Educational program with innovative seismic instrumentation for volcanic risk reduction in Canary Island (Spain) and Chichon Volcano (Mexico)

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Volcanic risk management in long period recurence volcanic areas relates to two important issues: **the lack of risk perception in population towards a possible eruption, and the lack of resources in monitoring and educational programs to reduce the volcanic risk effects.** Under these circumstances, it is necessary to develop educational-oriented programs to spread and improve the knowledge related to volcanic activity, including the use of new technologies to make it more attractive for young people. This type of educative program was initiated in Tenerife in 2001, among others, with SOCRATES-COMENIUS European project in which several schools from different countries exchange data and knowledge about volcanic activity (Canary Island, Azores and Sicily). This initiative was also driven and supported by the **Didactic Guide for Volcanic Risk**, published by the National Civil Defense of Spain in 2004. The new educative program presented here takes into account the installation of a seismometer in a school located in an active volcanic area. The seismometer is developed and the software compiled by low-cost modules and systems (ARDUINO and RASPBERRY), supported by educative activities as the construction of a seismic sensor combined with a commercial 4.5 Hz (~60€) short-period geophone. Seismic data will be registered, analyzed and discussed by the students, who will also exchange results with other students placed regionally or from other countries. The seismic station will be the first of other scientific modules for data acquisition as CO2, thermometer, etc. Other parallel activities will be conducted, such as field trips, development of self-protection and family emergency plan, visit interesting places, etc. We also explain how these affordable instruments are also being implemented at Observatori Fabra in Barcelona to digitize historical seismometers and other newer educational sensors for both professional and divulgation projects.

Action against natural disasters: Disaster management in the 20th century was characteristic in its emergent reaction. The result was the repetition of the tragedies all over the world, especially in the developing countries, because of the lack of preparation. In the 21st century the focus of disaster management is shifting from the reaction centered-management after the disaster to *the preparedness-centered management before the disaster.* The Disasters are non-daily happenings. Education is a daily work. Our daily life is remote from non-daily disasters. What's necessary is to make non-daily happening connected with daily education. To fulfill this I would suggest some key words. They are *to connect the students' dreams with disaster management* and *education to be a survivor and to be a supporter*. (Seiji 2006)

Learning from Japan: The Japanese are also prepared to quickly react to quakes and tsunamis due to a highly-developed public education program. It is important to emphasize here how education and schooling can play such a significant role in preparing citizens for such catastrophic natural disasters. (Anderson 2011)

MITIGATION EFFORT INDEX

The Teide 2004 unrest started under the worst possible circumstances: Lack of preparation of authorities and people; lack of educational programs and evacuation plans; lack of communication strategies; personal or professional conflicts among scientists. However, many goals have been reached since then. This situation may be quantified as an intended proposed index.

Scientist response	Max Value	Teide
Is there a Monitoring Network?	0-1	1
Is there a Volcano Warning System?	0-1	0
Is there an Event Tree of expected volcanic activity?	0-1	1
Is there a Volcano Hazard Map?	0-1	1
Is there a Volcano Risk Map?	0-1	1
Are there volcano research programs?	0-1	1
Civil Protection response	**Max Value**	**Teide**
Is there any public or private INSTITUTION dedicated to managing emergencies?	0-1	1
Does the INSTITUTION have experience in organizing preventive massive evacuations?	0-1	1
Have the INSTITUTION personnel received training related to volcanic hazards?	0-1	1
Have volcano drills or exercises been carried out by the INSTITUTION?	0-1	0
Is there any interaction between the INSTITUTION and the community	0-1	0
Community response	**Max Value**	**Teide**
Has the community got the the capacity to self-evacuate?	0-1	1
Is there a volcanic hazard perception in the community?	0-2	1
Is there an official volcanic hazard educational program in schools?	0-1	0
Is there a periodic self-protection educational program for the community?	0-1	1
Is the Volcano Warning System known by the community?	0-2	0
Is the Volcano Warning System understood by the community?	0-2	0
Is there an official public report about volcano activity?	0-1	0
Does the community trust its volcano emergency managers?	0-2	1
Has the community got volcano historical memory about VEI <3 eruptions?	0-1	1
Has the community got volcano historical memory about VEI ≥3 eruptions?	0-1	0
Does the community remember causalities due to volcanic activity?	0-1	0
What knowledge do people have about volcanic hazards?	0-2	0
Total	**17**	**5**
MITIGATION EFFORT INDEX	**36**	**13**

Technologies Development to know the Volcano activity

New technologies have a strong attraction for young students. Embedded modules such as Raspberry Pi or Arduino, allow them to easily develop basic elements to monitor the volcano activity and basic software to analyze and understand data available. The educational centers are being used for the deployment of volcano monitoring networks, taking advantage of their Internet connection. With this approach, people/students can collaborate directly not only in the understanding of volcanic activity but also during real volcanic crisis, improving the relationship with the scientific teams. This approach was used by our group during the crisis of the Teide volcano in 2004 and in the follow-up of the eruption of El Hierro 2011-2015. Currently, scientists from the University of Sciences and Arts of Chiapas (Mexico) are using this approach to follow the seismic activity of the Chichon and Tacana volcanoes.

In the *Tierra Viva* (2000-2004), a project funded by the Government of the Canary Islands, the first educational seismic network was deployed in schools in Tenerife, Gran Canaria, Lanzarote, Fuerteventura, El Hierro, La Palma and La Gomera. The project also included activities such as periodic meetings with the teachers involved in the management of the project, field trips to learn about the volcanic environment in their vicinity and preparation of teaching materials. Initially, 1Hz geophones and conventional PCs were used in the school, which were replaced by 4.5Hz geophones with extended response and HP200LX notebook computers. The incorporation of embedded computers such as ARIETTA and RASPBERRYPI with Linux Debian operating system was also an important progress in the design of this instrumentation, reducing the cost/price and facilitating the software development, access and data transfer. The eruption of El Hierro 2011-2015 allowed to evaluate the possibilities of the system and its optimization in a crisis situation.

Implementation of the technological educational project in an active volcanic area

Regional volcanic activity.
Type of eruptions.
The precursors:
Seismic Gases Deformation.
Instrumentation to be built by the students
Seismograph CO2 meter GPS low cost L1L2
Start up:
Data obtained with the monitoring system
Analysis of data & catalogs available for the area.
Exchange with other schools at national and international level

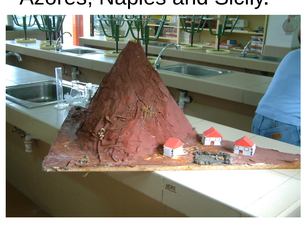
In the seismic monitoring network of the Chichon volcano some seismometers are installed in rural schools that have satellite internet access. Students examine seismic data every day

Knowledge of the natural environment as a strategy to reduce volcanic risk

In 2000 we started the educational activity to mitigate the volcanic risk in the Canary Islands, implementing educational/scientific projects funded by the Educational Counselor of the Canary Government

Educating in seismic and volcanic risk 2000-2005 COMENIUS1 2001-2006 01-ESPO1-S2C01-00940-1 European Project (Spain-Portugal-Italy)

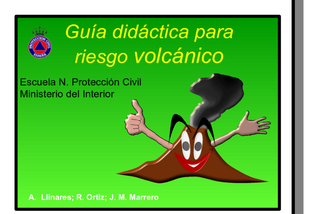
coordinated by the canarian group, the project that included the exchange of information between professor and students of different countries and visiting some European active volcanic areas such as Canary Islands, Azores, Naples and Sicily.

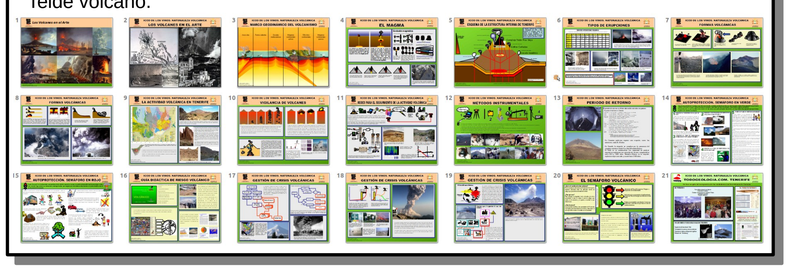


To understand the volcanic risk, the students build models of volcanoes with the aim to assess the lava flow hazards, placing a container inside the crater and houses located in the base of the volcano. Then the eruption was simulated by adding bicarbonate and vinegar, producing a chemical reaction that overflowed the crater and flowed according to the topography of the model affected some houses.

The crisis of the Teide volcano in 2004

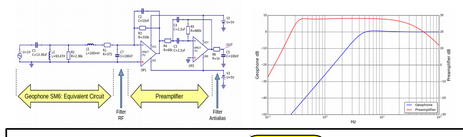
The volcanic crisis was characterize by the occurrence of a series of earthquakes felt by people in the surroundings of the Teide volcano slopes accompanied by an increase in the fumarolic emissions. Because of that, Spanish Civil Protection entrusts us with the realization of a didactic guide for teachers. We also organized and participated in several meeting with local population with the aim to explain the volcanic activity and the expected scenarios. An important exhibition was prepared in Icod de los Vinos, one of the municipalities affected by a possible eruption of Teide volcano.





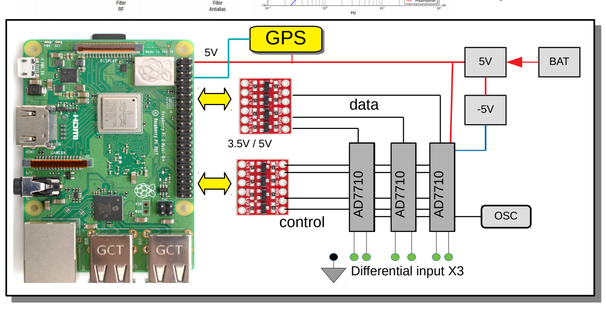
Instrumentation (2018)

Affordable high quality seismic instruments are crucial to allow small institutions or scientific groups, such as ourselves or even amateurs, to continue working and developing many interesting low-cost projects. With these iniciatives, the educational programs are encouraged through a citizen seismology. The progress in electronics and specially the development of embedded computers of high performance and low power and price, allow to design instruments for seismic monitoring at a very low cost.



QUCS (Quite Universal Circuit Simulator)

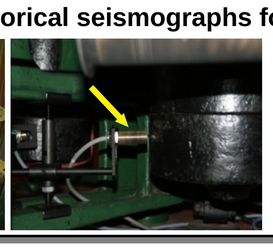
The simplest way of extending the frequency response is to use the 'inverse filter method



Features

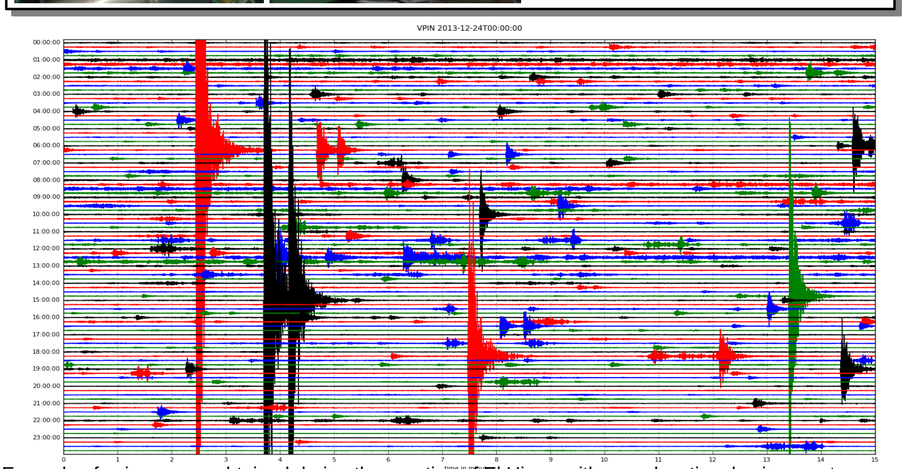
Operate 50/100 sps
16/24BITS
Public WEP page
last hour & last 24 hours.
each 5 minutes
Send data by SSH & email each hour
OBSPY compatible format
Installed in schools in the Canary Islands and Mexico

Digitization of historical seismographs for educational purposes.



An electromagnetic linear *Variable Displacement Transducer* LVDT is used so as not to modify the 1914 original Mainka horizontal pendulums. The instrument continues in traditional operation mode using smoked paper.

Observatori Fabra Barcelona



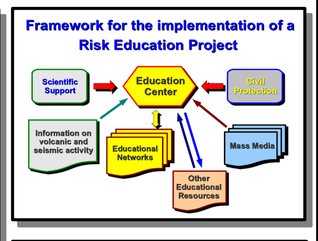
Example of seismogram obtained during the eruption of El Hierro with an educational seismometer.

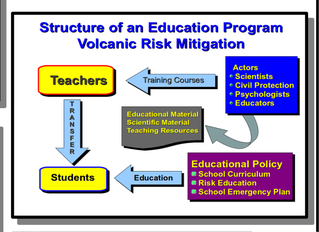
In 2004 Spanish TV program RUTA QUETZAL dedicated to nature was made in Mexico with the theme volcanologist for a few days. 370 young people from Europe and America participated. The volcanoes Paricutin, Popocatepelt and San Martin were visited and the topics of volcanic monitoring instrumentation, and volcanic risk were developed. CSIC (Spain), UNAM, CENAPRED and Civil Defense (Mexico) provided the scientific support.

Volcanes de Canarias also support field trips for students: e.g. Berlin Free University

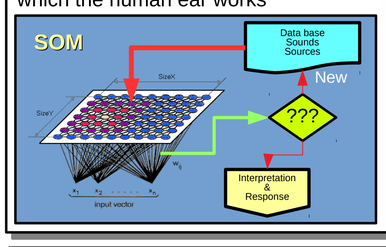
International training courses in volcanic hazard mapping, volcanic activity forecasts, touristic guides, teachers, etc.

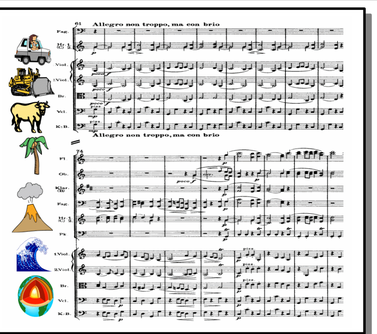
Training course specially dedicated to volunteers who want to collaborate in a volcanic emergency.





This example shows the method used to differentiated between volcano seismic signal and the seismic noise fron other sources, imitating the way in which the human ear works





Authorities' obligations to mitigate volcanic risk

Education

Continuing education programs throughout the curriculum.
Continuing adult education in natural hazards.
Teachers training in natural hazards
How to develop a Family Emergency Plan
Self-protection measures against natural hazards
Participation in emergency drills and exercises

Works to promote and develop mitigation of natural disasters

Political coordination, scientific, civil defence emergency management
Establish the Volcano Early Warning System
Emergency plans at all levels (national, regional, local)
Research Projects volcanic risk
Periodic emergency drills and exercises.

Information Dissemination

Local Emergency Planning. Evacuation route signalling
Information about the activity of the volcano.
Visitor information centers explaining the steps to take in case of seismic or volcanic crisis

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