspeople who are committed long-term to environmental protection, development aid or education. When you combine social action with entrepreneurial thinking, people can ultimately help themselves and we can take back seat.

Can you give us an example of an entrepreneurial solution in the field of water supply?

With the Safe Water Enterprises, we’re working to provide a sustainable supply of clean drinking water in rural regions of Kenya and in Uganda. Small kiosks use mobile SkyHydrant water filters with microscopic membranes to remove suspended particles, bacteria and viruses from the water. That does not require any electricity, which means that the Safe Water Enterprises can operate even where there is no power supply. The approach of launching the mobile filters as small social enterprises and training locals as kiosk managers proved to be expedient. Even though the water is sold very cheaply, ongoing costs are covered. Other small entrepreneurs run a bicycle courier service that delivers water to customers in the surrounding area.

A further important working area is Education ...

... and focuses on sciences and technology. The promotion of education is not only an economic necessity, it is also a social and moral responsibility. High unemployment among young people can only be combated through training and qualifications. A society's prosperity and cohesion depends on it. Every responsible citizen in our society needs a certain level of technical education.

Can you give a concrete example?

Imagine you’re 15 years old, unemployed, with no educational degree, and you’re standing in line at the employment office. You can hardly complete the form because you can’t read properly. Then you and eight other applicants are referred to a factory that’s looking for someone to work on a production line. Everyone undergoes a one-day trial period, but your knowledge is so rudimentary that you don’t have a chance. A sound education in the STEM subjects – science, technology, engineering, and mathematics – is the key to success today.

What funds does your foundation provide for that?

We support science education by means of various instruments, with the focus on the Experimento program. We give educators and teachers further training so that they can apply their knowledge in kindergarten groups and schools classes, and we're committed to providing broad-scale support. And we offer an extensive collection of relatively simple and low-cost materials on numerous subjects. Pupils of any age group can use them to carry out scientific and technical experiments.

Aren't three- to six-year-olds too young for such experiments?

We now know that it's easy to kindle enthusiasm for science among children, who approach it completely naturally and without inhibitions. That becomes more difficult after age twelve. That's why we feel early childhood education with Experimento is so important. The experiments then build on each other, from kindergarten to matriculation. The youngest are introduced to the fields of energy, the environment and health and this experience is developed further at school. At universities, the experiments are linked to their application in industry, science and everyday life. As a result, values such as social skills are nurtured – on the side and in a playful way.

How's that done in the classroom?

The children learn to work together as a team, they communicate, change their perspective, respect decisions, and show solidarity and tolerance toward each other. Those are abilities and skills they need.

Do STEM careers offer young people in particular opportunities in emerging and developing countries?

Not only there. Young people in these professions are sought everywhere. In Germany, many academics from a migrant background work in STEM vocations. It's an integrative profession. If you don't have knowledge of sciences, you're excluded from a major part of the employment market.

At its summit last year, the United Nations adopted the "Agenda 2030" with 17 global goals for sustainable development. "Quality education" is fourth on the list. That sounds good, but how can you break down such overarching goals into a foundation's work?

We aim to promote an understanding of science and technology. We reach children, youngsters and young adults with Experimento. And with our program, we make a contribution to higher-quality education, even though that cannot be measured precisely. And also to other goals of the Agenda 2030: No poverty. Zero hunger. Peace. Justice.

Who doesn't want that? But how can that be achieved by 2030?

We've got an example from Medellin in Colombia, a city that's notorious for extreme violence and aims to combat it through education. The city spent 40 percent of its budget on education up until 2015. Educationalists and school psychologists who use Experimento there report that working together on experiments not only arouses pupils' interest in STEM subjects, but also changes their behavior. Violence and a tendency toward aggression have declined in classes that use Experimento. Social behavior and self-confidence have increased sharply. Mexico is another country that's fighting drug wars and corruption. You can counteract those issues through education. And we have fantastic partners at all levels.

Who are you thinking of, for example?

The educational organization Innovec. Its board member Mario Molino won the Nobel Prize for Chemistry and gave a lasting boost to climate protection with his findings on the impact of chlorofluorocarbons on the ozone layer. With his discovery, he influenced a worldwide movement to avoid CFCs. It's great that's he now involved in the effort to promote STEM education for children in Mexico.

All that is part of your Education and Basic Needs working areas. But you also initiate cultural projects. How does that fit in with the foundation's portfolio?

Cultural projects play a major role in relation to the issue of social innovation. Societies in the countries where we work are undergoing rapid, intensive transformation. We need to be aware of that. The key question is therefore about the identity of a society. Who are we? What's happening here? And in what sort of world do we want to live? Every change has a social and cultural aspect, is a challenge, but also offers opportunities. Artists in particular can heighten awareness of that.

What do you see as other important tasks in the year ahead?

We don't want to plant a flag in every country, but we do want to go where it makes sense. We have several

projects in Africa. In Latin America, we're engaged in Argentina, Bolivia, Brazil, Chile, Ecuador, Colombia, Mexico and Peru. We brainstorm with Siemens' local companies there, who help us with their network. In Mexico, we've been able to win over academic institutions, as well as partners from business, civil society and politics who are also committed to helping our projects. We collaborate with UNESCO. We staged an initial pan-Latin American network meeting of Experimento partners and multipliers in Santiago de Chile in the spring – 44 education experts from Argentina, Brazil, Chile, Colombia, Peru and Germany discussed the questions of how we can comprehensively promote sound education in the STEM subjects, qualify teachers, and cooperate and leverage synergies even more strongly. As a result, we're creating international momentum. We have to stick together on such an important matter as education; every contribution counts.

So your work regularly takes you all over the world?

We have fine partners on the ground, mostly small organizations that work effectively and with dedication, but the presence of employees from our foundation is important. We can't and don't want to just be someone who provides funding. Instead, we reap success where we're involved with our own projects and ideas. That's not a burden, but an enrichment. We learn something new and transfer that knowledge to other countries, too. It's therefore important to travel to another continent once a month.

Awakening curiosity and quenching a thirst for knowledge

Siemens Stiftung's education program Experimento

Looking back at their chemistry or physics lessons at school, few adults will remember the facts they had to copy down from the board, such as the chemical formula for salt or the velocity of a freely falling object. The lessons that tend to stick in the mind are those where something changed color, started to smoke or, best of all, exploded. What this tells us? The things we have experienced with our own senses are those that are easier to recollect.

A further insight into learning is that working in small teams enables us to solve problems in a simpler and more playful manner. Finding out whether ice or water is heavier, for example. Or coming together as a group to determine the things that need to be assembled in order to illuminate a light bulb. Such lessons are fun for both pupils and teachers alike, as witnessed by Siemens Stiftung's trainers when they conduct courses for teaching staff.

This sense of enjoyment can be achieved through simple experiments, such as by looking at an image reflected in aluminum foil and then bending the foil to make the image stand on its head. And making a pinhole camera out of cardboard is an "eye-opener" for pupils in every sense of the word. These experiences show that, once their curiosity is aroused, children have an almost inexhaustible thirst for knowledge about science and technology.

The educational researcher Professor Manfred Prenzel, a cooperation partner of Siemens Stiftung, has confirmed that material is more easily taken in when pupils are emotionally involved in the learning process and can apply solutions to their everyday lives. Although it's legitimate for teachers to begin by introducing the subject on a theoretical level, they should then initiate a discussion of the questions involved in solving the particular problem: Which result do we expect? How should we go about it? How do we evaluate our findings?

The social climate in the classroom is equally important. Pupils need to feel accepted and respected even when they still lack a particular skill or piece of knowledge. Teachers must support them in their willingness and resourcefulness. Cramming formulas, dates and facts into pupils' heads in order to get them through the next exams can only ever be a short-term solution. It's practically useless from a long-term perspective, and pupils have normally forgotten everything within the space of two months. These finding are backed up by the OECD's (Organization for Economic Cooperation and Development) PISA study. In the most recent ranking, Mexico was significantly below the OECD average in the natural sciences area.

Initiated in 2010, Siemens Stiftung's international education program Experimento seeks to promote scientific and technological knowledge among children and young people. It encourages them to experiment, discover and comprehend, using topics from the fields of energy, the environment, and health. The core elements of the program are lessons, teaching material and experiment kits for around 130 experiments that introduce children and young people to global challenges such as the greenhouse effect, clean drinking water or renewable energies. These experiments build on one another to form part of a continuous program of knowledge acquisition across the entire educational chain – from preschool to graduation.

In courses lasting several days, teachers are familiarized with the concept behind Experimento and trained on how to use the experiments in the classroom. Further knowledge transfer then takes place using the multiplier approach, in which teachers who have already gained experience using Experimento pass their expertise on to their colleagues. Aids such as student worksheets and instructions for teachers - also available in electronic format - help staff conduct the experiments in the classroom environment. The experiment kits contain materials that are already familiar to pupils from their everyday lives. No labs are required to perform the experiments, they can be conducted in any classroom.

Cooperation with local partners who are well acquainted with their country's individual educational environments is particularly important for the international acceptance and dissemination of Experimento. These partners are vital to the implementation of the education program.

Understanding the world and developing values

Science and technology are shaping our world to an ever greater extent. Solutions to global developments such as climate change and digitalization can only be found through scientific knowledge and an acceptance of our responsibility for the underlying values involved. In order to use artificial intelligence, ensure data privacy or take decisions about genetic engineering, to name just a few examples, we need to understand these technologies and be able to assess their impact.

Today, however, a basic grasp of science and technology is not only important for our global challenges – it's also vital to understanding and participating in our modern everyday world. The world is changing, and education needs to change with it – starting preferably at primary school level. This is why Siemens Stiftung is promoting the teaching of STEM subjects (science, technology, engineering and mathematics) throughout the world. "How are people supposed to come to decisions about the use of new technologies when they lack the basic knowledge of their effects and interrelationships?", asks Nathalie von Siemens, Managing Director of Siemens Stiftung. "How can they exist in modern working environments, and exercise their rights and privileges as responsible citizens?"

Keeping pace with modern, global developments is extremely difficult, especially for less well-developed countries. Even at an early age, there are major differences in pupils' knowledge of the STEM subjects depending on their social and regional backgrounds. But knowledge of these disciplines is vital if these children are to play an active role in society and help shape the future.

Alongside facts, however, taking actions and decisions in a responsible and independent manner also requires values with which the individual concerned is able to identify. Apart from the family, schools are the best place in which to communicate such values to children and young people. Siemens Stiftung regards science and technology lessons as a particularly suitable "experimentation environment" for the discussion of values. As parts of its endeavors, Siemens Stiftung strives to combine the shaping of individual values with topics that are relevant to the future. Some of these values are those that are important to the learning process itself. They shape the relationship between teachers and pupils and between the pupils themselves, helping teams to work together and take on responsibility.

The second group of values pertains to object-related attributes like solidarity, environmental consciousness and sustainability.

"We encourage people to live in a self-determined and responsible way, regardless of their social and cultural backgrounds", says Nathalie von Siemens. "And to achieve this objective, we can't rely solely on old, familiar approaches."

Open Educational Resources (OER)

Nathalie von Siemens makes an important fundamental point about the work of Siemens Stiftung in the area of education: unless learning and teaching methods change, less well-developed countries will not be able to keep up with their competitors in a global context. At the same time, however, the Internet represents an opportunity to better integrate these countries into modern educational programs and supply them with high-quality learning materials. Open Educational Resources (OER) are an example of this.

OERs are teaching and learning materials that are freely available on the Internet under open licenses, including complete courses, worksheets, tests, textbooks, videos, software applications and a whole lot more. This collection of documents and information can be seen as a global knowledge base that has its origins in the Open Source movement of the late 60s and early 70s. During the 90s, these activities evolved into the Open Access movement that called for free access to scientific literature, especially research that had been paid for through public funding. These endeavors formed the backdrop to the development of the free Linux operating system and Wikipedia. UNESCO defines an OER as "an educational, non-commercial resource" that is provided to "a diverse community of users". The resources are typically distributed by means of information and communication technologies. OERs are growing steadily in importance as recognized teaching resources.

In the "Paris Declaration on Open Educational Resources" from 2012, UNESCO calls for the provision of educational materials with an open license. And this is exactly what Siemens Stiftung is doing with the materials in its media portal. Teachers are allowed to download, modify, combine and pass on these resources as long as they indicate where they have made any changes. Teachers involved in the Experimento program in Mexico, for example, can download the relevant material, make any individual modifications of their own (such as translation), shorten it or combine it with other materials. It can then be printed out and distributed to pupils or made available for online access, depending on the technical equipment available at the school. The modified material can even be re-published, provided the author uses the same free license that allows other teachers to utilize it. This approach gives teachers across the world free access to tried-and tested educational material – material that is of a high quality and easy to modify.

The educational concept

Children and young people are curious about the world around them. When they are given the opportunity to discover natural phenomena on their own, their motivation to do so increases accordingly. This principle of learning by discovery forms the basis of the Experimento concept. Pupils and teachers work together to shape the learning process. The students learn as a group and from one another. The learning process is at work while they are documenting their activities, processing images or painting pictures. The experiments are designed to awaken the curiosity of students across all age levels, encouraging them to have fun through experimentation and stirring their interest in the topic of the lesson.

In the case of the youngest children (Experimento I 4+), the aim is to give them a first, basic introduction to the topics of energy, environment and health.

During their later schooling (Experimento I 8+), their understanding is widened and reinforced. It is also important to maintain a balance between theoretical and practical learning approaches. Just like "real scientists", pupils should be allowed to formulate their ideas and assumptions, conduct experiments, write down their observations and analyze their results.

In secondary schools (Experimento I 10+), the experiments are then linked to their application in science, industry and everyday life. This module also contains a number of experiments that are suitable for use in cross-discipline projects. Complex topics such as shortage of drinking water are easier for students to appreciate when they can view them from a number of different perspectives (physics, chemistry, biology, geography).

Experimento across the world

Up to now, Experimento has been successfully deployed in ten countries across Europe, Latin America and Africa, and is available in four languages. Around the world, around 4,500 teachers and 380,000 pupils* are working with the program. It takes account of the conditions in the different "educational markets" by appropriately modifying its content and methodology. Educational requirements are strongly influenced by the cultural setting in each specific country. And this is why it's so vital to integrate cooperation partners such as education ministries and universities. These partnerships help meet different countries' individual teaching and learning requirements. In the classroom situation, it's not possible to take ideas and methods that work in one country and simply apply them in identical form to others.

Inequality of educational opportunities

Foundations are taking on more responsibility for STEM subjects

With 120 million inhabitants, Mexico has the eleventh-largest population in the world. It has a large number of very young people and some who are extremely poor: more than half of Mexicans are aged under 29, more than 50 million live in poverty, and the divide between rich and poor is increasing all the time. At the same time, the country is on the threshold of becoming an industrialized nation, and a good education for all sections of society is therefore of vital importance. Mexico has its problems of course, of which the government is aware and going to great lengths to combat: the ubiquitous corruption and the power of the drug barons, but also the ethnic diversity of a country with 90 indigenous languages. There is compulsory elementary and secondary schooling, which is why there are few people unable to read or write. Nevertheless, some absolute figures remain shocking: there are three million children who don't attend school and a large number who leave before they gain any qualifications. A third of all children never go to preschool. Up to now, no government has been able to remedy the inequality of educational opportunities. There are sharp disparities between girls and boys, urban and rural areas, the indigenous and non-indigenous population as well as state and private schools.

As far as educational policy goes, however, things are not so bleak. In February 2013, President Enrique Peña Nieto's government passed an educational reform. The new legislation brought in competition-based rules for employing and promoting teachers. Nationwide performance tests are now based on standards laid down by the OECD, the organization behind PISA. Up to now, Mexico has been one of the poorest-performing members of the OECD with regard to education.

A further impediment to these reforms are the exploding numbers of elementary and secondary students: since 1950, there has been a ten-fold increase in school attendance from three to 32 million, now making up almost a third of the total population. This is compounded by the fact that conditions vary widely from region to region. One example: The state of Nuevo León is one of Mexico's richest regions and achieves significantly better educational results than Chiapas or Guerrero, areas where there is a large indigenous population and a low per capita gross domestic product.

In the meantime, the government has increased expenditure in the education sector. Mexico now invests 20.6 percent of its public spending in education, a disproportionately high amount according to the OECD: after New Zealand, this is the second highest figure of all OECD countries. However, 93 percent of this spending goes towards paying teachers' salaries. This leaves very little for investments in books and the further training of education personnel.

Siemens Stiftung is partnering with Innovec

Cooperation for learning through experimentation

In Mexico, Siemens Stiftung is partnering with the non-profit organization Innovec (Innovación en la Enseñanza de la Ciencia), an initiative supported by the Mexican education ministry to improve teaching and learning methods for STEM subjects. Founded in 2002, Innovec is now operating in eleven of Mexico's 31 states. The organization boasts a Nobel Prize Laureate for chemistry among its board members, Professor Mario Molina. With its science education program SEVIC (Sistemas de Enseñanza Vivencial e Indagatoria de la Ciencia), this institution trains more than 10,000 teachers every year, reaching around half a million pupils. SEVIC stands for experience- and investigation-oriented science learning, i.e. learning through experimentation. Pupils are encouraged to try things out, raise questions and find their own solutions as a means of developing logical ways of thinking and techniques for communication. In SEVIC lessons, pupils are allowed to experiment with a wide range of materials, including chemicals or living organisms such as plants or insects. The method aims to let pupils experience science with their own senses. Innovec is financed by grants from the Mexican states it operates in and funds from private foundations. It receives advice from experts around the world, including institutions such as the France-based "La main à la pâte". A main contributor is the Smithsonian, that also donates teaching materials, curricula and assessment methods. SEVIC has been adapted from the Smithsonian's own STEM program. Founded in 1846, the Smithsonian is a U.S. education and research institution based in Washington. It operates 19 museums throughout the world, including the United States National Museum that was founded in the same year. The Smithsonian is the world's largest museum and research complex. Its goals are to preserve the country's cultural heritage and discover and share knowledge, also through collaboration with organizations such as Innovec in Mexico.

Innovec gradually adapted the entire Experimento program in order to integrate it into the Mexican educational context. Experimento thus complements SEVIC, which already offers education modules for preschools and elementary schools.

"The pupils are motivated and enthusiastic"

Catalina Everaert, INNOVEC's project manager for the cooperation with Siemens Stiftung in Mexico, talks about adapting Experimento I 8+ for use in elementary schools.

Ms Everaert, your SEVIC program is all about independent experimentation. Why have you opted to work with Siemens Stiftung's Experimento as well?

Experimento is an extremely well-structured program that complements our own. The topics are not identical, but even where there are similarities, there are differences in how they are handled. The experiments in the Experimento program are designed to be completed in shorter time period and are mostly self-contained. With SEVIC, however, experiments take place over a longer period.

Pilot projects were started at four schools at the end of 2014. Where are these schools located?

Two are in the city of Querétaro, about a hundred kilometers north of the capital and home to a number of international firms and important universities. But many of the pupils belong to the indigenous population and are children of poor families. Two schools are located in Guanajuato in central Mexico. A rich and attractive city, it's a World Cultural Heritage Site and boasts its own university. But poverty is rife in the shanty towns surrounding the city, and this is where our two schools can be found. Both cities have a deficit in well-trained workers. Up to the end of the year, we had trained 24 teachers. These are working with around 700 elementary school children from the first to the sixth grade. We have started to use Experimento I 8+ for pupils from the third to the sixth grade. Teachers report that the material is of high quality and not too complicated. The children are motivated and enthusiastic, not just memorizing things by heart but understanding what is going on.

Have there been suggestions for improvement?

Yes, we have received a few suggestions. The teachers believe that the experiments should be more rigorously categorized according to age group. They also need to be better adapted to the curricula defined by the education ministry.

What can you do to remedy this?

We have set up a working group to adapt the Experimento program for teachers in Mexico. For the most part, Experimento will target children in the sixth grade, and the program will deal with topics from the areas of environment and energy. Thematically, these lessons will fit in better with ministry guidelines. There will be more experiments following on from one another and these will go into greater detail.

Won't Experimento simply become a copy of SEVIC?

No, they complement each other and have the same objective: the training and continuing education of teachers. Our work at Innovec focuses mainly on teacher training. We believe it makes a radical difference whether teachers are well- or poorly-trained. Teachers in Mexico have been undergoing performance evaluations since the last educational reform. For both SEVIC and Experimento, all teachers underwent several days of training in the use of the materials at their schools. We then went into the classroom with them, observed their lessons and made any necessary adjustments.

Doesn't this mean that know-how is disseminated in a slower fashion?

Yes, extremely slowly, but quality is guaranteed. We're also proceeding extremely carefully with the pilot project for Experimento. Innovec currently only reaches out to around ten percent of the Mexican population. We want to find ways to impact science education for everyone. To do this, we need to go digital and develop effective online programs for teaching staff.

SIEMENS | Stiftung

Siemens Stiftung
Kaiserstraße 16
80801 München, Deutschland
Tel.: +49 89 540 487-0
Fax: +49 89 540 487-440
www.siemens-stiftung.org

Dr. Barbara Filtzinger
Project Manager Education
München
barbara.filtzinger@siemens-stiftung.org

Ulrike Wahl
External Consultant for Siemens Stiftung in Latin America
Santiago de Chile
ulrike.wahl.ext@siemens-stiftung.org
Tel.: +56 9 56 88 41 86

Text: Uschi Entenmann
Photography: Uli Reinhardt
Layout: Astrit Vatnika
Zeitenspiegel Reportagen
www.zeitenspiegel.de