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# A science & arts sensitization program in Chapultenango, 25 years after the 1982 El Chichón eruptions (Chiapas, Mexico)

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**Abstract**

Volcanic risk perception may drastically decrease after eruptions and during periods of volcanic quiescence. Despite the fact that the adults in Chapultenango, a Zoque indigenous community near El Chichón volcano (Chiapas, Mexico), lived through the 1982 Plinian eruptions, their awareness of present volcanic risk is low. In particular, children, adolescents and young adults (born after 1982) should be informed about the activity of El Chichón, as they are more likely to be affected by possible future eruptions. This grass roots level sensitization project uses a novel approach to poll risk perception and to transmit knowledge of El Chichón volcano among 6- to 11-year old children by combining scientific information sessions with arts workshops. Similar scientific sessions, although without the arts workshops, were less efficient for the older age group (Secondary School students). Moreover, the local *Protección Civil* and *Gobierno Municipal* was invited to participate in a basic monitoring of El Chichón volcano. A lack in continuity in local political terms presented the major barrier for an effective and self-sufficient following-up of the volcanic surveillance. The entire population of Chapultenango was involved during informal meetings and semi-scientific projections of "their volcano", offering an alternative and more scientific view on El Chichón's activity, often referenced in a more mystical-religious frame. It is experienced that the volcanologist is recognized as a highly trusted professional, bridging the gap between the official authorities and society.

**Keywords:** Science & arts; Social volcanology; Education; Risk perception; Civil protection; Zoque community; El Chichón

## Introduction

The cocoon-effect in volcanological research often makes volcanologists forget that the most critical reviewers of their scientific work are the local people living near active volcanoes. Volcanologists often believe they are the most qualified to interpret the observations and measurements revealed by an active volcano, and to transmit information to all those who need to be informed on volcanic phenomena and related hazards. The dynamics are probably more complex, as volcanologists are only one of the many stakeholders (Macías Medrano 2005). Nevertheless, after friends and relatives, scientists are found to be the most trusted source of volcanological information, while government authorities are generally distrusted (Barberi et al. 2008; Gavilanes-Ruíz et al. 2009; Haynes et al. 2008a; Eiser et al. 2009). In recent years, some volcanologists feel that their work should be guided by its social relevance (mode 2 research), rather than being purely determined by traditional, research-based science (mode 1 research, Gibbons et al. 1994) (Johnston et al. 1999; Cronin et al. 2004a, b; Gregg et al. 2004; Barberi et al. 2008; Haynes et al. 2008a, b; Donovan et al. 2011, 2012a, b; Bowman and White 2012; Donovan and Oppenheimer 2012; Johnston 2012).

Volcanic risk is conceptualized as the product of the volcanic hazard (the probability an adverse event occurs at a certain time for a certain area of the volcano) and the effect this adverse event will have on the inhabited environment (vulnerability) (e.g. Paton et al. 2008). Volcanic activity itself and related hazards cannot be prevented, but risk can be reduced by increasing the

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awareness of people living near active volcanoes (Paton et al. 2001, 2008; Barberi et al. 2008; Carlino et al. 2008; De la Cruz-Reyna and Tilling 2008; Gavilanes-Ruíz et al. 2009; Bowman and White 2012). A major goal for many deterministic volcanologists is to forecast adverse events by studying the physical object "volcano", although for the same adverse event, resulting damages do often more depend on the preparedness and risk awareness of people rather than on the hazardous outcome itself. Probabilistic methods of eruption forecasting do not directly consider the broader social context of science either, but they can be a "more objective" link between scientists and decision-making authorities or society (Aspinall et al. 2003; Marzocchi et al. 2004, 2008; Sandri et al. 2009; Lindsay et al. 2010; Aspinall 2012; Marzocchi and Bebbington 2012; Donovan et al. 2012c). Based on the "trust" and "risk" concepts above, with the scope of increasing the public awareness of volcanic risk, the direct involvement of volcanologists seems most efficient. Nevertheless, volcanologists may be seen by local people as "invaders" (data gatherers), "stealing the soul" (samples) of "their volcano" (the study object), in the social context a counterproductive measure, but on the other hand, necessary constraints to better understand the natural system "volcano" (Cronin et al. 2004a). Periods of volcanic quiescence are most appropriate to increase people's risk awareness, as crisis situations are often too short and chaotic to sensitize. In times of crisis, local decision making authorities and population often oblige the scientists to give their opinion on risk mitigation procedures, beyond any purely scientific contexts, putting the scientists legally at risk when disaster strikes (e.g. L'Aquila case, Italy). This stress effect is enlarged when socio-economic and cultural differences between scientist and the population or authorities exist, or when religious factors play a role (Cronin et al. 2004a, b; Chester 2005; Vera Cortés 2005; Cashman and Cronin 2008; Chester et al. 2008; Haynes et al. 2008a; Donovan 2010).

A statistically based survey in May 2004 of the residents of Chapultenango (questionnairy), an indigenous Zoque community 10 km east of El Chichón (Limón-Hernández and Macías 2009; Figure 1a), demonstrated that the perception of risk posed by "their volcano" is inadequate, and surprisingly, worst for the elder generation, despite the fact that they lived through the 1982 eruptions. The elders might have forgotten the 1982 eruptions, or alternatively, believe that the volcano will not erupt again. A recent evacuation simulation (2009) for El Chichón volcano (Marrero et al. 2013) stressed the need of flexible and volcano-specific evacuation plans, as mitigation action time strongly depends on local socio-economic conditions (e.g. for El Chichón, the lack of self-transport, people living in remote areas), besides the behavior of the volcano itself.

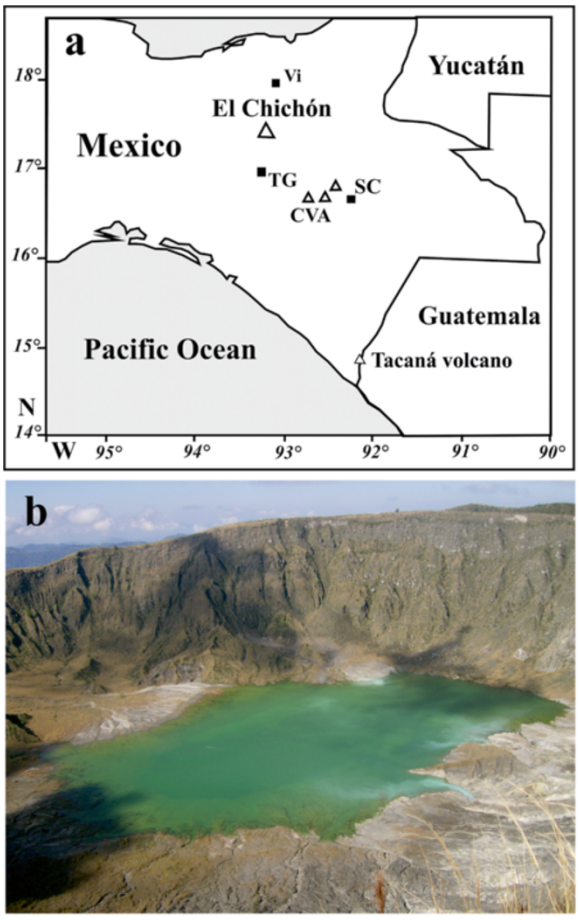


**Figure 1 El Chichón volcano in NW Chiapas, Mexico. a** Location map. Vi = Villahermosa, TG = Tuxtla Gutiérrez, SC = San Cristóbal de Las Casas, CVA = Chiapas Volcanic Arc. **b** The El Chichón crater and its lake (November 2006) formed during the 1982 Plinian eruptions.

El Chichón volcano (Chiapas, Mexico, Figure 1a) erupted violently (VEI 5, Plinian eruptions) during the week from 28 March to 4 April 1982 (Luhr et al. 1984; Sigurdsson et al. 1984), leaving a 1 km wide crater hosting a lake since then (Figure 1b). These "black swan" eruptions surprised local people. In general, the level of preparedness for a volcanic eruption is low when eruption frequency is low (Kates 1971; Gregg et al. 2004; De la Cruz-Reyna and Tilling 2008). El Chichón erupted at least 11 times during the last 8,000 years, with intereruptive periods of 100 to 600 years (Espíndola et al. 2000): a relatively high frequency, volcanologically speaking, but a low frequency on the human time scale. Similarly large (VEI >2) eruptions are not likely to happen in the near future (<14% probability during the next 50 years; Mendoza-Rosas and De la Cruz-Reyna 2008), although late post-1982 dome growth could be accompanied with minor phreatic eruptions (Rouwet et al. 2008, 2009). Nevertheless, two previous eruptions occurred in a similar situation as at present (Macías

personal communication in Vermaut et al. 2002; Macías et al. 2003): a dome-less crater with hydrothermal manifestations. It is thus not ruled out that dome growth has to occur when entering a new phase of magmatic unrest.

In this study, we applied a community-based "grass roots level" approach (Kar and Chambers 2008; Donovan 2010; Wellington 2012) to increase the public awareness of the people in Chapultanengo, on past, present and future volcanic activity. Increasing the perception of volcanic risk and community resilience is most efficiently obtained when focusing on the local situation (Donovan et al. 2012a; Cronin et al. 2004a, b), El Chichón in our case. In November 2006 and March 2007, local authorities (*Gobierno Municipal* and *Protección Civil*, GM and PC hereafter, respectively), primary and secondary school students, and the entire community of Chapultenango was involved in this social, science & arts sensitization project (funded by the *Belgische Stichting Roeping-Vocatio*). By mixing among local people and respecting a bottom-up approach (Cronin et al. 2004a; Donovan 2010), often neglected during scientific campaigns, we aimed to change the public perception of science and scientists. The importance of direct involvement of children and students in educational programs in areas threatened by an active volcano has been demonstrated earlier (Johnston and Ronan 2000; Gregg et al. 2004; Barberi et al. 2008; Carlino et al. 2008; Limón-Hernández and Macías 2009). In this study, we especially focused on the young children as they are statistically more likely to be affected by future volcanic activity, and as we assumed that children would also inform their family to reach a wider public (Ronan and Johnston 2001; Carlino et al. 2008).

This independent and informal study is based on good-will, common sense, working ethics and morality, rather than on a pre-meditated education method or strategy (e.g. Participatory Rural Appraisal, Cronin et al. 2004a, b), with the goal to increase the public awareness of volcanic risk. Communication means were adapted to each target-group. The outcomes are contextualized by methods in social volcanology and the effect of the sensitization campaign is evaluated retrospectively. Information from this study can help to better understand the importance of cultural and ethnic factors on volcanic risk perception. This study hopes to stimulate (1) volcanologists to translate their scientific knowledge to local communities near volcanoes, and (2) all stakeholders to interact more proactively in order to mitigate risk more effectively.

### The Zoque community of Chapultenango

The Zoque are an indigenous population in northern Chiapas and the northern Isthmus de Tehuantepec area (~42,000 people; http://www.cdi.gob.mx/index.php?option=com_docman&task=doc_details&gid=182). Zoques are related to the Mixe instead of the Maya culture, the most dominant culture in the rest of Chiapas and Central America. It is thought that past eruptive activity of El Chichón influenced the Olmec and Maya cultures in Chiapas, Tabasco and the Yucatán Peninsula: from the use of volcanic ash in ceramics to causes of the collapse of the Maya civilization (Espíndola et al. 2000, and references therein). In 1494, the Zoque were defeated by the Aztecs and, shortly after, conquered by the Spanish colonialists (1523) (Collier and Quaratiello 2005; Zeitlin 2005). After the Mexican independence (1810), the living conditions of the subdued Zoque did not improve. Following the 1910-1920 Mexican Revolution (1922), Zoque communities were assigned *ejidos*, communal lands split into specific parcels for farming and cultivation. The *ejidos* near Chapultenango are still used for farming (cattle ranches, and corn, beans, cacao and chilli crops), although they are mainly owned by ranch holders rather than by the original *ejidatarios*.

Nearly half of the Zoque community of Chapultenango is bilingual: Zoque-Spanish. Chapultenango is divided into two religious communities: Roman Catholic (84%) and Seventh Day Adventists (12%). The Dominican church of Chapultenango, *Convento y Templo de la Asunción*, was a main centre of Zoque evangelization since the 16th century (Figure 2). Child birth is high (5.9 children/woman; ~7,000 inhabitants in 2000). Correspondingly, 71% of the population is younger than 30, and the average age is 16. This implies that most people in Chapultenango did not live through the 1982 Plinian eruptions.

### The March-April 1982 eruptions of El Chichón

The March-April 1982 eruptions of El Chichón surprised the inhabitants of Chapultenango (Tilling 2009). (Canul RF, Rocha VL: Informe geológico de la zona

**Figure 2** *Convento y Templo de la Asunción*, **the 16th century church of Chapultenango.**

geotérmica de "El Chichonal", unpublished) mentioned in an internal report of the *Comisión Federal de Electricidad* (the national Mexican Energy Company, including geothermics) that earthquakes were felt, and that an eruption was possible. Evident earthquakes from January 1982 (Báez-Jorge et al. 1985) were ascribed to the hand of Goddess ("fe en San Miguelito", interview in Vermaut et al. 2002), or contextualized by the oral legend of *Piowacwe*, of an old lady dwelling in the village, announcing that "her son will get mad" (the eruption?) (Limón-Hernández and Macías 2009). Personifications of volcanoes are common in prehispanic traditions (e.g. Don Gregorio at Popocatépetl volcano, Vera Cortés 2005). Despite clear precursory signals (felt earthquakes), local people were still not aware of the presence of an active volcano. From the beginning of March 1982, earthquakes and explosions were registered by seismographs of the Chicoasén hydroelectrical power plant (Yokoyama et al. 1992). After these evident precursory signals, the news of an impending eruption of El Chichón, based on rumors from the local people who had informed the authorities of Chiapas, reached the researchers at the *Universidad Nacional Autónoma de México* (UNAM hereafter) on 26-27 March 1982. The scientific committee organized an expedition that left on 29 March, while the eruption had already started the evening before (De la Cruz-Reyna, oral communication, in Vermaut et al. 2002). On 29 March the Army lead the improvised evacuation (45,000 people; Macías and Aguirre 2006).

The first Plinian eruption occurred on the evening of 28 March (Luhr et al. 1984; Sigurdsson et al. 1984; Espíndola et al. 2002) and partly destroyed the central domes. The eruption column reached 27 km, and ash fell over Chapultenango and eight other nearby towns. Distal ash fall affected Chiapas and surrounding states. Between 29 March and 3 April, volcanic activity remained low, but escalated. On 4 April, the most destructive hydromagmatic eruptions generated pyroclastic flows and surges as far as 10 km from the crater (Scolamacchia et al. 2005). The Plinian eruption column reached stratospheric heights (32 km) and dispersed in NE direction (Carey and Sigurdsson 1986). Subsequent tephra fall complicated logistics during rescue and evacuations.

On the eruptions, people talked about "fire, ash, gravel, sand, darkness, lightning and smoke" and reported collapsed roofs, dead cattle, chicken and goats, a "unique experience", and acts of robbery (Vermaut et al. 2002). The latter may be the reason why people refused to evacuate after the first eruption (28 March), or decided to resettle soon after three days of apparent volcanic calmness, assumed to be the end of the eruption, as announced by a senior scientist on site (Tilling 2009). As a consequence, during the second and third phase of the Plinian eruptions (3 and 4 April 1982) ~2,000 people were killed. A third of the area of Chapultenango was severely affected by the week of eruptions. The roof of the church collapsed after excessive ash loading.

## Methodology

### Gaining trust

Increasing the risk awareness of people in Chapultenango can be facilitated by involving the widest possible public.. A direct confrontation with the population could give a qualitative, although highly subjective view on the impact of the present project. As discussed by (Haynes et al. 2008a) and Barberi et al. 2008) (note: after November 2006-March 2007), scientists are more trusted than government authorities or media. This trust is based on four pillars (Haynes et al. 2008a): (1) reliability, (2) competence, (3) openness, and (4) integrity. Reliability stems from consistency and dependability; competence is acknowledged when people think that the volcanologist is able and skilled to do a good job (expertise, Eiser et al. 2007); an impression of openness is transmitted when people feel that the volcanologist does not hold back any information and proactively engages with the population (Eiser et al. 2007); integrity is reached when people believe the volcanologist is offering his/her service pushed by a right moral, for honorable reasons, rather than out of ego-chasing. Trust is more easily gained among people with a similar social identity and/or a similar understanding of specific situations (Cronin et al. 2004a, b; Haynes et al. 2008a; Eiser et al. 2007, 2009; e.g. volcanologists who go down the crater want to know the risk they will be exposed to). Being aware of our different social background, respect for and openness to the society of Chapultenango were necessary to possibly have some kind of impact. Humility rather than exhibition of hard scientific facts is preferred (Cronin et al. 2004a, b), despite the fact that professional experience is largely based on deterministic volcanology (mode 1 research). The presence of DP, a native Mexican, was not only necessary for his professional skills, but also "for just being a Mexican". Demonstration of local knowledge and mixing among local people is a method to become accepted by lay public as an "intruding" scientist near active volcanoes (Geertz 1973; Donovan et al. 2012a; Gaillard and Mercer 2012). Basic methods of mixing among the local population were adopted: living and working in Chapultenango. Other motives to increase trust could be: (1) being a researcher from the UNAM, the most recognized university in Mexico, and (2) do not depend on a governmental institution. Despite the short duration of the actual science & arts sensitization program (9 days in November 2006, 20 days in March 2007), the previous six years of scientific

research at El Chichón (2-4 campaigns/year for 2001-2006) were necessary to gain credibility and trust as a scientist in Chapultenango (reliability). Additionally, during the period 2001-2006, the knowledge on the local culture grew (Chester 2005; Donovan et al. 2012a; Macías Medrano 2005); transmission of the impression of local knowledge is of help to gain trust. Based on personal experience from previous years of scientific campaigns at El Chichón, we assumed that the population of Chapultenango is sceptical to the authorities and have more trust in scientists.

The period of the elaboration of the project preceded and coincided with the 25th anniversary of the 1982 El Chichón Plinian eruptions. The retrospective atmosphere of this period reigning among the population of Chapultenango could have positively affected the impact of this study.

### Top-down actions

Out of professionalism, interaction with local government and authorities cannot be avoided, being aware of the risk to be less accepted by the population (Haynes et al. 2008a). Respect for the local PC in their task came first. This top-down approach was decided after a first attempt to involve a local citizen, our year-long guide during our scientific campaigns. He recommended us to not bypass the local PC, mainly to protect himself from envy of the local government as well as the rest of the population.

In November 2006, we spent nine days in or near Chapultenango (from 19 to 27 November 2006, Table 1). Before meeting local authorities, El Chichón volcano was visited for a routine sampling campaign (Rouwet et al. 2004, 2008, 2009; Taran and Rouwet 2008) to update on the state of the volcano (19 and 20 November; Table 1). To break the ice during the first visit, a face-to-face approach was preferred to a more "aggressive" projection of a presentation. We reported on our work with the secretary of the PC (21 November), and explained the reason of our visit: involve them in the monitoring of "their volcano". PC staff in Chapultenango is mainly composed of policemen, many of which never visited the volcano. El Chichón is only 10 km west of Chapultenango, but climbing the volcano requires a ~4-hour walk. On 24 November, we met the mayor of Chapultenango, and afterwards united the GM for a detailed information session (27 people present). Information posters on El Chichón volcano were distributed and located in strategic spots (Figure 3). In the evening, DR had a one-hour informal meeting with the priest of the *Convento y Templo de la Asunción* (Table 1).

A first group of GM members was guided into the El Chichón crater (25 November, 3 people, Table 1). In the evening, a meeting with the inhabitants of Chapultanengo was held in the park. The day after (26 November), a second group of PC staff was accompanied into the crater (8 people) (Figure 4). The lake water sampling procedure was demonstrated and volcanic features were explained. The day after, sampling equipment and a digital camera was gifted to the PC secretary (Table 1). Most encounters and events were recorded on video to permit a retrospective analyses.

**Table 1 Time schedule of the November 2006 visit to Chapultenango and El Chichón volcano**

| | |
|---|---|
| **Sunday 19 November 2006** | Sampling in the crater |
| **Monday 20 November 2006** | Sampling in the crater |
| **Tuesday 21 November 2006** | - Meet the PC Secretary of Chapultenango<br>- Visit the local press agency in Pichucalco, invitation for Friday 24/11 |
| **Wednesday 22 November 2006** | Sampling Agua Roja |
| **Thursday 23 November 2006** | Sampling Agua Caliente thermal springs |
| **Friday 24 November 2006** | - Meet school principles<br>- 10 h: meet the Chapultenango mayor<br>- Talk PC and county council, Palacio Municipal Chapultenango<br>- 20 h: meet the priest |
| **Saturday 25 November 2006** | - Visit crater with GM members<br>- Demonstration sampling methods<br>- Informal meeting with the population, explanation and Q&A session |
| **Sunday 26 November 2006** | - Visit crater with PC and police staff (8 people)<br>- Demonstration sampling methods |
| **Monday 27 November 2006** | - Sampling Agua Tibia thermal springs<br>- Gift camera and sampling equipment |

### Bottom-up actions

#### *Primary and secondary schools*

Top-down actions have shown to be little efficient in increasing risk awareness. A bottom-up approach should necessarily be incorporated between involved stakeholders (scientists, civil society and local and regional government) to reconcile science with local tradition and culture (Cronin et al. 2004a, b; Macías Medrano 2005; Gaillard and Mercer 2012).

On 24 November 2006, DR met three school principals (2 Primary, 1 Secondary School), to explain the education project and ask permission for future sessions (Table 1). Between November 2006 and March 2007, written permissions were collected.

From 12 to 14 March 2007 (Table 2), six scientific information sessions were held at the *Escuela Primaria*


**Figure 3** Information poster on El Chichón.

*Bilingüe La Trinidad*, adapted to the various age groups (from 6 to 11 years). Topics dealt with are: (1) what is a volcano? (2) the 1982 eruption of El Chichón (buried houses eruption column, dome destruction, formation of the crater, thick deposits, darkness), (3) the climb to the summit, (4) hydrothermal manifestations in the crater (lake, fumaroles, geyser, boiling springs, bubbling gases), (5) thermal flank springs and cascading rivers, (6) flora and fauna, (7) peculiar features in macro photos (sulfur crystals, mineral precipitations, foamy bubbles, sedimentation ripples), and (8) a final question: "do you think El Chichón will erupt in the future?". The eight topics were exposed in an animated powerpoint presentation, in an interactive way by continuously asking questions to the children to stimulate output from their part rather than input from the presenter's part (DR).

Immediately after the information session, the students painted their impressions in group (5-6 children for each painting, 5-6 paintings for each age group, 34 paintings and ~200 students in total, Figures 4, 5, 6, 7, 8,

**Figure 4** A painting of 6-year old children.

9). The available artistic means were: paint, sand, different types of pencils and oil crayons, brushes and rolls, and stencils. The direction and guidance from DR right after the scientific session and from the art teachers, MI and DP, was reduced so as not to interfere with the creative process of the children in representing their impressions on the volcano. On the final day, the artworks of the various age-groups were exposed during the school recreation break and a game with the entire groups was played: on turn, the children called the color of a feature represented in one of the paintings after which the others had to recognize in which painting. All paintings were photographed. Most paintings were left at the school (28), to be attached in their class rooms; six paintings were preserved by the authors. Afterwards, artworks were analyzed for each age group regarding the appearance of key phenomena for El Chichón such as the 1982 eruptions and their effects, the representation of the crater lake (the most remarkable feature at present), hot springs, flora and fauna (dealt with in the scientific session) and general cohesiveness. A comparison of the artworks of the various age groups was made.

In the *Telesecundaria* Secondary School two scientific information sessions were held (Table 2), although not followed by the art workshops. Instead, abundant time was taken for questions (Figure 10). Large parts of the sessions in both schools were recorded on video, enabling retrospective interpretations.

#### *Broader population*

After the Commemorative Conference "El Chichón Volcano: twenty-five years later" in San Cristóbal de Las Casas, Chiapas (19-27 March, Table 2) the GM of Chapultenango organized their commemorative festivities in town (traditional music and dances on the town's basketball court), closed by a projection of pictures and semi-scientific information on El Chichón for the entire population (44 slides) (Figure 11). In our opinion, the festivities had the intention to entertain the inhabitants of Chapultenango, rather than commemorate the 1982 eruptions of El Chichón. The volcano was only shortly mentioned. Due to the large attendance (200-300 people) a direct interaction with spectators during the semi-scientific information session was not possible.

## Results and discussion

### Response of local authorities

Initially, the PC secretary and staff seemed to have understood their task to monitor El Chichón: sample the lake once a month. Nevertheless, after November 2006, the El Chichón crater lake was sampled only once (January 2007; Rouwet et al. 2009), and the desired picture of the lake from the crater rim for a basic visual monitoring (Rouwet et al. 2004, 2008, 2009; Taran and Rouwet 2008; Rouwet 2011), to be send by email, never arrived. The main reason was explained to be anomalously rainy conditions during the 2006-2007 dry season.

A major problem in volcano monitoring with the help of authorities is the lack of continuity in politics (Limón-Hernández and Macías 2009; Donovan and Oppenheimer 2012). The 3-year terms of the GM and PC of Chapultenango are too short to install a personal relationship (Paton et al. 2008; Donovan and Oppenheimer 2012), reach a sufficient awareness of volcanic risk. It is often recognized in similar situations that local authorities are extremely poorly prepared to face natural hazards and related risk (Macías Medrano 2005). Another fact is that El Chichón is "far away" from Chapultenango (i.e. without a direct view of the volcano), decreasing the awareness of its presence. Moreover, the probability that El Chichón volcano will erupt during one single political term is very low. Finally, the GM probably has to deal with more urgent daily needs to serve its population (e.g. socio-economic issues, alcoholism, violence, infrastructure), putting the volcano logically in second place.

It remains an open question if a more citizen-science based approach would have been more effective to involve the local population in the basic monitoring of El Chichón. It probably would, as (1) the most suited people, our guide and his family, are the ones who best know the volcano, (2) direct follow-up by email would have been efficient to steer the process during our absence, (3) continuity would be assured, (4) mutual trust and respect is high. We respected his choice not to involve, and opted to collaborate with the GM instead.

The young (30-35 years), Chapultenango-born, priest was very receptive on the information on El Chichón and the educational project. He recognized the importance of science-based education on El Chichón volcano. Religious leaders may be considered highly trusted persons (e.g. Haynes et al. 2008a), often sought out during periods of crisis (e.g. *tiemperos* in villages near the more active Popocatépetl volcano, Central Mexico; Vera Cortés 2005). He will often be an intermediary between the local authorities and the public, and potentially between the volcanologist(s) and the public. Moreover, providing a science-based view of a natural feature, such as volcanic activity, could be of help to not only contextualize eventual future eruptions with religious or mystical explanations. The priest was willing to advise people to listen to the scientists rather than encouraging mystical explanations for volcanic activity, which he did not put forward during the informal meeting.

The interest and curiosity in the information posters was initially high, although in the following months no further reactions or questions were received by email (Chapultenango has internet). This lack of feedback suggests that the used language (in Spanish) was probably

**Table 2 Time schedule of the March 2007 visit to Chapultenango and El Chichón volcano**

| | |
|---|---|
| **Friday 9 March 2007** | Sampling in the crater |
| **Saturday 10 March 2007** | Sampling in the crater |
| **Sunday 11 March 2007** | Sampling in the crater |
| **Monday 12 March 2007** | - Scientific information sessions and art workshop, *Escuela Primaria La Trinidad*, 6 and 7 year old children<br>- Scientific information session *Telesecundaria* |
| **Tuesday 13 March 2007** | - Scientific information sessions and art workshop, *Escuela Primaria La Trinidad*, 8 and 9 year old children |
| **Wednesday 14 March 2007** | - Scientific information sessions and art workshop, *Escuela Primaria La Trinidad*, 10 and 11 year old children<br>- Scientific information session *Telesecundaria* |
| **Thursday 15 March 2007** | - Exhibition of the all the paintings, *Escuela Primaria La Trinidad*<br>- Scientific information session *Telesecundaria* |
| **Friday 16 March 2007** | San Cristóbal de Las Casas |
| **Saturday 17 March 2007** | San Cristóbal de Las Casas |
| **Sunday 18 March 2007** | San Cristóbal de Las Casas |
| **Monday 19 March 2007** | Commemorative Conference "El Chichón Volcano: twenty-five years later" in San Cristóbal de Las Casas, Chiapas |
| **Tuesday 20 March 2007** | Commemorative Conference "El Chichón Volcano: twenty-five years later" in San Cristóbal de Las Casas, Chiapas |
| **Wednesday 21 March 2007** | Commemorative Conference "El Chichón Volcano: twenty-five years later" in San Cristóbal de Las Casas, Chiapas |
| **Thursday 22 March 2007** | Commemorative Conference "El Chichón Volcano: twenty-five years later" in San Cristóbal de Las Casas, Chiapas |
| **Friday 23 March 2007** | Meeting in Chapultenango during the Commemorative Conference "El Chichón Volcano: twenty-five years later" in San Cristóbal de Las Casas, Chiapas |
| **Saturday 24 March 2007** | Field trip (deposits) of the Commemorative Conference "El Chichón Volcano: twenty-five years later" in San Cristóbal de Las Casas, Chiapas |
| **Sunday 25 March 2007** | field trip (crater) of the Commemorative Conference "El Chichón Volcano: twenty-five years later" in San Cristóbal de Las Casas, Chiapas |
| **Monday 26 March 2007** | Search thermal springs near the NW dome |
| **Tuesday 27 March 2007** | Sampling Agua Tibia thermal springs |
| **Wednesday 28 March 2007** | - Non-scientific commemorative festivities in town<br>- Projection of pictures and semi-scientific information on El Chichón |

too academic for a population who speaks an indigenous language and has its own risk religious-sincretic perception of El Chichón's activity (e.g. Macías Medrano 2005; Vera Cortés 2005). Our local knowledge was probably not profound enough to have included non-scientific views of volcanic activity in these information posters, prepared in advance.

### Response of students

The interaction during the science & arts sessions was dynamic, especially for the youngest children (6-8 years). The paintings were exposed and explained afterwards by each group to share the ideas on how they represented "their volcano". A selection of the children's artwork is presented in Figures 4, 5, 6, 7, 8, 9. Clear jumps in the representation of the volcano are noted for the different age groups. The paintings of the 6-year old lack cohesion, are chaotic and often composed of single drawings of individual artists (Figure 4). The volcanic eruption was the main theme, with ballistic blocks, glows, trajectories, colored curls, blue waves, finger-painted or dripping dots, and houses and people covered in dense clouds (Figure 4). The volcanic structure was often covered in "chaotic darkness"; the crater lake generally came second.

The paintings of the 7-year old have a more "organic" aspect (Figure 5). Three out of five paintings are brown-dominant in a very dense texture (using sand, Figure 5). Stylistic figures (plants, flowers, birds, houses), inside these "dark eruption clouds" in an unordered manner probably point to the destructive nature of the eruptions, the loss of houses, death of people and animals (Figure 5). The interaction between the eruption and the environment becomes more obvious, although volcanic structures and the crater lake are poorly recognizable (besides in one painting, showing a blue lake at the bottom of the volcano, Figure 5).

The paintings of the 8-year old are less abstract and resulted more coordinated. All paintings represent a crater or an erupting volcano. Allusions to the crater lake appear in almost every painting. It is unclear whether a red circular structure represents a red hot (lava?) lake, or rather an eruption cloud from the volcano on its right. The "volca chichonal" and "catrer" writings are noteworthy (Figure 6).

The paintings of the 9-year old are more structured and detailed (Figure 7). It seems that each artist had his/her


**Figure 5** A painting of 7-year old children.

proper task to reach a cohesive result. The represented volcano became "more quiescent", similar to the present-day situation. The crater lake (blue, green or grey) is the central theme (Figure 7a, b). The sun (sometimes covered with dark ash clouds, Figure 7b), trees (Figure 7a, b), flowers (Figure 7c) and birds (Figure 7a, b) are present in almost every painting. Representing the eruption came second, and the volcanic structure (a crater or a cone, sometimes with a clear conduit) is more obvious. Fumarolic degassing is represented in two of the five paintings; thermal flank springs in one painting (Figure 7a).

Four out of five of the paintings of the 10-year old show the current situation: a green lake in a wide grey crater topping a cone shaped volcano (Figure 8). Within this present-day scenario, three paintings represent eruptive activity (dark clouds with lightning, dark brown-red "pyroclastic flows"). Bubbling degassing in the lake and sulfur are referred to in one painting.

The paintings of the 11-year old are clearly "more scientific" (Figure 9). The most striking painting represents El Chichón in its three stages, shown by three different volcanoes: before, during and after the eruption (Figure 9). The pre-1982 El Chichón is a green hill with a peaceful village and a blue river below. The eruption is represented by a red lava flow pouring out of the crater and a dark ash column. Red, grey, blue and ochre dots dominate the entire painting. The present-day situation is represented by a vegetation-less ochre cone topped by a blue crater lake. Houses are lacking on the foot of the erupting and post-eruption volcano. Three out of five paintings show a large crater with a lake, underlain by a magma filled conduit. Two of them show cascades on


**Figure 6** A painting of 8-year old children.


**Figure 7** Paintings of the 9-year old children.

the volcano flank (thermal flank springs). Yellow clouds are present in one crater, indicating the present fumarolic degassing. One painting represents a perfectly cone-shaped green volcano in eruption, without any similarity to El Chichón. All five paintings show grey clouds or eruption columns, despite the rather peaceful aspect of the volcanoes. This might indicate that children are aware that El Chichón could return to erupt in its present state.

After the information sessions in the *Telesecundaria* Secondary School questions were asked (Figure 10). Besides some individual exceptions, the students of the *Telesecundaria* Secondary School showed less interaction, suggesting that (1) it might not have been their first time to attain an information session on El Chichón experiencing some boredom, or (2) children demonstrate less inhibition during a creative process as they do verbally. One particular student asked many very insightful questions, specifically on El Chichón, and on volcanoes and tectonics in general. He showed extreme knowledge, despite his young age. The impression was that some of the children already visited the volcano. Climbing El Chichón is a common activity for local weekend pilgrimage in the area, generally guided by religious organizations. These statements were not verified and are merely personal impressions.

### Response of the broader population

Public attendance at the projection of pictures and semi-scientific information was high (200-300 people, Figure 11). Children were most abundant. The public was silent; the atmosphere was serene, even intimate. Few questions or reactions followed the session. The integer and serene environment during the 28 March information session matches the introvert indigenous culture. Theistic explanations of volcanic features did not emerge. It is not excluded that people "believe what they always believed" (e.g. "the eruption was a curse of God") and took the more scientific approach as it is. People probably have a mixed perception of what causes a volcano to erupt (Gregg et al. 2004; Macías Medrano 2005; Vera Cortés 2005), combining a physical explanation with their religious beliefs. This interpretation of the poor feedback from the population must be clearly identified as a personal reflection. Anyway, providing a science-based alternative to their convictions on what El Chichón means to them intrinsically increased their awareness.

## Conclusions

The major shortcomings of this educational project are (1) a too short period to have a broader impact, and (2) the lack of continuity. Nevertheless, trust of the local people of Chapultenango was built up during the previous six years, by (1) not being an unknown anymore, (2) continuous


**Figure 8** A painting of 10-year old children.

**Figure 9 A painting of 11-year old children.** The three stages of El Chichón's activity are represented, from left to right: present situation, the 1982 eruption, the pre-1982 volcano.

scientific work during sampling campaigns (2001-2006, and during the period of the project), (3) being a researcher of a high-quality and autonomous research institution (UNAM), (4) a tendency to mix among local people in a relaxed way, (5) respect local dynamics and culture, and (6) recognizing that each voice is equally valid by demonstrating a listener rather than a teacher attitude. We believe the four pillars to create trust (reliability, competence, openness, and integrity; Haynes et al. 2008a) were transmitted to the population during the period of the project (November 2006-March 2007), and before (2001-2006).

After the initial enthusiasm to collaborate in the monitoring of El Chichón volcano, the Civil Protection staff of Chapultenango did only show minor follow-up of the taught tasks. The main reason is probably the lack of continuity in the political terms of the local government, reaching the end of the term (2005-2007) during the period of the project. Despite their responsibility, most members of the PC staff did not even know the volcano. With the present state of activity of El Chichón, the PC and GM do not consider the volcano as a primordial concern for the daily life in Chapultenango.

During the science & arts sessions in the Primary School, arts has demonstrated to be a novel and efficient tool to elucidate on the awareness of volcanic risk in the age group from 6- to 11-years old. A detailed analysis of the children's artworks suggested that the 6-8 year old children have a more "fatalistic" view of the volcano,


**Figure 10 Scientific information session in the *Telesecundaria* Secondary School (12 March 2007).** People with visible faces still are Agnes Mazot (left) and DP (right), used with permission.

**Figure 11 A semi-scientific information session on the evening of 28 March 2007, exactly 25 years after the onset of the 1982 eruptions.**

shown by the eruption-focused paintings. The >9 year old probably visited the volcano, recognizing El Chichón in its present, more quiescent state. The 11 year old have a more scientific approach, probably suggesting that they have been taught previously on El Chichón's activity. Beyond the concrete contents of the artworks, the fact to have participated in this alternative experiment to increase the volcanic risk awareness of the children will probably be printed in their memories, and will hopefully permeate into future generations. The scientific sessions in the Secondary School were less interactive. Alternatively, similar arts workshops (adapted to the age-group) or excursion trips with the adolescents to the volcano accompanied by a volcanologist, could become more efficient means to increase interaction, participation and thus knowledge and risk perception. The public interest in the information sessions for the people of Chapultenango was high. Two sessions took place in a familiar, serene and respectful way. Religion is not experienced as a barrier, and the involvement of the priest resulted constructive. Nevertheless, the introvert indigenous culture made it sometimes difficult to penetrate, avoiding to get a correct view of the impact of the information sessions and risk awareness of the adult population.

A major concern for the future perception of volcanic risk in Chapultenango is the fact that, by the time of the next eruption, the people who lived through the 1982 eruptions will probably have died, inevitably leading to lost memory, and decreased risk awareness. For El Chichón, as for most volcanoes, it is important that educational programs should focus on knowledge transmission on the "intereruptive" (>100 years for El Chichón) and "intergenerational" time scale. Educational programs with children, the part of the society most prone to live the next eruption, seem to be most efficient, having a longer reach in the future. Nevertheless, the short political terms on local level avoids continuity, stressing the need of a change in national, or even international policies to enhance volcanic risk education programs (Gaillard and Mercer 2012), for El Chichón as for other volcanoes. This study –within its simplicity and imperfections– demonstrates that the volcanologist is recognized by the local population as a capable and highly trusted professional, bridging the gap between the generally distrusted official authorities and society. The collaboration between social scientists and volcanologists, with the aim to translate knowledge on volcanic hazards and risk, seems to be the most efficient way to increase the risk awareness of populations near active volcanoes.

#### Competing interests
The authors declared that they have no competing interests.

#### Authors' contributions
MI and DP guided the artistic process during the arts workshops. MI helped in the interpretation of the artworks.

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