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Bridging Māori indigenous knowledge and western geosciences to reduce social vulnerability in active volcanic regions

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Abstract

A new pedagogical methodology is proposed to reduce the social vulnerability of indigenous communities occupying areas subject to volcanic activity, as a potential interactive approach between those communities, scientists, and scientific institutions. The multidisciplinary methodology aims to increase scientist's understanding of the relationship between native inhabitants and active volcanoes in indigenous territories, and to improve the effective dissemination of information. Also, the proposed methodology offers to the local community the scientific knowledge in an understandable and useful way, in order to maximize people's awareness of their exposure to volcanic activity. The procedure starts with the recognition of the local ancestral comprehension of the volcano and the cultural, ecological, and economical bonds between humans and volcanic processes. Subsequently, the transmission of the indigenous knowledge to the scientific community and the appropriation of geological knowledge by the children and teachers in a specific Māori primary school in New Zealand, allowed: (1) the establishment of a common language, (2) enhanced communication and collaboration between the participants involved in understanding and living with an active volcano, and (3) increased awareness about the relationship between humans and active volcanoes.

A permanent application (and site-specific adjustment) of this method, and the use of the resulting teaching tools, could reduce social vulnerability and empower indigenous communities in the development of volcanic risk mitigation strategies by revitalizing and sharing knowledge, rather than imposing one epistemological system onto the other.

Keywords: Body language; Contact-Improvisation; Iwi; Mātauranga; Ngāti Rangī; Volcanic risk

Introduction background

The lack of dialogue among stakeholders undertaking volcanic risk management hinders agreement in front of decision-making processes (cf., King et al. 2007). The scarcity of programs that integrate scientific-knowledge with the local epistemology, including the environmental and cultural relationship between the community exposed to volcanic eruptions and the volcano itself, is a key factor increasing the social vulnerability (cf., Alexander 1993, Paton et al. 2001, Paton et al. 2008, Vervaeck 2012). This

is critical in the case of lands occupied by indigenous communities where the relationship between people and territory is long and more complex than a simple land occupation for resource management (cf., Marsden 1988, 1992).

In most of the indigenous communities worldwide, the territory is the centre of their identity, culture, livelihood practices, ecology, economy, and knowledge and belief systems (cf., Feiring 2013). Therefore, the concept of territory is usually closest to the scientific notion of "ecosystem" than to the western concept of "land". However, it differs in that the perception of the territory by most indigenous people is also based on the idea that everything in the environment has life and spirit (cf., Berkers et al. 1998). Although spirituality has been traditionally excluded from any scientific approach, Anderson (1996)

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pointed out that “all traditional societies that have succeeded in managing resources well, over time, have done it in part through religious or ritual representation of resource management. The key is not religion *per se*, but the use of emotionally powerful cultural symbols to sell particular moral codes and management systems”.

The value of traditional knowledge in sustainable development and ecosystem management, biodiversity conservation, and climate change adaptation has been increasingly recognized by the western knowledge (scientific) systems (Feiring 2013). In Oceania cultures (including Polynesians), Berkers et al. (1998) identified one of the richest set of ecosystem applications, where the key characteristics defining the territory as an ecosystem-like unit are: (1) a unit with the height of land between adjacent valleys serving as the biophysical boundary; (2) the recognition of land and sea space as a continuum; (3) the presence of a social and ethical mechanism for integrating humans and nature, where elders and leaders encourage the responsibility for the land within a system of conservation-through-use. Within these concepts, western science increasingly acknowledges indigenous understanding of the non-linearity and openness of the natural ecosystems, which are not always predictable and, certainly, not always controllable (cf., Gunderson et al. 1995, Ludwig et al. 1993). Moreover, the criteria of territory delimitation in many traditional cultures worldwide are watershed-based, which has been interpreted by Berkers et al. (1998) as a mirror of their dependence on local resources.

Understanding the local indigenous vision about nature, as well as the cultural and environmental links with the territory is critical, not only for the development of conservation strategies (e.g., Stevenson 1996), but also for hazard mitigation and risk management (cf., King et al. 2007; Cronin and Cashman 2008). For example, King et al. (2008) postulated how Māori Environmental knowledge in New Zealand provides a collection of observations, records, monitoring and forecast methods of changes in their physical environment that contribute to hazard mitigation. Likewise, Lowe et al. (2002) demonstrated how Māori oral history of volcanic eruptions were a valuable source of information, not only on past eruption records, but also, on the understanding of past response and recovery of Māori tribes to volcanic hazards. Similarly, King et al. (2008) carried on an extensive approach on how Māori oral narratives, laments, quotations, proverbs, songs, and place names relate with natural hazards and have served to teach, preserve, and explain their occurrence. The importance of oral tradition for volcanological investigations has been also demonstrated in other Polynesian islands, such as Hawaii (cf., Swanson 2008).

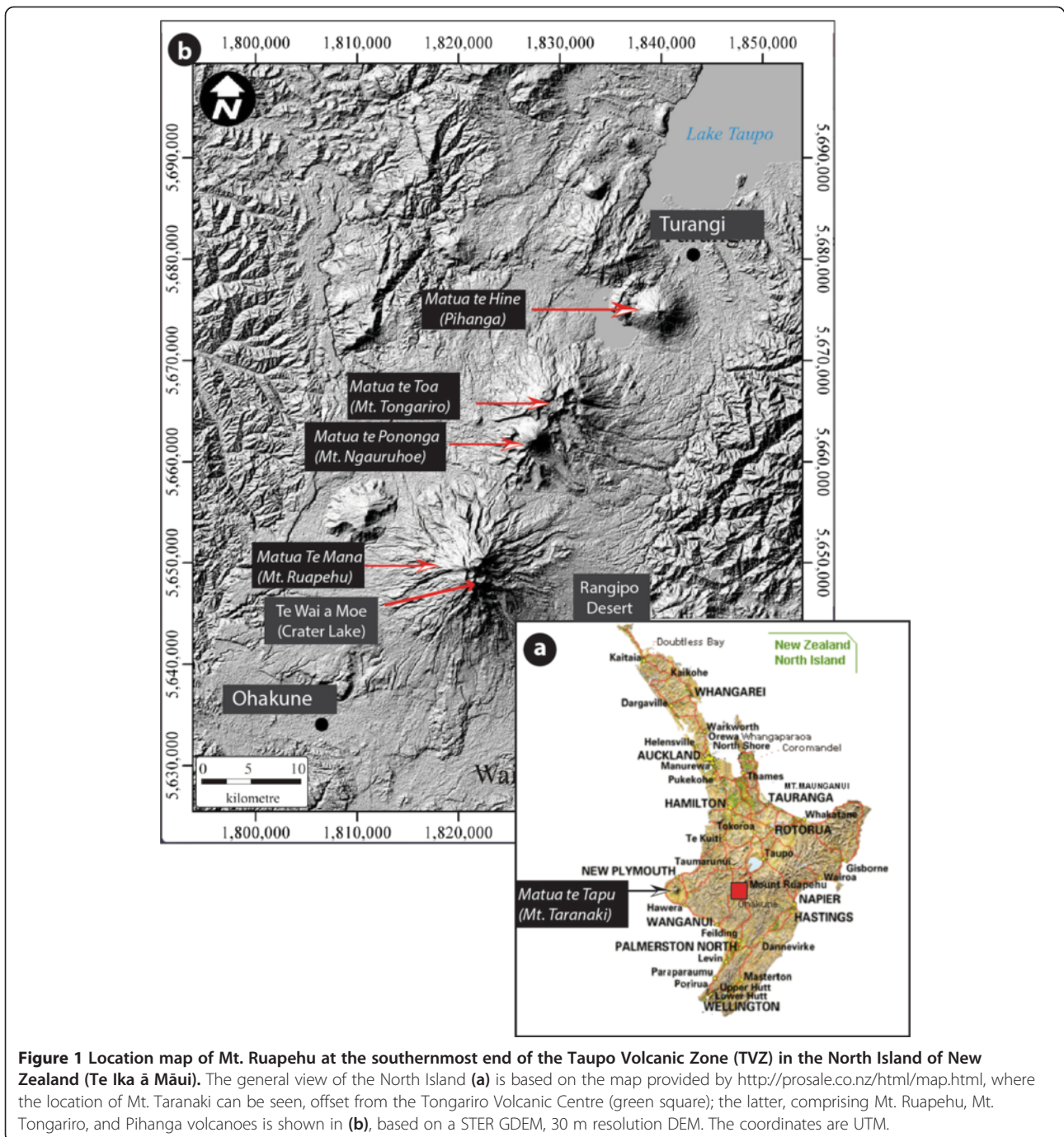
This study aims to contribute to the development of hazard mitigation strategies by reducing the social vulnerability

of indigenous communities exposed to volcanic eruptions through recognition of their traditional knowledge and its integration with the geological understanding of the world. The feedback between different, but not necessarily exclusive epistemological systems combines multiple sources of expertise and enhances communication between the variable participants in volcanic risk management (e.g., scientists, local communities, extendable to governmental agencies such as geological surveys). Rather than “imposing” western science onto indigenous communities living around active volcanoes we propose a participative dialogue in order to maximize the local awareness and build up a strategy derived from multiple disciplines for risk mitigation. The methodology was developed in collaboration with and applied within the native Māori tribe *Ngāti Rangī Iwi*, in the North Island of Aotearoa (New Zealand), inhabiting the influence zones of Mt. Ruapehu (Figure 1) volcanic activity.

Indigenous knowledge in the New Zealand context is termed “*mātauranga māori*”, and for this project would specifically be referred to as “*mātauranga a Nāti Rangī*”, referred to hereafter as *mātauranga*. Here, we will show how the body language (dance and other non-verbal forms clarified below, in the methodology chapter), in combination with other expressive forms (verbal language, writing, drawing) is a useful tool to bridge *mātauranga* and earth sciences. The integration of *mātauranga*, science, and arts served to (1) communicate the current understanding of geological and volcanological processes from multiple perspectives; (2) empower indigenous communities living on active volcanoes to increase their awareness; (3) develop a teaching tool for current and future generations, which can be used at different levels within the community. Furthermore, this method follows an adaptive management approach that allows iterative amendments, to ensure the tool remains relevant as societies and volcanoes change through time.

Mt. Ruapehu volcano geological context

Mt. Ruapehu is one of the most active stratovolcanoes of New Zealand (Cronin and Neall 1997). Located at the southern end of the Taupo Volcanic Zone, it has erupted low-K andesitic-dacitic magmas in effusive and explosive (from phreatic to Plinian) eruptions since ~270 ka (Donoghue et al. 1995, Pardo et al. 2012). The main edifice is asymmetrical; it comprises lava-flows, rare domes, and has been affected by events of sector collapse (cf., Palmer and Neall 1989, McClelland and Erwin 2003, Procter et al. 2010, Tost et al. 2014). The volcano is capped by small permanent glaciers and snowfields and comprises overlapping craters (Hackett and Houghton 1989, Cronin et al. 1996). Historical activity has been centred at the youngest South Crater, currently occupied by an acidic Crater Lake (Christenson and Wood 1993), from which lahar generation



is common (e.g. Cronin and Neall 1997, Neall et al. 2001, Lube et al. 2009). Holocene eruptions have been predominantly phreatic, producing base surges and ballistic fall-out, and phreatomagmatic, producing subplinian columns (Cronin et al. 1997, Kilgour et al. 2010).

Ngāti Rangi Iwi

“Whaia e au Manganui-o-te-ao kia tau au ki runga o Ruapehu ki Ngā Turi o Murimotu ko te Ahi-kā o

Paerangi-i-te-Whare-Toka i puta mai ai Rangituhia, Rangiteauria me Uēnuku-Manawa-Wiri”. [Translates “I follow the Manganui o tea o river, I settle up on Ruapehu and the sacred alter of *Nga Turi o Murimotu*, the eternal flame of *Paerangi*, from hence we originate. *Paerangi* begat *Rangituhia*, *Rangiteauria*, and their sister *Ueunuku Manawa Wiri*”]. This is how *Ngāti Rangi* people introduce themselves, and intrinsically links their ancestry to the land, its geomorphology, and the flowing waters

The *Ngāti Rangi Iwi* falls under the mantle of *Te Kāhui Maungā* an identity, which encompasses the mountains of the district and its original inhabitants. The ancestors of *Te Kāhui Maungā* were the earliest inhabitants in the area, arriving before many other Māori (cf., Waitangi Tribunal, 2013). They were also known as the descendants of *Paerangi-i-te-Moungaroa*, also known as *Paerangi-i-te-Whare-Toka*. *Paerangi* is an ancestor of *Ngāti Rangi*, a chief who is described in the narratives as one of the first inhabitants of New Zealand (i.e., the “original people of the land”). The names of his daughters have specific meanings, *Rangituhia* meaning “written in the heavens”, *Rangiteauria* meaning “the joining of the heavens to the earth”, and *Uenuku Manawa Wiri* meaning “the rainbow, the anchorage of the pulsating heart”.

European history

From the time of European arrival and settlement of the central North Island during 1800 Māori were recognised as the native inhabitants and custodians of the land. During the mid 1800s, increasing settlement and interest in New Zealand from overseas required land to be secured by the Crown for purchase. During this period, a Native Land Court collected a large amount of information on the connections that *iwi* (i.e., tribes) and individuals had with the land. Unfortunately, the Courts of the time were focused on ownership rather than tribal identity, history and traditional land tenure systems, resulting in individual cultural identity being overlooked, poorly recorded and not understood.

The events of the formation of the Tongariro National Park (comprising Mt. Ruapehu, Mt. Tongariro and Pihanga volcanoes; Figure 1) with the gifting of a 2 km radius of land around the peak of Mt. Ruapehu by Horonuku Te Heuheu, on behalf to the neighbouring *Tūwharetoa* tribe, also did not take into account *Ngāti Rangi* culture and status over their tribal region and ancestral *maungā* (mountain). *Ngāti Rangi* and other *iwi* from the Whanganui district (Figure 1a) strongly protested this action and asked for their areas to be subdivided out of the National Park. This was against the thinking of the current government and the National Park was established (cf., Waitangi Tribunal, 2013).

Ngāti Rangi, like many other maori tribes, has a rich belief system that has developed over the last 1000 years of occupation, with numerous spiritual and ritualistic practises that occur at different times and locations. A large number of these practises have disappeared due to the introduction of European culture and Christianity. However, several historical accounts that form the basis of *Ngāti Rangi* belief system are now publicly known and treated as stories, myths and legends.

Many of these stories have been over simplified over the years with many different versions being portrayed.

Unfortunately, the real meanings behind many of these stories and practices have been lost or altered to be consistent with European beliefs. This has forced *Ngāti Rangi* to guard the remainder of their history and spiritual connections to their *rohe pōtae* (i.e. tribal homeland), to ensure that their *mana* (status) and principles are not disrespected and that they endure.

Te Maungā

Paramount in *Ngāti Rangi* belief structure and culture are the volcanoes that make up *Te Kāhui Maungā*, in particular Mt. Ruapehu. The dominant longstanding feature in the landscape (Figures 1 and 2) is central in creation records, chronicles of settlement, and ritualistic practises. The mountain is viewed as touching the heavens and is seen as a place of gods and the resting place of their ancestors (C.Wilson, personal communication 2012).

The connection *Ngāti Rangi* have with the *maungā* is highlighted in its name *Te Kāhui Maungā ki Tangaroa*. The name signifies both their connection to the creation of the land, their place of belonging (and the term used to describe their natural grouping or *iwi*) and the source of their *awa/wai* (river system) and *mouri* (*Ngāti Rangi* dialect for *mauri*, meaning Life Principle, Life Force; cf. Best 1982). *Ngāti Rangi whakapapa* (i.e., genealogy) refers to the people that fished up and created the North Island. Their spiritual beliefs centre on the *atua* (gods and spiritual guardians): *Tangaroa* (Guardian of the Ocean), *Ranginui* (Father Sky), *Papatūānuku* (Mother Earth), and *Ruaumoko* (Guardian of Earthquakes and Volcanoes, the youngest son of *Rangi* and *Papa*), all of them connected by water and before the island was “fished up” by the Polynesian demi-god *Māui*. The “fish” would breath through a hole or vent connected to the top of the South Island called ‘*Te Ihungangana a Ruapehu i rō wai*’; when fished up, the birth of Ruapehu calmed the fish.

Mt. Ruapehu later became known as *Matua te Mana* (the powerful one) with himself and the *Te Wai-ā-moe*, which refers to the Crater Lake, as the spring that brought forth life from *Papatūānuku* (Mother Earth), supplying spiritual and physical sustenance to the land and *Ngāti Rangi*.

Maori belief structure

The beliefs and values of Māori are based on their relationship with the natural environment and their influence on management. Primary values associated with land include: *tikanga* (customs) and *whakapapa* (genealogy), which form the basis of any *kaupapa Māori* (knowledge, skills, attitudes and values of Māori society) process. Other Māori environmental concepts such as *tāonga* (treasures), *mouri* (life force), *wairua* (spiritual health and wellbeing), *kaitiaki* (guardians), and *ahi kā* (unbroken connections) are important concepts used in

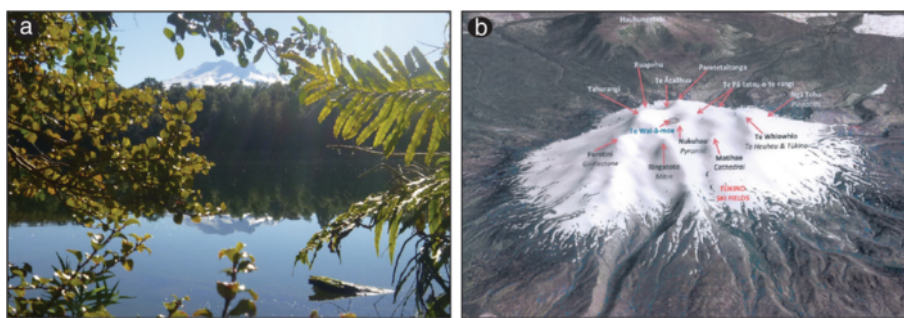


Figure 2 Matua te Mana (Mt. Ruapehu) as (a) seen from the sacred lake of Rotokura, and (b) labelled with the *Ngāti Rangi* names of each sacred location considered in their narratives (map designed and provided by *Ngāti Rangi Iwi*).

environmental management to essentially monitor the state of the (cultural/Māori) environment or the interconnectedness. *Kaitiakitanga* (guardianship) is another more recent concept, which provides the framework to put into practice these concepts and applies them to today's western management systems and legislation. *Kaitiakitanga* refers to the sustainable access, use, and conservation of natural resources, developed by a specific community occupying a particular geographical area (cf., Marsden 1992). None of these concepts form or relate to any legislation or policy that guides natural hazard identification or the emergency management process.

Kaupapa Māori research

Kaupapa Maori is the term used for the indigenous, epistemological research system in New Zealand, which includes the initiation, procedures, evaluations, construction and distribution of newly defined indigenous knowledge (cf., Bishop 1999, Moewaka Barnes 2000). Many indigenous cultures have traditionally occupied fertile, active volcanic areas. In New Zealand, Māori have observed and monitored, as well as responded to and recovered from, numerous hazardous (volcanic) events during the last ~800 years (Cashman and Cronin 2008; King et al. 2007, Severne 1995). The knowledge, referred to as *mātauranga māori*, gained from these experiences is rarely considered when scientifically identifying volcanic hazards, yet it does contain a unique, valid epistemology and data (Roberts 1995, Durie 1996, Durie 1998). By extracting and combining portions of both Māori and western science within an applied spatial context, utilising both scientific and *kaupapa* Māori frameworks (Smith 1990), we can begin to develop unique solutions to natural hazards and increase resilience to hazard events (cf., Rainforth et al. 2012).

Methods

We suggest that body language in combination with other forms of human expression, such as, fine arts,

music and poetry, are highly effective tools to teach geological and volcanological concepts. By reconsidering the concept of “The body as a cultural object”, discussed by authors such as Foucault (1977), Mary Douglas (1973), (Merleau-Ponty 1945, In: Silverman 1976), and Gardner (1993), it is possible to develop different strategies using the body language to experience, adopt, and translate the scientific information. The concept of “body language” refers to the collective expressions, which use the physical body as the main subject of human perception, nonverbal expression, and communication (cf., Merleau-Ponty 1945, In: Silverman, 1976; Fran 1988). Body expression is conceived as an intrinsic human, non-verbal ability articulating personal sensitivity, thoughts, imagination, and creativity, complementing other expressive tools such as, talking, painting, and writing (cf., Stokoe and Schächter 1977). It has been recognized since the 1970s as a powerful pedagogical tool (Stokoe 1978), which encompasses the concepts of (1) free-style dance, as an individual search; (2) dance to move, to communicate, and to create or improvise (Kalmar 2006). In addition, body language is encompassed within the concept of “bodily knowledge”, also known as “somatic knowledge”, which is a wide pedagogical research field comprising the ways humans understand themselves and their environment through the body, and make meaning of the world through their bodily experiences (Green 2002).

For this project, we chose the *Ngāti Rangi* children as the main representatives of the tribe to work with. The reason for this selection was based on the hypothesis that children are (1) excellent receptors and questioners of knowledge, (2) participative in an innovative classroom, and (3) communicators to older generations by sharing their learning with their families. Also, children's psychomotor abilities and development are expected to be better than in ordinary adults. We adapted the strategies explained below to the conditions of *Ngāti Rangi* population, which had one Māori medium primary school at Ohākune *Te Kura Kaupapa Māori o Ngāti*

Rangi, which is taught between 80-100% in *Te Reo Māori* and comprised 20–26 students between 5 and 13 years old in 2012–2013 (grouped within two classrooms). The initial stage of the project consisted in meetings between the volcanologist and the Māori Principal of the primary school. In this phase, the volcanologist could learn about *Ngāti Rangi* history, the meaning of Mt. Ruapehu for the community, the relationship between the tribe and the volcano, and how Māori explain, understand and relate to the origin of the Universe, Planet Earth, and volcanic activity in general, and to Mt. Ruapehu, in particular. The questions from the Principal to the volcanologist were also raised in this initial phase, together with the main interests of the community around how volcanology could contribute to and straighten their knowledge system and practices. Since *Mātauranga Māori* (Māori knowledge) is transmitted across generations through oral tradition (prayers, narratives and songs), the meetings served to clarify the meaning of the narratives, with particular attention to all Māori etymology and toponymy referring to Mt. Ruapehu and related activity.

From the first stage a rich database resulted, which helped to identify the concepts within the *mātauranga* that could overlap with western scientific (geological-volcanological) theories. From this process, a correlation between the indigenous and geological knowledge systems could be established and the main teaching subjects were selected: (1) The origin of the Universe, Solar System, and Planet Earth; (2) The Structure of the Earth; (3) Earth dynamics (covering tectonics, earthquakes, magma, and volcanic activity).

The third stage consisted in the design of multidisciplinary workshops focused on teaching geosciences by using the body language and knowledge developed in performing arts. The starting motive was always the Māori perception of each concept, followed by the presentation of the corresponding scientific point of view. The entire aim was to evidence the agreement between both systems and to bring about the need for respectful and reciprocal interactions between people, natural processes and resources to prevent disasters.

A series of five workshops were designed, each one consisting of: (1) an introductory session (~1 hour long) using different types of body expression exercises, including Contact-improvisation dance (Smith and Nelson 1997), theatre, and interpretative dance (Root-Bernstein and Root-Bernstein 2003, Servos 1981), improvisational playmaking and game-dynamics (Boal 1979, 2002). The traditional narratives were recreated (i.e., performed) during this sessions, by using them as motives and guides for the improvised body movement/expression. This activity was followed or alternated by a guided-dance part to first experience the physical processes addressed in each

subject (e.g., The Origin of the Universe, of the Planet Earth and all forces of nature), in order to have an initial “empirical-somatic” comprehension of the phenomena before receiving the theoretical explanation. Therefore, the methodology is based on experiencing concepts and physical phenomena through the body movement, body expression, and by acquiring body knowledge at first. Contact-improvisation dance, for instance, is based on the improvisation that arises when two bodies establish contact, following the physical laws that govern their motion: gravity, momentum, and inertia. Therefore, it is an extremely useful technique to experience with the body these physical laws. The bodywork was occasionally shortly interrupted to reinforce the oral tradition and to provide the scientific explanation of the same experience.

(2) A session (~1 hour long) of interactive talks followed, to construct the concepts experienced with the body in the first session. The theoretical scientific background was explained in continuous feedback with the Māori view about the same processes. Audio-visual aids, such as images, videos, and power point presentations were used in this session to specify and clarify the concepts by visualizing real natural images or virtual models. This session had to be strongly interactive, allowing streams of questions asked by the children to be discussed and answered. (3) A subsequent practical session varied from observations directly in the field (on Mt. Ruapehu) to laboratory or hands-on exercises (e.g., construction of volcano models; Diet-Coke® and Mentos® experiment following Coffey 2008). (4) Collaborators (teachers and artists) conducted a further session, which varied according to the workshop. Learned key concepts were synthesized and posed as motives to produce other art forms, such as poetry, pictures, paintings, and songs. This activity (1 hour to several days) allowed further assimilation of the learned concepts. During all stages, a collection of existing and absent terms in *Te reo Māori* language was recorded, in order to build up a glossary of geological terms in the native tongue.

Finally, the documented process and artistic products were later used to (5) produce a teaching tool in video and power point presentation formats. This tool was left as a permanent resource to the school for continuing work with future generations. It was also given to other teachers, other members of Ngati Rangi community, and researchers conducting investigation on Māori culture, *mātauranga*, and risk mitigation strategies, to be used as an interactive tool in order to extend the process to the elder generations.

Results

Mātauranga Māori (the Māori Knowledge System)

The meetings (*hui*) and conversations (*kōrero*) between volcanologists and the Principal focused on the Māori perception and their explanation about the Origin of the Universe, the Planet Earth, Earth dynamics, Mt. Ruapehu

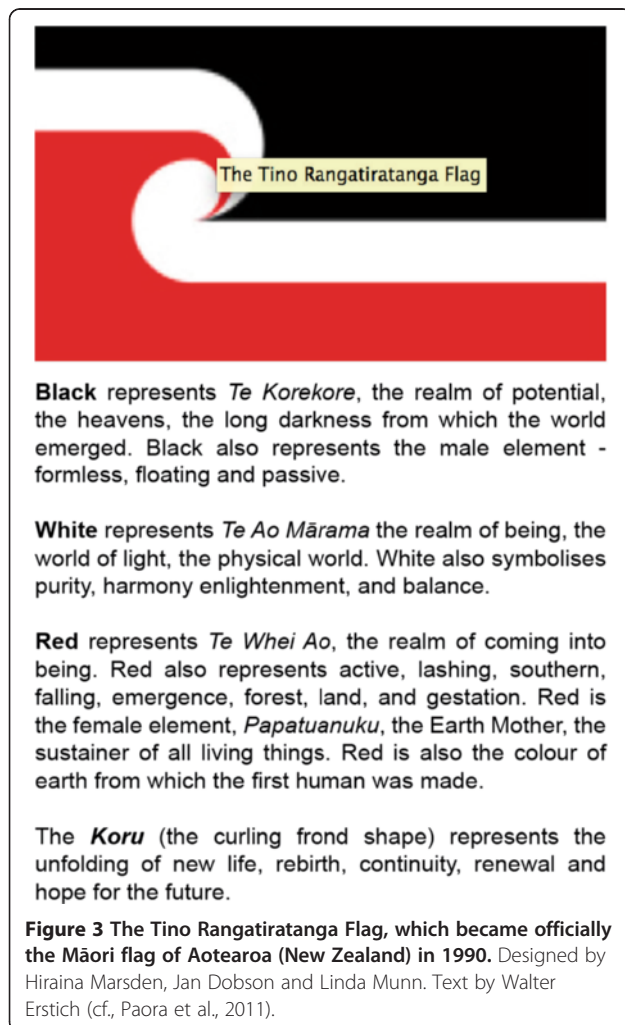
and the relationship between the tribe and the volcano. The discussions emphasized the concept of *Kaitiakitanga* (guardianship), which encompasses the philosophical and practical components that establish the local indigenous environmental ethics. By protecting and managing the land that Māori have been occupying over generations, where the community exercises authority for decisions made regarding the land (*mana whenua*) and manages natural resources, the guardianship enhances the health of valued species (*mouri o ngā tāonga*) and the local ecosystem (cf., Forster 2011). Therefore, Māori environmental theories and practices derive from long (hundreds of years) cultural and ecological relationships with their ancestral land.

To understand the meaning of the Māori territory, it is crucial to clarify their explanation about the origin of the world known by humans. In the Māori tradition, the Universe is a dynamic process, a continuous transformation allowing the “unfolding of consciousness and thought”. Its roots comprised (1) *Te Korekore*, meaning the original void and the potential being (Figure 3); (2)

Te Pō, meaning the original darkness and the world of becoming; and (3) *Te Ao Mārama*, meaning the world of light, the world of being. Māori genealogy starts from here, from the beginning of the universe, developing into the establishment of time-space, night and day, and the formation of the male and female principles: *Ranginui* (Father Sky) and *Papatūānuku* (Mother Earth). From their union all the spiritual powers were born and became the guardians of their various domains, including the ocean, the wind, earthquakes, volcanic eruptions, forests and birds, the cultivated food, uncultivated crops, human beings, and war. Within Māori cosmogony, humans were born in the latest time of this genealogy (cf., Kowhai Consulting Ltd. 2004).

Along with the unfolding universe, the ability of cosmic processes to give, but also, to destroy has been widely recognized by Māori. There, the concept of *Tapu* arises. It refers to the sacred and also to the forbidden places, activities, and things, and it is therefore used as a protective measure that establishes ethical and practical norms, also imposing a social control. *Tapu* is the Māori system to cultivate appreciation and respect for another human being, another form of life, and any life force (cf., Kowhai Consulting Ltd. 2004). Volcanic craters, crater lakes, geothermal springs, water springs, and other specific landscapes are *tapu*. For example, *Ngāti Rangī* refers to the Crater Lake on Ruapehu as *Te Wai a Moe*, the Sleeping Water, which is a place of *Tapu*. This is not trivial, since the most recently frequent eruptions of Ruapehu regard unpredictable phreatic events that may not significantly impact a large area, but certainly is a threat for visitors on the volcano slopes and crater rim. Likewise, a story about the origin of the Mangawhero River from a tear escaped from *Ranginui* as he got separated from his lover *Papatūānuku* could be used as a starting point to explain the different lahar triggering mechanisms. Similarly, the *Rangipōs* desert (Figure 1b) is also referred as *Tapu*, corresponding, from the volcanological perspective, to the proximal and medial locations of pyroclastic deposition during past, sustained Plinian and subplinian eruption columns. *Tapu* can be therefore considered as a native hazard mitigation strategy (cf., Tapuke et al. 2006, King et al., 2007, Grattan and Torrence 2010), which identifies a place as sacred and forbidden because it is known to be dangerous, ultimately discouraging people to approach (e.g., it regulates exposure to volcanic hazards).

A recurrent story within the Māori narratives regards the “Three baskets of knowledge”. In the story, the supreme creator *Io* gave these baskets to *Tane*, the god and guardian (*kaitiaki*) of the forests and direct ancestor of the human kind. The three baskets correspond to: (1) the knowledge beyond space and time, the ultimate, and unknown to us, reality; (2) the “womb of the universe”,



the initial knowledge from which the universe originated; (3) “that before us”, corresponding to the knowledge that we acquire through the senses allowing the current understanding about the natural world around us. Within this context, the Māori education system develops, providing the first principles or ground rules, and the customs from which “one would guide oneself” (cf., Kowhai Consulting Ltd. 2004). This “living and behaviour guide” is transmitted throughout generations through the *karakia* (prayers), *waiata* (songs), *kōrero* (oral stories), and other forms of performing arts collectively named *Kapa-Haka*.

Ngāti Rangi's starting point when approaching any discussion about Mt. Ruapehu was their *karakia* (prayer) to the volcano, titled “*He Ruruku: Mai ara ra!*” (Appendix 1). The prayer recalls the tribe's genealogical link to Mt. Ruapehu, which is not simply described as a geomorphological accident consisting of *Rua* (two) *Pehu* (craters), but is mainly referred as: (1) *Koro* (Grandfather), (2) *Matua te Mana* (The powerful progenitor), and (3) *Te Whare Toka o Paerangi* (The house of stone of Paerangi, their ancestor).

The *karakia* mentions the “Mountain Clan”, which refers to Mt. Ruapehu (*Matua te Mana*-Absolute Wisdom), Mt. Tongariro (*Matua te Toa* - Absolute Warrior), Ngāuruhoe (*Matua te Pononga*-Absolute Negotiator), Pihanga (*Matua te Hine*-Absolute Feminine), and Mt. Taranaki (*Matua te Tapu*-Absolute Sacredness) (Figure 1b). The Māori story explains the actual distribution of the volcanoes, with Mt. Taranaki location offset to the west coast and detached from the N-S volcanic trend within the Central Volcanic Plateau. These volcanoes conformed the ancestral mountain clan and originally lived together in the central North Island. Pihanga represents the only female character and was engaged with Tongariro. However, a love affair with Taranaki provoked conflict, from which Tongariro got furious and finally “blew his top”. Within the *Ngāti Rangi* version of this story, Ruapehu, *Koro* (the grandfather), watched the scene with worry and decided to send Mt. Taranaki (who was responsible for the sacred *kōrero* of the clan) to the west, with the responsibility to “be the guardian of the setting sun”. From there, he cries whenever he reminds Pihanga and sends his caresses from the West in the form of clouds. The story clearly places Ruapehu as the wise elder, *Matua te Mana*, who protects *Ngāti Rangi* from the force of Tongariro. Although we could not completely confirm the entire story with geological evidence, Mt. Ruapehu Plinian eruptions (>27-11 ka cal. BP) are older than Tongariro largest explosive events (>10-7 ka cal BP). Also, the shape of Mt. Tongariro has progressively changed with time as violent eruptions and sector collapses have occurred (cf., Donoghue et al., 1995; Cronin and Neall, 1997; Narin et al. 1998; Moebis et al., 2011).

Ruapehu also plays a central role in *Ngāti Rangi* songs and other stories, where it is referred as the shining scale of the Great Fish caught by *Māui* (Polynesian *demigod*), which subsequently became the North Island of New Zealand (*Te Ika o Māui*; cf., Te Ahukaramū Charles Royal 2012). From the conversations, it was clearly understood that from the Māori perspective, the land and the volcano clearly preceded human occupation in the cosmogony.

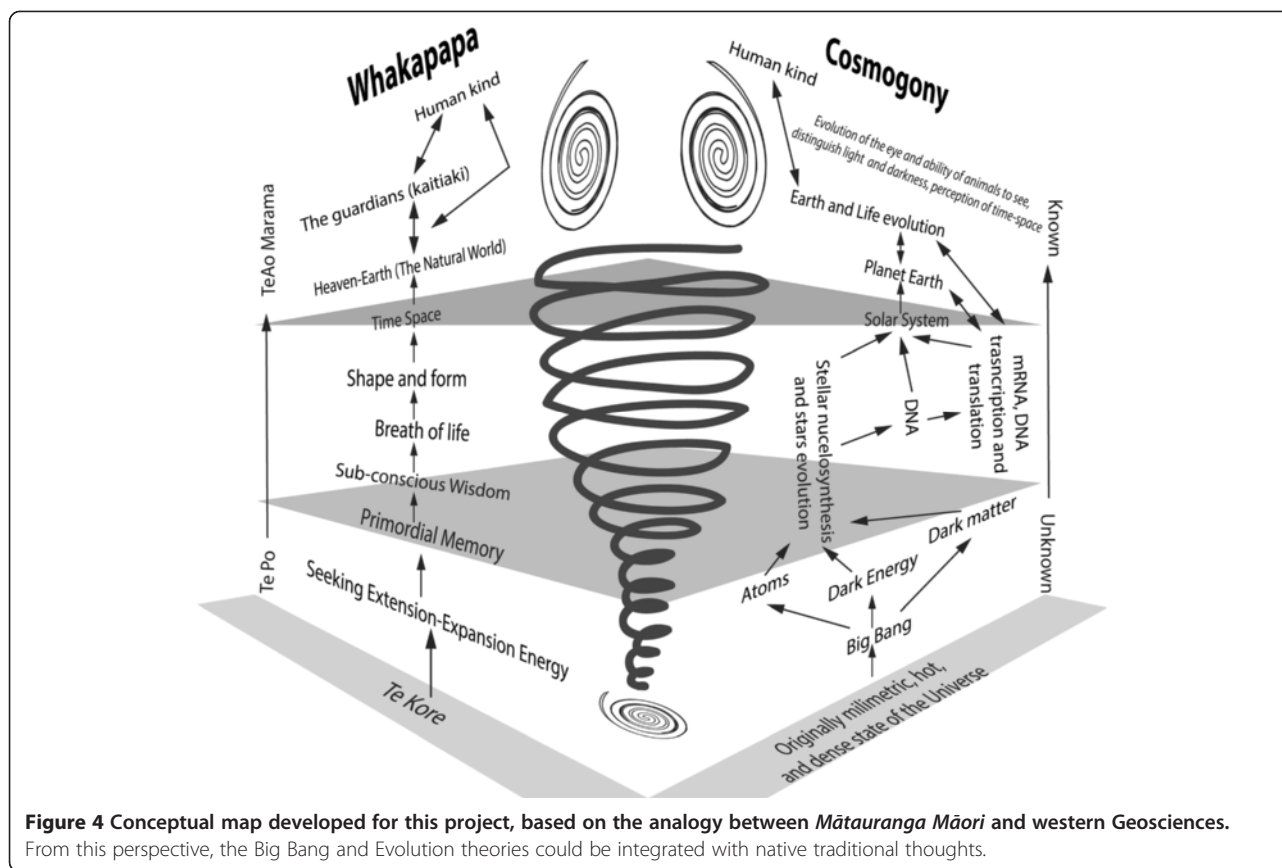
Mt. Ruapehu is therefore considered one of the ancestors who provides benefits to the tribe and regulates the balance of their territory. “If he needs to do his *mahi* (job) then we need to let him. He needs to do what he needs to do”. *Ngāti Rangi* permanently emphasized this perception about the volcano, constantly repeating that the tribe does not consider Ruapehu as a hazard; indeed, *Ngāti Rangi* asked volcanologists to avoid this term from the beginning of this project. During the meetings there was a recurrent message reinforcing the tribe's lack of fear in front of volcanic activity of Ruapehu, and the strong acknowledgement for all the benefits provided by the volcano, which included: (1) Their water resources, embracing rivers, water springs, the Crater Lake, and the Rotokura lake (located on the SE ring-plain of Ruapehu and considered to hold water with healing properties). (2) The ski field, which is the main source of economical and recreational activities during winter. (3) The productive volcanic soils, and (4) protection from the eruptions of Tongariro (last erupted in 2012; Jolly and Cronin 2014).

Bridging Māori and western-gescience systems

By integrating Māori and scientific perceptions, a conceptual map was proposed (Figure 4; Table 1) in which for each Māori concept there corresponds an analogue scientific one. The resulting lines and arrows connecting concepts and processes attempt to correlate the two.

For example, the genealogy from creation to mankind detailed by Mātauranga Māori, starting from the root-cause, the original void, and developing into the expansion energy, primordial memory, sub-conscious wisdom, and the seed-word breath of life, can have an equivalent in science, starting from the *Big Bang*, and developing into the formation, replication, transcription, and translation of DNA. Similarly, the Māori notion about the unfolding of life is comparable to the scientific theory of evolution and the typical spiral representation of the geological time.

In the resulting integrative map (Figure 4), the lessons from the past experiences and from the observation of the present moment play a role in the mental projection of the future. From the mythological point of view, past experiences are lessons for present generations; from the scientific, geological point of view, the observations of



current processes are the key to reconstruct the past events (Principle of Uniformitarianism). Both systems look forward to study trends and envisage the future (events/generations), which is a key procedure to design strategies for risk mitigation and emergency planning.

Workshops for Māori children

Through the development of the conceptual map (Figure 4; Table 1), the idea of humans as part of the environment, rather than separated from natural processes was reinforced, and a sense of responsible participation could be shown and shared with children. The co-validation of *Mātauranga Māori* and western Geosciences aimed to reach an agreement between both perceptions, which helped to design four, one-day long workshops (one per school-term), where geology could be taught without interfering but nurturing and being nurtured by the traditional Māori understanding.

At the end of the first workshop (*Te whakapapa o Papatūānuku*), the concepts of Time-Space, Matter and Energy, the Laws of Thermodynamics, the States of Matter, The four Fundamental Forces, the Origin of the Universe, Solar System, Planets, Earth structure, and the importance of soils and water conservation were effectively shared (Table 2a and 2b).

At the end of the second workshop (*Ruaumoko* shakes), the concepts of Tectonic Plates, stress-and-strain, earthquakes, seismic waves, Earth crustal response to stress (i.e., fragile, ductile, plastic, and elastic behaviour of matter), orogenesis, and the general theories of Earth's dynamics were integrated with the stories of *Ruaumoko*, the god of earthquakes and volcanoes (Table 3).

The third workshop (*Te Whare Toka o Paerangi*) reviewed the structure of the Earth and focused on the Tectonic Rock Cycle. This was successfully integrated to the Ruapehu narratives as being the "House of stone" of *Paerangi*, the *Ngāti Rangi* ancestor (Table 4).

The fourth workshop that could be developed within the time of this project (*Matua te Mana* and Crystals) focused on the generation of magma, magma crystallization, degassing, and the origin of volcanoes (Table 5). The last workshop (*Te Mahi o Ruapehu*) focused on volcanic eruptions, volcanic products, and their benefits to humans and, in particular, to the *Ngāti Rangi* people (Table 6).

As described above, all workshops included an initial session of bodywork by integrating Contact-Improvisation dance, partner-yoga, and somatic-dance exercises, which provided a guided, free-style movement with scientific and traditional native contents (here called Earth-Contact Dance). The images, movements, and questions driven by

Table 1 Comparative table showing the analogy between Māori knowledge system (*Mātauranga Māori*) and Western Geosciences

Maori knowledge	Western-Science
<i>Mātauranga Māori</i> : Empirical and spiritual methods, inherited tradition and customs	Astrophysics, Geology, Palaeontology, Biology, Archaeology, Anthropology
<i>Whakapapa</i> (Genealogy)	Cosmogony
The three baskets of knowledge	Principle of Uniformitarianism, Law of Superposition, non-linearity of Space-Time
<i>Atua</i> : ancestors (divinities) with influence over particular domains	Potential Energy
<i>Mouri</i> : the principle of life-force or essence within all animate and inanimate things, and resulting interconnection between all forms of life. It is the power that creates unity in diversity, the binding power that unifies.	Dark energy, principles of thermodynamics
<i>Hihiri</i> : absolute energy, a form of illumination or aura, which appears in all living things	Electromagnetic and gravity fields
<i>Mouri-Ora</i> : the life principle existing in animate and inanimate things and remains with them throughout its existence.	a) Earth Physics (dynamics): convection within Earth Nucleus and Mantle, Plate Tectonics, the Rock cycle, earthquakes, orogeny, volcanic activity, atmospheric processes, formation of soils, crystals. b) Living things: Genetic code
Male and Female principles	Sexual reproduction
<i>Papatūānuku</i> : Mother Earth as a living being	Planet Earth: Dynamic System
<i>Ruamoko</i> : god of earthquakes and volcanoes represented as the youngest son of Papatuanuku and living underneath her.	Earth's core and mantle convection, Plate tectonics
<i>Kaitiaki</i> : divinities created by the love of <i>Papatūānuku</i> (Earth, female principle) and <i>Ranginui</i> (Sky, male principle). Some of the most mentioned in the narratives are <i>Tangaroa</i> (god of oceans), <i>Tawhirimatea</i> (god of winds), <i>Tanemahuta</i> (god of forests), <i>Whiro</i> (darkness, god in charge of illness, strengthen by death)	Natural forces and cycles
<i>Kaitiakitanga</i> : Active, interdependent relationship between <i>Atua</i> , natural resources, ancestors, present human generation. It considers the inhabitants knowledge of the physical space and the "layers of events and relationships that have occurred in that area over time" (Forster, 2011).	Ecology, Environmental Sciences, Stratigraphy, History
<i>Tāne Mahuta</i> , the direct ancestor of Man: humans and trees are genetically related	The Human being and trees share some DNA
<i>Mana whenua</i> : the potential of the land	The ability of the land to produce the benefits of nature. It is linked to environmental conservation, land distribution
<i>Matua Te Mana, Koro, Te Whare Toka o Paerangi</i> : name of Mt. Ruapehu, considered as Ngati Rangi ancestor	Mt. Ruapehu: the most active inland volcano of New Zealand.
<i>Ka Ora tenei whenua</i> : Mt. Ruapehu protects the tribe, provides healing water, rivers, soils, snow	Benefits from volcanoes, including: (1) Main water sources for Ngati Rangi territory, (2) Soils fertilization from degradation of volcanic ash, (3) contribution to Earth's atmosphere composition, (4) Tourism
The <i>mahi</i> (job) of volcanoes, needed to maintain the life, natural cycles, processes, and the world as we know it	Volcanic hazards
<i>Tapu</i>	Vulnerability and Risk perception and management
Ngati Rangi Iwi identity and awareness of their geologically active environment	

the instructor pulled out the attention towards observation of the own body and construction of empirical knowledge. After the physical sensations were explored through the body language the children had time to narrate their perceptions. From here, the physical-laws and geological concepts were constructed together with the teachers, making always the paragon with Māori knowledge. The

process resulted in a continuous creative education practice during which the teacher was constantly inducing research by the students. Rather than limiting the lessons to a unidirectional talk by the teacher, the permanent thinking-induction through questions to the children allowed the construction of concepts by themselves. The emotion triggered through this process allowed the

Table 2 First Workshop design: *Te whakapapa o Papatūānuku* (From the Big Bang to the Origin of Planet Earth)

Workshop	Body-Language teaching technique	Māori narratives	Scientific concepts	Example-exercises	Audiovisual aid	External collaborators
a.						
<p>1. <i>Te whakapapa o Papatūānuku</i> (The Genealogy of The Earth): Introductory workshop</p>	<p>Theatre-dance and somatic dance: māori and/or the scientific story performing through body sensitization. By guided attention, an exploration of the physical sensations was directed while building up the narrative of the origin of the Universe and the Earth. The movement was connected with feelings, findings, needs, desires (e.g., the need of light and order in the cosmos, the desire of expansion and space). Rarely the children needed to imitate the teacher and most of the time, a free-style movement was established in order to focus attention on the individual processes. According to the physical laws experienced with the body (i.e., gravity, momentum, inertia) and the image or narrative given by the instructor, the scientific explanation was provided either during the dance or in short pauses used for discussion circles. At the end of the movement-session a talk-circle served to construct concepts through the interactive</p>	<p><i>Te Kore</i>, transition from <i>Te Pō</i> to <i>Te Ao Mārama</i></p> <p>Space</p>	<p>Expansion of the Universe (Big Bang)</p> <p>1) Matter and Energy. Physical particles and their interactions: collision, rejection, bonding, fusion. 2) Stellar nucleosynthesis, and Origin of Life.</p> <p>Laws of Thermodynamics</p>	<p>Laying down with closed-eyes, starting to explore the ground and describe textures, temperature, solidity, the feeling of darkness and confusion. Then, continuing the exploration with open-eyes and feel the difference. Slowly start to explore the space in the vertical direction while changing levels (from the floor to standing), experiencing the force of gravity, inertia, and momentum.</p> <p>Changing Partner games: (1) Find a partner in the space and establish short interactions (e.g., establish eye-contact for a few seconds and approach without touching, then leave-to feel magnetism-reject, collide, make bonds). (2) Find a partner and play mirrors for a few seconds. With these exercises we aimed to reproduce all possible particle interactions in the space after the Big Bang. A group of children start to come close to gether until forming a cluster, feeling gravity and density, and guide them towards liberating themselves from that, recreating how stars are born.</p> <p>The activities above are done at different speeds, including stopping the movement.</p>	<p>1) Images about nebulae, star dust, galaxies and you-tube videos about star formation and the origin of the Solar System and planets. 2) <i>Te Koru</i>, an unfolding spiral representing the Maori evolution of the Universe, and Geological time in Science.</p>	<p>Jen Hyde-Independent Performing artists, expert in Acro-yoga, Circus, Theater of the oppressed, Games, and Teaching for social justice</p>

Table 2 First Workshop design: *Te whakapapa o Papatūānuku (From the Big Bang to the Origin of Planet Earth)* (Continued)

	discussion between teachers and students.		Explained from activities above.				
		Forces: Gravity, Magnetism, Electricity, Nuclear Force	Moving in the space while feeling the centre of gravity, experiencing what happens when changing levels.				
	Separation between <i>Papatūānuku</i> and <i>Ranginui</i>		Representation by teachers and collaborators using acro-yoga techniques				
		States of Matter: liquid, solid, gas-vapor	Free-dance experiencing/performing the states of water when changing temperature				
		The Origin of the Solar System and planets	A group of children form a central cluster (Sun), by making a circle holding hands and recreating collapse, explosion, rotation, initiation of the Star. In the meantime, the rest of the children stay around, individually moving in circles, as asteroids. Careful creation of larger clusters (planetoids) by embracing children along selected orbits, adding more "mass to each planet"				
	Papatūānuku	Planet Earth: location in the Solar System and Structure	Closed-eyes sensitivity by doing an imaginary trip from the Earth's core towards the surface, feeling all the Earth's layers beneath us.	An apple was used to visualize the proportions of potable water and soils.			
	Kaitiakitanga	After explaining the Earth's Structure, the attention focused on the nature, scale, and value of water and the soil.					
b.							
1. Te whakapapa o Papatūānuku (The Genealogy of The Earth): Introductory workshop [continued]	Partner Yoga	Introduction to <i>Ruamoko</i>	Stress and stress-release: earthquakes and volcanic eruptions need to happen to guarantee natural cycles and Life on Earth as we know it	Stretching exercises in partners, feeling tension and its release, weight and its release.	Field-visit: a short excursion to the Eastern Ring Plain of Ruapehu to learn how to identify East, South, West, and North at Onetapu,	Each student wrote a poem in native language about Papatūānuku, natural forces, and the need of volcanic eruptions to support Life. Each	Jen Hyde-Independent Performing artists, expert in Acro-yoga, Circus, Theater of the oppressed, Games, and Teaching for social justice
		Gravity					

Table 2 First Workshop design: *Te whakapapa o Papatūānuku (From the Big Bang to the Origin of Planet Earth) (Continued)*

Continuing theatre-dance	Magma, formation of gas bubbles within magma, volcanic eruptions, and pumice rocks and obsidian	Guided movement and somatic dance, feeling as if we were “magma”, detailing what a viscous behaviour is, the formation of a gas bubble, and the bursting response of the bubble when subject to decompression.	one of Ngāti Rangi sacred places. Identification of the surrounding volcanoes: Mt. Tongariro, Mt. Ngauruhoe, Mt. Ruapehu. Visit to a small valley to recognize the volcanic deposits of Ruapehu, learn how to read the geological history. The children were able to connect the morning dance exercises and recognized that pumice is solidified magma, and its voids are the bubbles.	poem was accompanied by pictures taken by them during the workshop, and an exhibition in the classroom followed.
<i>Papatūānuku</i>	Cardinal directions, orientation, and coordinates Stratigraphy: how we read the story of the Earth by using the Principle of Uniformitarianism and the Law of Superposition. The analogue of the rivers “carving the skin of Papatūānuku” helped to explain river incision and the outcrops of horizontal tephra beds.			

Table 3 Second Workshop design: *Ruaumoko* shakes (An introduction to Earth dynamics and earthquakes)

Workshop	Body-Language teaching technique	Māori narratives	Scientific concepts	Example bodywork exercises	Audiovisual aid	Experience	Outcome	External collaborators
2. <i>Ruaumoko</i> shakes: introduction to earthquakes and seismic activity	Guided movement to recreate the return to the original void, darkness, space.	<i>Mai ara rā!</i>	Review of the Big Bang and Earth Structure.	Short version of the corresponding activity of workshop 1.			1) New vocabulary in English and Māori languages. 2) Art-piece: a sculptured series of paintings displayed as P, S, and R-seismic waves	Other Te Kaupapa o Ngāti Rangi teachers
	Partner Yoga	<i>Papatūānuku's</i> stress and forces	Stress and stress-release: earthquakes and volcanic eruptions need to happen to guarantee natural cycles and Life on Earth Gravity	Stretching exercises in partners, feeling tension and its release, weight and its release. Contact-Improvisation exercises to experience: gravity, push, pull, roll, slide.	Class showing videos and pictures about the Earth structure, mantle convection, tectonic plates, and emphasis on Subduction processes.	A round of questions from teachers aimed to reinforce and synthesize the lessons. This activity was mingled with traditional songs.		
	Guided movement recreating mantle convection.	<i>Ruaumoko's</i> job (<i>mahi</i>) inside <i>Papatūānuku</i>						
	Free-style movement to experience the response of matter (strain) to stress.		Crustal strain and stress, and introduction to earthquakes	Free-style fluid, plastic, elastic, and fragile behavior with movements.				
	Game with a rope to recreate P, S, and R-seismic waves.		Seismic waves					
Game: one kid personified <i>Ruaumoko</i> triggering earthquakes, and a team of children represented the crust responding to the seismic waves by rolling, folding, pushing, sliding, until creating mountains.		Orogenesis						

Table 4 Third Workshop design: *Te Whare Toka o Paerangi* (A look to the Tectonic Rock Cycle)

Workshop	Body-Language teaching technique	Māori narratives	Scientific concepts	Audiovisual aid	Experience	Outcome
3. <i>Te Whare Toka o Paerangi</i> (Mt. Ruapehu: Paerangi's house of stone)	Theatre-dance: māori and/or the scientific story performing through body sensitization and somatic dance exercises. A free-style movement was guided to recreate the tectonic Rock Cycle, the action of water and wind on rocks. According to the physical processes experienced with the body, the scientific explanation was provided either during the dance or in short pauses used for discussion circles. At the end of the movement-session a discussion circle served to construct concepts about igneous and sedimentary rocks, erosion, metamorphic rocks, and the tectonic rock cycle as Earth's recycling processes.	<i>Ruaumoko, Te Whare toka o Paerangi</i>	Earth Dynamics, Surface processes and the Tectonic Rock Cycle.	Lesson in the classroom drawing the Rock-Cycle process and explaining each step. This explanation occurred with continuous questioning from the students.	Laboratory class: children were grouped in different teams according to age. A rock sample representing each rock-type was given to each group for observation and description. The teacher provided the name of each rock, and a representative of each team exposed the observations and the location of each rock within the cycle to the rest of the teams. An additional aid was the exhibition of thin-section pictures of each rock-type on a screen.	Pictures and new vocabulary.

assimilation of the learned concepts and the motivation to share their new findings with their families, promoting communication to elder generations.

Because of the conditions of this project, the guided movement and scientific explanations were given first in English, followed by the translation in *Te reo Māori* to assure comprehension.

The results were surprisingly positive because of the highly active participation and creativity of *Ngāti Rangī* students. Throughout frequent questions along the entire project we could confirm the appropriation of geological and traditional knowledge without conflict.

Resulting tangible products include a collection of poems, paintings, crafts, pictures, and a song. These products were integrated within a video and a power-point presentation formats, as a teaching tool for children and adults (being adaptable to all levels), for future generations.

Discussion

Expectations from the teaching tool

The didactic video/.ppt resource prepared for *Ngāti Rangī Iwi* is a continuous process, a compilation of visual and auditory material to provide insight into knowledge platforms uniting *Ngāti Rangī* historical and intellectual tenets, code of conservation beliefs and practices, and Geosciences. It emphasizes the interconnectedness of *Ngāti Rangī* knowledge, history, and contemporary teaching sources (poems and songs) in a learning atmosphere that engaged the children at primary school.

The following points below highlight some discussion points, which can be used for the development, integrated learning to produce a *Ngāti Rangī* geoscience resource. It provides a starting point to develop an entire glossary of geological terms in the native language, providing an instrument to support native language revitalisation, reclamation, and regeneration. It could be also used as a tool to inspire new songs, poems, dances, and theatre plays within the local art style, nurturing the tradition and knowledge for future generations. It ultimately brings an opportunity for *Ngāti Rangī* to lead in worldwide efforts to reinforce the capabilities of indigenous communities to manage volcanic risk reduction.

The message from *Ngāti Rangī* to the scientific community

Forced evacuation and displacements of native people away from their ancestral land impact their entire social, cultural, economical, and ecological network, which may increase their vulnerability in future events. Rather than imposing the results of western science and governmental decisions on indigenous communities exposed to volcanic activity, the participation of the community and the recognition of their own, empirical knowledge developed throughout generations of land occupation may be a better way to decrease social vulnerability. Empowering native and scientific community awareness and cooperative prevention strategies during volcanic repose periods, may enhance concerted participation in emergency planning and response.

Table 5 Fourth Workshop design: *Matua te Mana* and crystals (Magma and introduction to volcanic eruptions)

Workshop	Body-Language teaching technique	Māori narratives	Scientific concepts	Example bodywork exercises	Audiovisual aid	Experience	Outcome	External collaborators
4. <i>Matua te Mana</i>, Magma and Crystals	Somatic dance followed by guided choreography	<i>Mouri, Mana, Mahi</i>	Atoms, Atomic bonds, Molecules, molecule vibration within the solid state of matter				The lyrics of a song dedicated to <i>Matua Te Mana, Te Whare toka o Paerangi</i> , and all the interdependence of the lwi and Mt. Ruapehu.	Matua Te Huki-musician and kapa haka teacher. He composed the music, guided the creation of the lyrics, and carried on the final edition and recording of “Ko Matua te Mana” song (Te Huki 2013)
	Somatic dance and guided movement to recreate rock melting, magma genesis, magma chamber, magma partial crystallization, magma ascent, vesiculation, and eruption.	<i>Papatūānuku, Ruaumoko, Matua te Mana, Te Whare toka o Paerangi</i> , healing properties of crystals	Magma Magma degassing	While describing the physical properties of the magma children can “dance” these properties. With the imagination, children feel they are magma within the chamber, changing from being molten, to crystals, to bubbles. Each state is linked to a change in the physical conditions of the magma.		Experiments with Diet Coke and Mentos, following Coffey (2008)		
	Guided movement: recreation of crystal structures with our bodies.		Magma crystallization				Large megacrysts were brought to the classroom. The properties of each crystal/mineral were explained followed by a direct observation and sensorial experience with each crystals per group of 4 to 5 students.	
	Somatic dance and guided movement to recreate effusive and explosive eruptions, bubble burst and lava flows.		Volcanic eruptions: Explosive vs. Effusive	Crystal structures	Build-up each structure type with the bodies: one body equals one atom, and ropes were used to connect atoms. Then two lines were set up to explain the properties of crystals: mirror axis, planes of symmetry, centre of symmetry.		Lesson in the classroom with videos of real volcanic events and virtual models	

Table 6 Fifth Workshop design: *Te mahi o Ruapehu* (Volcanic products: events, deposits, and benefits)

Workshop	Body-Language teaching technique	Māori narratives	Scientific concepts	Example bodywork exercises	Audiovisual aid	Experience	External collaborators
5. <i>Te mahi o Ruapehu</i>	Somatic dance followed by guided choreography	<i>Te mahi o Ruauumoko, Te Whare toka o Paerangi</i>	Volcanic products: lavas, pyroclastic falls, Pyroclastic density currents (PDCs), lahars, debris-avalanche	A choreography was directed to represent (1) dome formation, and implied viscous-rigid behavior, (2) dome explosion and tephra fall dispersion, (3) eruption column collapse and the generation of PDCs. Then the teacher would detonate the first eruption at one team of students recreating eruption activity (1). They would select the next team, who would trigger activity (2), and so on with activities (3) and back to (1). A cycle of eruptions could be recreated and the implied processes were explained (e.g., Dome explosion would lead to Eruption column with ash dispersal, then eruption column collapse; after the gas got exhausted, a new generation of domes would grow).	Lesson in the classroom with videos of real volcanic events and virtual models showing: difference between effusive and explosive eruptions, ballistics, sustained eruption columns, ash-plumes, Pyroclastic Density Currents (flows and surges), lahars, edifice sector-collapse, and production of debris-avalanche.	A model of wheat, baking powder, and water volcano can be created to explore different magma viscosities (Acknowledgement to James Cowlyn and Ben Kennedy-University of Canterbury, New Zealand)	Ana Gabriela Mar Sarabia. Children psychotherapist specialized in dance-therapy and Hata yoga teacher
		The Mountain's clan	Relationship of the volcanoes in New Zealand to the Subduction along the Kermadec trench				
		Tongariro blew his head	Explosive eruptions modify the shape of the volcanoes				
		<i>Wai-ā-Moe</i>	Crater Lake, phreatic and phreatomagmatic eruptions				
		<i>Onetapu and the Origin of Mangawhero River</i>	Lahar triggering mechanisms: eruptive and non-eruptive				
		<i>Rangipōs</i> desert considered as <i>Tapu</i>	Rangipō desert is under the dispersal axis of major (Plinian) past fallouts				
		<i>Ka Ora, Kaitiakitanga</i>	Volcanic benefits (water sources, geothermal springs, fertile soils), Environmental Geology				

This project showed how traditional knowledge and western, modern sciences are not necessarily exclusive or in conflict. Their integration can in fact be a powerful education tool to empower native communities to actively contribute to volcanic risk mitigation strategies, and take their insights abroad to other indigenous and non-indigenous groups and institutions leading to disasters prevention. Specifically, the *Ngāti Rangī* objection to referring to volcanic activity of Mt. Ruapehu as a “hazard” (with a potential negative outcome) is an invitation to the scientific and governmental communities to include traditional knowledge within emergency planning strategies. The tribe emphasized a perception about the volcanic activity, which has been more likely to produce benefits than disasters over generations. Within this point of view, the Māori community asks scientists and government to guide human kind behavior, politics, and decisions by considering that it is not about controlling the Earth and natural processes, but about living in harmony with volcanism. In a sense, this is an invitation to use science in a way that supports the traditional conservation practices and that proposes mitigation strategies worked within consensus with the local native communities. The ultimate aim is to reduce vulnerability and optimize social response during volcanic crises.

Conclusions

By using the “body” as the mirror of our own point of view about the world rather than being an object in the world (Merleau-Ponty 1945), it is possible to understand scientific ideas by experiencing and feeling them first, and then by adding words to the given information to construct concepts. We showed how physical processes and concepts, such as the principles of thermodynamics, the origin of the Solar System and formation of Planet Earth, as well as how earthquakes and volcanoes work can be recreated and experienced through basic exercises of Contact-Improvisation dance, somatic dance, games, and other ludic activities based on body language and bodily knowledge. We showed how the resulting Earth-Contact Dance could bridge languages that could be misinterpreted as contradictory, such as native traditional belief systems and western earth sciences, to create a new way of looking at volcanic activity and hazard.

Blending traditional indigenous and scientific knowledge systems reduces social vulnerability by: (1) increasing awareness of volcanic phenomena by the local indigenous communities, (2) increasing awareness of scientists and government about the cultural and vital relationship between the communities and volcanoes, and (3) providing a better environment for active community participation and potential positive response during emergency management. The integrative approach can

contribute to living safely with active volcanoes and reducing risk, during eruptive and non-eruptive periods.

Appendix 1

Māori prayer (*Karakia*) to Mt. Ruapehu titled *He Ruruku: Mai Ara Ra!*

Mai ara rā! Mai ara rā!
Mai ara rā te Tupua!
Mai ara rā te Tawhito!
Tēnei au
Tēnei au te rangahau ana, ki te ao, ki te pō
Kia Ranginui e tū iho nei,
Kia Papatūānuku e takoto ake nei.
Mai ara rā, mai whea ra tōku ahunga mai?
Tāhuri whakataumaha, huri whakamāmā
E te Kāhui Maungā ko wai ra koe?
Inā, Matua Te Mana te aunahi piataata mātahi
Pikimai Rawea te kai-kukume ake matua whenua rō wai
Te rongo nei ia hīhi,
Te rongo nei ia hāhā me huka tātairango.
Tina, tina toko te manawa ora, he manawa ora!
Ko te Roi-a-Rangi mo Rua-te-Tipua
Ko te Roi-a-Rangi nō Nukuhau e
Te pātukituki ka tū whakahirahira Kāhui Maungā mā.
Ko toka pokohiwi ka hora maru tapu, e Ngā Turi-o-
Murimotu
Te ahi kā o Paerangi i te Whare Toka
Te puta mai te Kāhui-o-Rangi, te Kāhui-a-Rua
Tōna hekenga mai i Te Wai-ā-Moe ki Paretetaitonga
Ko te ara hekenga, ko te ara hokinga mo ngā uri kōtuku
Ka tuku, ka tuku atu i ngā hau kaha ia Parakakariki,
ia Mouwhakaarahia
Hei tohu, hei whakaatu ki te ao!
Whiti, whano, hara mai te toki!
Haumia! Hui e!
Taiki e!

He Ruruku: Mai Ara Ra! (English translation by Che Wilson, *Ngāti Rangī Iwi*, 2012)

Let us return to our origins!
Returning to the time prior to common knowledge
Returning to the time of the ancient knowledge
Searching
Understanding the evolution of life
Absorbing the force of Father Universe
Absorbing the energy of Mother Earth
To truly understand who I am
Internalising this learning...
I now know who I am.
I am the first shiny scale of the Great Fish
I am the energy that turned the Fish to Land
Warmth embraced
Cold embraced, I am the blanket of snow
I am the pulse of the Great Fish
I am the tears of the heavens for Rua-te-Tipua

I am the tears of the heavens from Nukuhau
Divine connection, I embody the Mountain Clan
Anointed as custodian of life, as window to the spirit
world

I am Ngā Turi o Murimotu.
The fire from the House of Stone of Paerangi, I am
The genesis of the Sky Clan, I am
The genesis of the River Clan, I am
Emanating from out of Te Wai-ā-Moe
The alpha, I am. The omega, I am
The upper winds, I am
The lower winds, I am
This is my declaration!
A declaration sanctified by stone
Let us unite as one
Unite in conscious thought!

Competing interests

This project was supported by the project "Mātauranga Māori and Volcanic Hazards", funded by the Natural Hazards Research Platform (grant number 2012-MAU-01-NHRP) of New Zealand. The authors declare that they have no competing interests.

Authors' contributions

NP conceived the study, carried out the meetings with the indigenous communities by representing the volcanology expertise integrated the indigenous and western geoscience systems, designed and led the workshops, and drafted the manuscript. HW was the Principal of the māori school at Ohakune, being the main representative and communicator regarding *mātauranga māori*, *mātauranga a Ngāti Rangī*. She provided all the resources regarding indigenous knowledge, facilitated the logistics at the school, and translated the instructions from English to Te Reo Maori during the workshops. H. Wilson was the main collaborator during the workshops and participated in the edition of the manuscript. JP, as leader of the main sponsoring project "Mātauranga Māori and Volcanic Hazards", funded by the Natural Hazards Research Platform (grant number 2012-MAU-01-NHRP), facilitated the logistics at Massey University, the official meetings between the University and *Ngāti Rangī*, drafted the background of manuscript, and edited the final text. EL contributed to workshops 1 and 4th design and development, provided all the techniques to include responsible use of soils, and guided some of the creative stages of the workshops. TB participated in clarifying the lines of expected results during the process, edited and enhanced the teaching tools, and drafted part of the discussion section of the manuscript. All authors read and approved the final manuscript.

Authors' information

NP carried out this project during the last year of her PhD at Massey University (Palmerston North, New Zealand) and during her postdoctoral fellowship at Volcanic Risk Solutions research team of the same university. Her present affiliations are the Colombian Geological Survey (SGC) and Universidad Nacional de Colombia at Bogotá D.C.

Acknowledgements

This project would not have been possible without the active participation and collaboration of all the students at Te Kura Kaupapa Māori o *Ngāti Rangī* (*Ngāti Rangī* Primary school at Ohākune, New Zealand) between 2012 and 2013. Similarly, we acknowledge Che Wilson (Ngāti Rangī Trust), Kate Arentsen (Massey University), and all the staff of *Te Kaupapa o Ngāti Rangī*. Special gratitude to all the artists and external pedagogical collaborators who nurtured the workshops with great creativity and support: Matiu Te Huki, Jen Hyde, and Ana GM Sarabia. We gratefully thank Professor John Ham (Hirangi School, Tūrangi, New Zealand) for requiring, facilitating, and nurturing the development of similar, short workshops at Te Kura o Hirangi in 2013 (after Mt. Tongariro eruption 2012). He also enriched the discussions about the method. Hanna Rainforth (*Ngāti Rangī* Trust), Garth Harmsworth (New Zealand Landcare Research), Javier Agustín-Flores, and Professor Shane

Cronin (Massey University), are also thanked for their valuable comments, suggestions, and support.

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Received: 30 June 2014 Accepted: 16 December 2014

Published: 5 February 2014

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doi:10.1186/s13617-014-0019-1

Cite this article as: Pardo *et al.*: Bridging Māori indigenous knowledge and western geosciences to reduce social vulnerability in active volcanic regions. *Journal of Applied Volcanology* 2015 **4**:5.