Grand scale implementation of the Climate Change Education project at middle and high school levels

Mario Molina Center

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Abstract

Since 2010 the Mario Molina Center has designed, tested and improved materials for professors and students at middle and high school levels (Physics, Chemistry and Ecology), equipping them with not only knowledge but of an innovative pedagogical approach that helps students develop critical thought, analysis and solutions for current day problems. The objective of this grand scale project consists in using materials and methodologies previously developed in past stages so that students and teachers at middle and high school levels know and apply scientific foundations over which are the causes and consequences of climate change, as well as solutions using inquiry-based learning. The grand scale implementation project has as one of its objectives to expand the margin of action during the 2013-2014 pilot test (where we worked with 2 States: Veracruz and Zacatecas) with a total of 23 teachers and close to 500 middle school students; and of 2016-2017. This expansion included incorporating the project to the following States: Mexico, Nuevo Leon, Quintana Roo and Veracruz, as well as Mexico City for the grand scale middle school test and with high schools through a Federal Entity of the Middle School Education subsystem with almost 100 schools participating in more than 30 States. Furthermore, we had the participation of middle and high school institutions from the State of Mexico and Quintana Roo which included other high school modalities such as official state high schools, community televised high schools, and technological high school centers. Even though to the day of this report student testing has not concluded, we have the results of several tests and evaluations carried out, which demonstrate the strength of the materials we developed, the importance of teacher training in the process of developing a new teaching method for science, the potential of technological tools when they are managed hand by hand with teachers, and the key role of government authorities in the success of implementing programs of this nature.

1. Introduction

The Mario Molina Center has worked since 2010 in the development and implementation of education materials which scientifically and objectively communicate the causes, consequences and solutions of climate change, while they provide students with a better understanding of scientific concepts related to Chemistry, Physics and Ecology. The Center´s proposal has the teacher as the main player so many of the efforts have centered in equipping professors with knowledge of climate change and tools for applying inquiry-based learning by introducing innovative elements such as instructional methods which favor learning, promote wide and focused mental efforts instead of memorization, and virtual labs through computer simulators.

In the pilot tests of 2013-2014 and 2016-2017, we worked with small groups of teachers in two States, and during the grand scale test we incorporated Mexico City, Nuevo Leon, Quintana Roo and Veracruz for middle school levels. For high school, we incorporated teachers from the education subsystem UEMSTIS (Technical, Industrial and Services High School Education Unit) from 30 States, and from the high school state systems of Mexico and Quintana Roo which included other high school modalities such as official state high schools, community televised high schools and technological high school centers.

2. General Objective

The objective of this Project was to inform on the causes, consequences and solutions of climate change while promoting science education supported by an effective inquiry-based learning model to teachers and students in middle and high school.

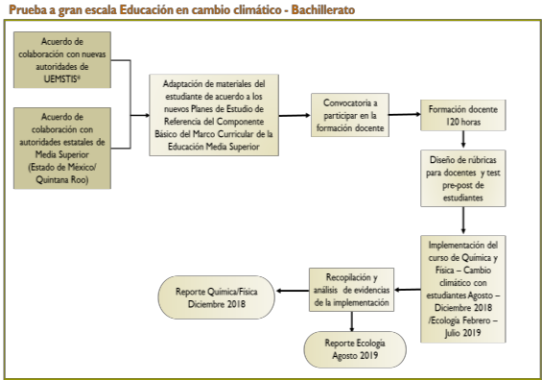
3. Particular Objectives

- Teacher training. Create in middle and high school teachers abilities to teach climate change related topics and the inquiry-based teaching method through a 120 hour Climate Change Teaching Course.
- Implement at a grand scale the climate change education program for middle school in the school calendar year of 2018-2019. Duration: 1 school year -70 hours.
- Implement to a grand scale the Chemistry and Climate Change course during one semester -60 hours (August-December 2018).
- Implement to a grand scale the Ecology and Climate Change course during one semester -60 hours (February-July 2019).
- Implement to a grand scale the online course for Physics and Climate Change – Framework theme "Interaction of matter and energy" during one semester -25 hours (August-December 2018).

4. Methodology

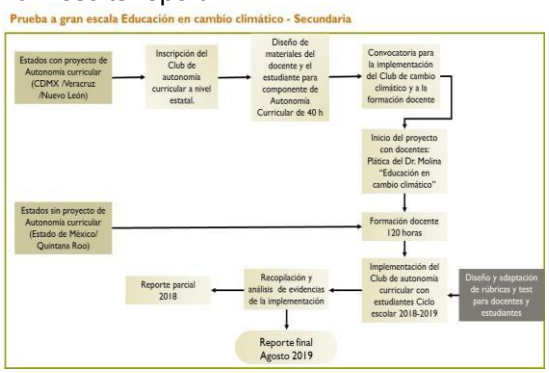
The high school Project was carried out with the support of UEMSTIS and the Undersecretaries for High School Education from the States of Mexico and Quintana Roo. The following required stages were carried out:

1. Collaboration agreements with state and UEMSTIS authorities.
2. Adapting Ecology, Physics and Chemistry materials to official Study Plans of the Middle School Education Curricula.
3. Application call for teachers in the Chemistry and Climate Change, Physics and Climate Change projects during the August-December 2018 semester.
4. Teacher training through the Climate Change Education Course (120 hours).
5. Designing validating tools for the courses.
6. Implementation with Chemistry I and Physics II students during the August-December 2018 semester.
7. Gathering evidence of the application.
8. Evidence analysis.
9. Results report.



The Middle School Project was carried out concertedly with different state and federal authorities in the case of Mexico City through the following activities:

1. Enrollment of the Project at state level in the modality of Curricular Autonomy (Mexico City, Veracruz and Nuevo Leon).
2. Designing teacher material for the Curricular Autonomy club.
3. Designing new student material for the Curricular Autonomy space.
4. Application call for teachers for the implementation of the Climate Change club.
5. Conference by Dr. Mario Molina for middle school teachers
6. Incorporation of participant States without a Project of Curricular Autonomy.
7. Teacher training through the Climate Change Education Course lasting 120 hours.
8. Designing and adapting headings and tests for teachers and students.
9. Applying materials with students in the 2018-2019 school year in the Climate Change Club.
10. Gathering evidence of the application.
11. Evidence analysis.
12. Partial results report.
13. Results report.



5. Results

Middle School

Materials

We adapted materials for the creation of the new curricular space, with a new student book and new teacher materials which comply with the requirements of the education offer and the Curricular Autonomy Projects in accordance to the criteria given by the Undersecretary of Basic Education.

Teachers

This scale test was carried out with teachers in front of classrooms in different modalities of middle schools: general, technical, televised, special education and nightly in the States with the following characteristics:

State	Number of teachers	Course progress
Mexico City	140	75 %
State of Mexico	80	40 %
Nuevo Leon	50	50 %
Quintana Roo	20	40 %
Veracruz	50	50 %

To the day of this report, all of the participants have finished Modul 1 of the Course and their grades, percentage of activity compliance and percentage of actual efficiency were reported here:

State	Actual efficiency	Compliance	Average grade
Mexico City	87 %	99	9.4
State of Mexico	77 %	85	9.2
Nuevo León	50 %	80	9.4
Quintana Roo	78%	80	9.1
Veracruz	94 %	92	9.4

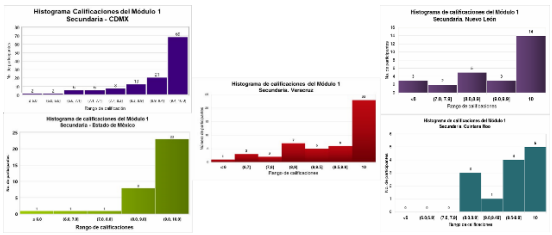


Figure 1. Grades from Module 1: Middle school

Students

Each teacher has in average an impact over 210 students, even though the results from applying the project to Climate Change Clubs will be ready until the end of the 2018-2019 school year, we give data that reflects classes in Mexico City and Veracruz where this curricular space started in October and will start in all schools in all states in January 2019.

High School

Materials

Changes were made to 2017 student materials for Chemistry, Physics and Ecology classes in order to make them compatible with Reference Study Plans from the Basic Component of the Framework Curricula for Middle and High Schools published at the end of 2017.

Teachers

This scale test is carried out with the participation of teachers in front of high school classrooms in the States with the following characteritics:

State	Number of teachers	Course progress
UEMSTIS	140	100 %
State of Mexico	50	40 %
Quintana Roo	40	40 %

Figure 2. Location of middle and high schools where the climate change education program is taking place

We report the results of the Course concluded by UEMTIS teachers and the progress of modul 1 by teachers from the States of Mexico and Quintana Roo.

State	Actual efficiency	Compliance	Average grade
Mexico City	73 %	96	9.5
State of Mexico	65%	88	9.1
Quintana Roo	69 %	78	8.7

Students

The following information is regarding work with 1st semester high school students in Chemistry and participants of the UEMSTIS of the States of Mexico, Michoacan, Nuevo Leon, Queretaro, Quintana Roo, San Luis Potosi and Mexico City.

In the pre-test part evaluated, we seek to find out of students can identify the differences between substances and mixes, size, mass and charge of elementary particles which comprise matter based on atomic models.

Also, if students recognize property tendencies of elements in the periodic table and if they identify physical properties of matter, as well as the purity and composition of mixes, compounds and elements. General grades show that 20% of students have previous knowledge on the described subjects, 27% obtained a grade of 7, 25% the minimum passing grade of 6, and 27% didn't identify the subjects of this test.

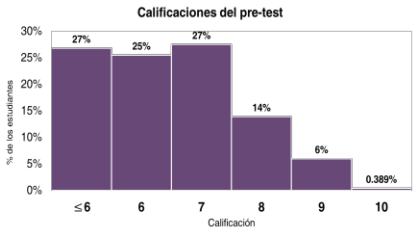


Figure 3. Grades of the Chemistry pre-test – UEMSTIS High School

We observed that the subjects understood by the majority of students are the ones related to matter, the water molecule and atomic models. A large percentage of students identified some characteristics of the periodic table, have basic notions on the formation of the universe and almost everyone has clarity on the first atomic models. Furthermore, they identify the difference between elements and substances. On the other side, a vast number of students have difficulty identifying matter in what they don't see, for example, gases in the air. Few identify chemical properties and they find it hard to differentiate between mixes and compounds.

In the post-test we observed an improvement in the number of students who didn't obtain a passing grade to 8%, and the rest were distributed as follows:

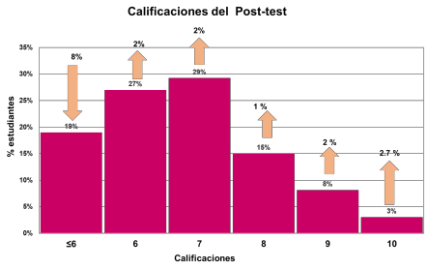


Figura 4. Calificaciones del post-test de Química I- Bachillerato UEMSTIS

Regarding the inquiry-based learning model, teachers reported the following practices in the classroom:

Aspects	Number of sessions
Always felt confident	73%
Gave opportunities to inquire during the lesson	75%
Included every student in activities with experiments	81%
Facilitated interaction among students in activities with experiments	83%
Fostered students to manipulate the materials	82%
Always carry out experiments in accordance to safety regulations	92%
Fostered students to give their own explanations	63%
Fostered analyzation of concepts	82%
Fostered the use of the Chemistry and Climate Change book	73%

During October, we created courses for 29 schools where more than 1200 students participated in Mexico City and the States of Chiapas, México, Guerrero, Puebla, Quintana Roo, San Luis Potosi, Yucatan and Zacatecas.

With the responses and activities from the participating students we identified the subjects related to the main area of matter and energy which the students know better. In the following figure we indicate which concepts were of more or less difficulty.

Subject	Pretest
Thermal equilibrium	20%
Energy Exchange – 1st Law	25%
Energy Exchange – Zero Law	22%
Energy Exchange - Convection	24%
Energy Exchange – Conduction	22%
Gas laws	27%
Temperature Units	25%
Properties of Matter	29%
Relationship between Energy and Matter	12%

Not all students have answered the post-test, given that they will finish school until December 14th. With data from 600 students available we found that the course has a positive effect in learning concepts related to the subjects revised in the course (Fig. 5).

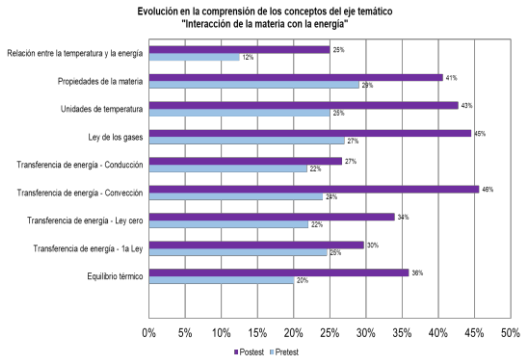


Figura 5. Resultados del post-test para Física y cambio climático.

6. Discussion

Teacher training through the online course for teaching Climate change is effective and allows reaching a larger number of teachers who recognize the advantages of having flexible schedules for working on their training, plus the advantages of tracking their activities.

Carrying out experiments with low cost materials is equally effective. It allows teachers to simulate, in their own context, how they would work with their students.

The Education on Climate Change course for high schools is compatible with the training scheme for teachers at this level and gives good results. Also, at middle school level, it allows developing among teachers the abilities and knowledge for applying this subject with students from 7^{th} to 9^{th} grade. We identified some aspects of great relevance for the successful formation of teachers:

a. Permanent tracking by facilitators of the Course, especially in activities involving experiments. Participants said they felt motivated by the personal attention and on the possibility to improve their future work.
b. The flexibility for carrying out their activities and the dates for handing in their work, even though there is a reference calendar. Multiple school activities sometimes made it impossible for them to carry out their assignments within the calendar so teachers manifested as a very positive sign to be able to hand in their work later than expected without being penalized.
c. Giving extra points for punctual handing in of tasks, as well as allowing extemporary hand-ins are appreciated.
d. Maintaining permanent communication with participants and their development in the Course helps teachers not abandon the course just because they feel they are not at the speed hey thought was required.
e. The way in which teachers are contacted to apply for the course by education authorities is an important factor. Having teachers sign-up through a payment is not favorable for long training processes. It´s important to fully inform teachers and invite them to participate on a voluntary manner where possible.
f. Support by education authorities is fundamental. In the States that had changes in the personnel involved during the teaching process we noticed there was a spike on desertion. Also, teachers obligated to take part in a course are the first to abandon it.
g. Finally, even though the objective of the training course is to learn new things, 70% of participants expect to receive a diploma or proof that they took the course, preferably backed by an education authority.

With information available up to this moment, the materials designed to be applied within the autonomous curricula are appropriate for the middle school context of 7^{th} – 9^{th} grade. With regards to high school materials, student materials were suited to new study plans and during the teacher revisions they concluded that they would feasibly be applied to the times stated. The results show that these allow for a more adequate learning process.

7. Conclusions and recommendations

The online course for Teaching Climate Change for middle and high school teachers is adequate, pertinent and successful. It allows easy tracking and verification of activities by teachers and is replicable and scalable.

We successfully incorporated student materials within the offer posed by the autonomous curricula and will be applied for the current school year (2018-2019) in the States of Mexico, Nuevo Leon, Quintana Roo, Veracruz and Mexico City. Teacher and student materials are appropriate for this school level. The activities proposed may be achieved in all social contexts. We recommend having the books in person because not everyone has access to the internet.

The materials for Chemistry students will be applied during the August-December 2018 semester in the States of Mexico, Michoacan, Nuevo Leon, Queretaron Quintana Roo, San Luis Potosi and Mexico City. The Chemistry book is accessible and students thus far have expressed their liking to the way in which different subjects are addressed.

Activities with experiments may be carried out in different social contexts, and we observed that the material is favorable for students to reach their learning goals.

The course for students on Physics and Climate Change was applied during the semester of August-December 2018 in the States of Mexico, Chiapas, Guerrero, Puebla, Quintana Roo, San Luis Potosí, Yucatan, Zacatecas and Mexico City. In the results obtained from the tests applied and the development of activities by students, we observe significant improvements in understanding concepts related to the subjects revised regarding matter and energy.

8. References

[1] National Research Council. (2012). A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. Washington, DC: The National Academies Press.

[2] Anderson P.T., N. T. (2006). Evaluación de programas: estudios a gran escala y de pequeña escala. Algunas generalizaciones. Academia Internacional de la Educación. UNESCO.

[3] Bybee, R. W. (2002). Scientific Inquiry, Student Learning, and the Science Curriculum. En R. W. Bybee, Learning Science and the Science of Learning (págs. 25-37 Cap. 3). National Science Teachers Association Press.

[4] Bybee, R. W. (2015). The BCSC 5E Instructional Model: Creating Teachable Moments. National Science Teacher Association Press.

[5] C. E. Heiner, A. B. (2017). Preparing students for class: How to get 80 % of students reading the textbook before class. American Journal of Physics, 82(10), 989-996.

[6] Chia-Yu Liu, C.-J. W.-K.-W.-K. (2017). Scientific modeling with mobile devices in high school physics labs. Computers & Education, 105, 44-56.

[7] Galan, D. R. (2017). The experiment editor: supporting inquiry-based learning with virtual labs. European Journal of Physics, 38(035702), 1-12.

[8] Jane Jackson, L. D. (2008). Modeling Instruction: An effective Model for Science Education. Science Educator, 17(1), 10-17.

[9] Scott Freeman, S. L. (2014). Active learning increases student performance in science, engineering and mathematics. Proceedings of the National Academy of Science of the United States, 111(23), 8410-8415.

[10] Shavelson, e. a. (2008). On the Role and Impact of Formative Assessment on Science Inquiry Teaching and Learning. En D. R. Edited by Coffey J., Assessing Science Learning. Perspectives from Research and Practice (págs. 21-36). NSTA Press.

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