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ORIGINAL RESEARCH PAPER

Education: Can a bottom-up strategy help for earthquake disaster prevention?

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Abstract To comply with the need to spread the culture of earthquake disaster reduction, we rely on strategies that involve education. Risk education is a long-term process that passes from knowledge, through understanding, to choices and actions thrusting preparedness and prevention, over recovery. We set up strategies for prevention that encompass child and adult education, as a bottom-up approach, from raising awareness to reducing potential effects of disruption of society. Analysis of compulsory school education in three European countries at high seismic risk, namely Portugal, Iceland and Italy, reveals that generally there are a few State-backed plans. The crucial aspects of risk education concerning natural hazards are starting age, incompleteness of textbooks, and lack of in-depth studies of the pupils upon completion of their compulsory education cycle. Hands-on tools, immersive environments, and learn-by-playing approaches are the most effective ways to raise interest in children, to provide memory imprint as a message towards a culture of safety. A video game, *Treme–treme*, was prepared to motivate, educate, train and communicate earthquake risk to players/pupils. The game focuses on do's and don'ts for earthquake shaking, and allows children to think about what might be useful in the case of evacuation. Education of the general public was addressed using audio-visual products strongly linked to the social, historical and cultural background of each country. Five videos tackled rising of awareness of seismic hazards in Lisbon, the area surrounding Reykjavik, Naples, and Catania, four urban areas prone to earthquake disasters.

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1 Introduction

As well as causing urban disruption and human and economic losses, earthquake disasters reflect the coping capacity of the citizens as they face the emergency. The experience of a hazard appears to be crucial to trigger prevention behaviour, although human memory is much shorter than the recurrence time of damaging earthquakes. Because of their recurrence after long time intervals and due to their high impact, earthquakes are often subject to disbelief and fatalism. The attitudes of disbelief are incorporated into a personal distancing from the probability of occurrence of an earthquake, which deters the individual from any protective action. Fatalism defines the social attitudes according to which extreme events as powerful as earthquakes render irrelevant any individual behaviour to improve personal safety (Sousa et al. 2014). Moreover, individuals tend to prioritize awareness and risk perceptions to those threats they are most familiar with, and these might not necessarily be natural hazards. Indeed, in many countries violent delinquency or anxieties about employment are perceived as a serious threat much more than the natural phenomena (Donovan et al. 2014 and references therein).

Disbelieve, fatalism, short memory and prioritizing threats are some of the reasons for misperception of the risk, which means that people do not always act in their own best interests, and instead, ineffectively choose recovery over prevention. Prevention of death and destruction from natural hazards requires actions towards vulnerability reduction that involve the decision makers and authorities who are responsible for the financial aspects, and as such, it is far from being aligned with the long-term perspectives for socio-economic investment in prevention (World Bank 2010; Horton 2011). The need for prevention fights against the lack of efficient risk management, and often when a hazard does turn into a disaster, this exposes actions that had they been different, would have resulted in fewer deaths and less damage. However, research has shown that preservation of the memory of a hazard can be achieved through provision of information that is enhanced by education (Wisner 2006; Biernacki et al. 2008; Komac 2009; Komac et al. 2013).

Awareness and correct perception of the risk are salient, although not sufficient, prerequisites for fostering the adoption of protective measures regarding hazards (Sousa et al. 2014). Prevention strategies encompass the assessment of earthquake impact and adequate actions to reduce the structural vulnerability, although they need to be supported by adequate long-term actions, with emphasis on education. Generally speaking, education is fundamental to enhance the skills for the recognition of dangerous situations, and to address these in a reasonable way. In particular, education allows informed choices to be made to reduce the negative impacts of natural disasters, while improving the adaptive capacity to cope with such an emergency (Muttarak and Lutz 2014; La Longa et al. 2012). This great potential of education as a disaster prevention strategy is in stark contrast to the apparent lack of preparedness in school curricula worldwide (Komac et al. 2013). Bearing this in mind, the 'Urban Disasters Prevention Strategies using Macroseismic Faults' (UPStrat-MAFA) project has relied on education as a crucial issue that needs to be more extensively addressed, with suggestions for new strategies that will improve understand and instil a culture of safety (Musacchio et al. 2015).

The significance of risk education refers to a process that starts from knowledge of the environment, the understanding of a natural phenomenon and takes into account all those

actions that can imprint in the mind behaviours that will be recalled in the case of emergency. Education is therefore a process that relies on the didactic promotion and dissemination of science as well as the development of skills towards safety, although it also has to include the building of awareness. Here we present our analysis on current natural hazard education and awareness programmes and their accessibility within three countries that participated in the UPStrat-MAFA project: Portugal, Iceland and Italy. This has highlighted the major weaknesses of these educational systems, and consequently the need for the development of more efficient strategies towards the promotion of a culture of safety. Formal education is considered to be the primary way that drives individuals to acquire knowledge, skills and competencies that can influence their adaptive capacity (Muttarak and Lutz 2014). A large amount of literature is in support of the learning experiences associated with formal education, in terms of their long-term impact on the synoptic structure of the brain (Kandel 2007) and the enhancement of cognitive skills (Neisser et al. 1996; Nisbett 2009; Reynolds et al. 2010). School education provides better understanding and ability to process risk information and warning messages (Mileti and Sorensen 1990; Spandorfer et al. 1995). The problem-solving skills that are enhanced through formal education (Moll 1994; Ishikawa and Ryan 2002; Schnell-Anzola et al. 2005) might be fundamental in emergency, such as when a disaster strikes.

Children are capable of learning behaviours that will be recalled in the case of danger, which appears to be the best choice in terms of spreading a culture of safety and best practices through a domino effect (Cardona 2007; Stoltman et al. 2007; Wisner 2006; Kuhlicke et al. 2012). These children represent the future citizens who will have roles in the decision-making processes in the future. Protecting, and at the same time providing sound knowledge to, our youngest generation is an investment that will safeguard the future, the environment and our livelihoods (Briceño 2007). Therefore, herein, we have focussed on compulsory education, for a ground-level evaluation of what is accessible to pupils and students, and for the presentation of the strategies that we have developed towards risk education (Musacchio et al. 2014).

While children represent the citizens of tomorrow, we also have to cope with the need for the reinforcement of awareness in the citizens of today. We have pursued this objective with audio-visual products addressed to the layman and to stakeholders, and strongly linked to the social, historical and cultural backgrounds of each of these three countries. These learning tools and audio-visual products for the education of children and the general public, respectively, are discussed in the present report, while the dissemination strategies are a matter for more extensive presentation and discussion (Musacchio et al. 2015).

2 The study areas

In regions prone to seismic hazard, such as Portugal, Iceland and Italy, earthquakes belong to both history and personal memory, as they implant their consequences into the roots of societal groups. On the other hand, the seismic history of each place has yielded different societal (and personal) answers to disaster prevention. As a result, each country has a different way to address the population and for the dissemination of information.

The seismic risk in Portugal derives partly from offshore sources that can cause large events, such as the catastrophic 1755 earthquake that caused damage over a very wide area, and especially in the city of Lisbon. This earthquake was the most destructive one that has ever occurred in Portugal, and the Portuguese people have heard about this event at least once in their lifetime.

Located on the Mid-Atlantic ridge, which is a slow-spreading ridge, the seismicity and volcanic activity in Iceland relate to the interactions between the plate-tectonic settings and a mantle hot spot. The inhabitants of Iceland are acquainted with the widespread geothermal energy that is particular of the area and has strongly influenced the settlements since their early development. Regardless of the residents' knowledge social, cultural and economic factors play a central role in how people perceive natural hazards and how they deal with the fact that their lives and livelihoods could be at risk (Jóhannesdóttir and Gísladóttir 2010). In general Icelanders have a good knowledge about the existing evacuation plan and had participated in evacuation exercises (Bernhardsdóttir et al. 2015). However, seismicity exposes the population to risk, which is mostly related to indoor vulnerability. Reinforced concrete and low-story buildings are typical constructions in Iceland, and these have proven to be resilient during the last earthquakes.

Campi Flegrei is a volcano in southern Italy, which lies northwest of the city of Naples. The structure is that of a large, 12 km × 15 km caldera, where more than 300,000 people live. Together with the present restive state of the volcano, the predominantly explosive nature of its eruptions put this highly populated region at the highest volcanic risk level worldwide. Since the 1950s, the Campi Flegrei volcano has been in a state of unrest, which is characterised by periods of uprise of the caldera floor (bradyseisms), and the related seismic swarms. The latest crisis occurred in 1983, when about 40,000 people were evacuated from the town of Pozzuoli. Over the last 10 years, there were several minor uplift phases and seismic swarms, and a general intensification of the fumarolic outflow; overall, these contribute to substantial concern for the possible reappraisal of the volcanic activity in the area. A paradox concerning hazard perception drives lay people to be more aware and concerned for the volcanic hazard related to Vesuvius Volcano (Carlino et al. 2008; Ricci et al. 2013) or the seismic hazard related to the general tectonic setting of the area, than that related to their living just inside one of the most dangerous calderas in the world.

Mt. Etna volcano is located along the eastern coast of Sicily, Italy, in a complex geodynamic region dominated by convergence between Africa and Europe (Branca et al. 2011). Apart from the regional high-magnitude seismicity, this zone is locally characterised by creeping and seismogenic faults which have been a topic of underestimated hazard in the Etna region (Azzaro et al. 2012). There are frequent earthquakes with low to moderate energy release, and with maximum local magnitudes, ML, of 5. Nevertheless, their effects can be very destructive, either due to the high occurrence rate or due to the shallow seismic foci (a few kilometres deep), which can produce effects that are comparable to those of high-magnitude seismicity, although in very restricted areas. Consequently, the seismic risk is high due to the damage to private buildings and public infrastructure.

3 Natural hazards and risk education at schools

3.1 Analysis of compulsory education

The general criteria for evaluation of compulsory school systems and comparisons among different countries embrace assessment of the importance of risk education in State plans, the resources devoted to risk education by each country, the efforts towards raising awareness at an early age, and the teaching approaches. State education plans are a mirror of what any society considers to be valuable for its growth. We took into account the age at

which the geosciences or natural hazard education started, whether the natural hazards belong to a specific subject, the availability as compulsory teaching matter, and at what age risk education started to be included in science classes.

Early age education is considered to be a great opportunity to trigger the non-cognitive side of awareness and to imprint mind behaviours that will be recalled in the case of danger. Nonetheless, education in the three countries analysed here does not appear to profit from this opportunity.

Conversely, an in-depth understanding of the subject is lost by not teaching it in the later years of compulsory education. The present study reveals that seismology-related topics are not mandatory and do not belong to any specific class. These are often part of a geography class, and except for Iceland, they become part of science education only at a later age, and only where the students have chosen a science curriculum. This has a high impact on the ground-level education, and means that the education system must work on children today so that future lay people will be better prepared to understand what is discussed in the news and the media, and will be able to discuss, take or support crucial decisions towards safety tomorrow.

The second step for the evaluation of State education plans was an analysis of the textbooks used (Table 1). Previous studies that have investigated how the geosciences are

Table 1 Text-book list used for the analysis on earthquake hazard education for compulsory schooling

Portugal	Iceland	Italy
Costa, F., Marques, A. (2007) História e Geografia de Portugal. 5° ano, Porto Editora. Lisboa, 192 p. ISBN 978-972-0-20451-6	Grímsson, H. (2001) Auðvitað. Eðlis-, efna- og jarðfræði. Bók 1, Námsgagnastofnun, Kópavogi. 64 p. ISBN 978-9979-0-1339-6	Airoldi R, Morgese R, Morotti G (2006) I favolosi Quattro-Sussidiario 3, Giunti Scuola, Firenze, Italy
Costa, F., Marques, A. (2011) História e Geografia de Portugal. 6° ano, Porto Editora. Lisboa, 192 p. ISBN 978-972-0-20409-7	Grímsson, H. (2001). Auðvitað. Eðlis-, efna- og jarðfræði. Bók 2 Námsgagnastofnun, Kópavogi. 64 p. ISBN 9979-0-0606-4	Bresich, G. (2007) IperLibro-Sapere e Fare, Sussidiario delle discipline 5, DeAgostini Scuola, Novara, Italy
Rocha, A.; Lago, C., Linhares, M. (2006) Estudo do Meio. Amiguinhos - 4° ano, Texto, Editores, Lda. Lisboa. 144 p. ISBN 972-47-2976-1-1	Grímsson, H. (2002) Auðvitað. Eðlis-, efna- og jarðfræði. Bók 3, Námsgagnastofnun, Kópavogi. 64 p. ISBN 9979-0-1005-3	Canali, T., Girotti, G., Magistrali, L. (2008) Il tempo dei saperi-Sussidiario delle discipline con un percorso di educazione ai valori 4, Minerva Scuola, Milano, Italy
Rodrigues, A., Coelho, J. (2009) Viagens. A Terra: estudos e representações. O meio natural. 7° ano - Geografia. Texto Editores, Lda. Lisboa. 144 p. ISBN 978-972-47-3004-2	Hróarson, B. (2007) Ísland – veröld til að njóta, Námsgagnastofnun, Kópavogi. 96 p. ISBN 978-9979-0-1344-0	De Marchi, R., Ferrara, F., Dottori, G. (2010) Geografia popoli e territori. Vol 1, Gruppo editoriale il capitello
Rodrigues, A.; Pereira, C.; Borges, I. and Azevedo, L. (2009) Estudo do Meio 4. 4° ano, Areal Editores. Porto. 144 p. ISBN 978-972-6277-856-6	Kristinsdóttir, Þ. (2010) Ísland – landið okkar.Námsgagnastofnun, Kópavogi. 32 p. ISBN 978-9979-0-1450-8	Manganaro, V. (2011) Big bang, Storia-Geografia-Informatica 2 e 4 Editrice La Scuola, Brescia, Italy
Vieira da Silva, C., Monteiro, M. L. (2010) Júnior. Estudo do Meio - 4° ano. Texto, Editores, Lda. Lisboa. 144 p. ISBN 978-972-47-2971-8-1	Náttúruhamfarir og mannlíf 1996, accessed 4 April 2012, http://islandia.is	Negrino, B., Rondano, D. (2011) Come uno Scienziato- Corso di scienze per la scuola secondaria di primo grado con espansioni multimediali e LIM, Vol. B, Gruppo Editoriale il Capitello, Torino, Italy

approached in schoolbooks have revealed that a major concern is the many mistakes that can lead to teacher misconceptions being passed on to their pupils (Oldershaw 2004; King 2010; Benton et al. 2012). In addition, analysis of high school textbooks has revealed a great lack of preparedness of school curricula worldwide (Komac et al. 2013). Here we addressed compulsory school textbooks tailored on ages and topics. In doing so, we took into account the age at which natural hazards are generally taught in the three countries and we selected only those topics we ponder fundamental for a ground-level education (Table 2). Textbooks used in the 4th–5th grade (8–10 years old students) of elementary schools and in 3rd grade middle (13 years old students) schools were evaluated in terms of: (1) the number of pages devoted to natural hazards; (2) the completeness of any information; and (3) the accuracy of the information, and whether it was up-to-date and correct. The evaluation of the contents of these school textbooks was not blind in terms of the completeness and accuracy of any information, ensuring the development of more in-depth conclusions. The results show that none of the books analysed had all of the topics addressed. Also, quality might be a serious problem in terms of the level of information given and how accurate it is. An opportunity to improve the education of natural hazards in the countries definitely lies in more informative textbooks.

School education needs to be more efficient regarding seismic and volcanic hazards. Above all, we found a compelling argument towards the lowering of the age at which hazard education should start, to raise interest in the subject, and to transfer knowledge on safety measures. Moving from this evidence, we have taken actions for earthquake hazard education, which encompasses various tools that should be attractive for children. Hands-on and learn-by-playing approaches are among the best choices to raise the interests of children.

3.2 Earthquakes at school

3.2.1 The science world and educational tools

Science can efficiently and actively intervene to raise interest and curiosity towards the basic concepts that define hazard and risk. Outreach initiatives are considered to be valuable to discuss difficult and highly emotional issues in a non-conventional way, which relies on learn-by-playing and hands-on approaches, to target activities to the specific audience, age and environment (e.g., classroom, outdoors, open house, science festivals). These initiatives, run in the three participating countries (Table 3), are more than drill exercises, as they provide an opportunity for close contact with the world of science and scientists. At the same time, science might provide fundamental contributions when

Table 2 Topics taken into account to evaluate the textbooks with respect to their completeness for earthquake hazard education for compulsory schooling

Tectonics related	Earthquake-related	Volcano-related
Plate tectonics theory	What is an earthquake?	What is a volcano?
Faults	Where does it occur?	Description
Earth interior and dynamics	Epi- and hypo-centre	Volcano types
	How to measure an earthquake	Eruption types
	Seismic zones	National volcanoes
	Historical earthquakes	
	Safety and prevention measures	

planning specific educational tools that will be used to communicate concepts for risk reduction. Strategies encompassing the direct involvement of students with the most up-to-date pedagogical approaches were also analysed.

The immersive environments and hands-on tools were used in Portugal, Iceland and Italy. In Portugal for younger children (5–10-year old) the Civil Protection of Lisbon Municipality promoted a space that is known as the "House of Tinoni", where each child learns to identify and respond to the risks involved in everyday life, as well as to exceptional events like earthquakes. In Iceland, the June 2008 earthquake hit the city of Hveragerði seriously, and the major damage was related to vulnerability inside buildings. As a consequence, Hveragerði currently hosts a permanent exhibition that includes a small 'house' that can be actuated by a shaking table, which allows powerful earthquake vibrations to be experienced in a domestic environment (Thorvaldsdóttir et al. 2012). In another immersive environment, a kitchen is showed after the shaking, to promote vivid memories of what might happen to one of the most vulnerable rooms in a house if extremely simple actions are not taken to reduce risk.

In Italy, hands-on tools and educational games carried out in the classroom or during open days as *ScienzAperta* (Open Science) for the public at research centres are used to raise the understanding of earthquake occurrence and consequences. In the promotion of seismic retrofitting, examples of shaking table experiments are widely used to develop the awareness of lay people (Anthoine et al. 2010). A shaking table is basically a platform that can be moved in order to simulate seismic ground motion. The wide variety of shaking tables available all over the world can be classified according to their degrees of freedom, maximum achievable stroke or acceleration, load and size. Realistic personal disaster scenarios related to actual seismic hazards are simulated, to help each resident to gain

Table 3 Actions and tools for natural hazard and risk education in the three European countries in 2013

Natural hazard and risk education	Portugal	Iceland	Italy
Analysis on compulsory educational system	Yes	Yes	Yes
Educational tools (*School students and general public*)	Immersive: The house of Tinoni Video-game: Treme–treme	Immersive: Hveragerði shaking house	Hands-on: Educational shaking table Role play behavior games
Venues	Research institutions guided visits Generic informal environments Classroom lectures	Research institutions guided visits Generic informal environments Classroom lectures	Research institutions guided visits Classroom lectures Research institutions open house (*ScienzAperta* 2013) Seismological Observatories open days Science festivals
In-depth education for graduate students		International Earthquake Engineering and Engineering Seismology graduate summer course	

awareness of their own risk level, and to understand the need and methodology to adopt protective measures (Tobita et al. 2009). These experiments have relied on both visual and audio emotion to imprint these memories. However, an immersive tool is not an easy task to achieve, as it requires stringent measures towards the safety of the user. We therefore built a prototype educational shaking table that has two degree of freedom (i.e. moving directions) to simulate the earthquake ground motion action as it strikes a toy brick building. A Plexiglas pan filled with saturated sand on a simpler educational shaking table was used to simulate soil liquefaction as part of a discovery path on natural disasters presented to the Seismological Observatory Pre-alpine (Italy) open day. As the shaking was applied a truck toy placed on the surface overturned and eventually sunk, a Ping-Pong ball hidden inside the sand popped up.

Role games focussed on the do's and don'ts during an earthquake, or on what to take along in case of evacuation, can capture the attention of children and adults, and stimulate them to process thoughts on the need for preparedness to prevent disruption by earthquakes. These role games are used to address a wider audience with the use of an extremely attractive tool for the younger generation: a video game (see below).

To comply with the need for in-depth education at late age towards earthquake hazards, we promoted a new international Earthquake Engineering and Engineering Seismology graduate summer course that was held in Iceland on 21 June 2013 (Table 3). The course dealt with the nature and characteristics of strong earthquakes and their intense ground motions. Earthquake source processes, seismic wave propagation, wave amplification due to local site effects, and structural responses due to seismic waves were key elements of the course. The goal was to provide the participants with knowledge and understanding of the multi-disciplinary nature of earthquakes and their effects on the man-made environment.

3.2.2 Treme–Treme educational game

The synergy between scientific research into earthquake risk reduction and the experiences of people who felt an earthquake is an opportunity to create artefacts for knowledge acquisition. We designed a serious game (or an 'applied' game) that uses entertainment to motivate, educate, train and communicate earthquake risk to the players/pupils. The game is currently available in the Portuguese, English and Italian languages. The scarcity of pedagogical tools for earthquake risk education in Portuguese provided strong motivation for research in this field and the start of the development of this educational game. Annetta et al. (2010) acknowledged that the design of a computer game offers players a way to build their knowledge and to develop new skills through its progression.

"Treme–Treme" (Shaking–Shaking) is a video game that was developed to bridge the gap between researchers, teachers and students, to teach the basics of earthquake preparedness to elementary school students and families. The game will be available on a website that allows the students to play it from their browsers, with the advantage that this does not require the game to be installed on each computer. We have also created a Facebook page to disseminate the educational game (https://www.facebook.com/pages/Treme-Treme/731295750254697?ref=bookmarks), as well as to provide information related to the topic of earthquake risk and preparedness.

The game was developed according to two levels. For the first level, the learner has to build an emergency kit. This starts with a non-scrolling top view of a table with an empty emergency kit and a group of objects, and the player has to pick the correct items for the emergency kit (Fig. 1). The second level teaches the children how to behave before, during and after an earthquake. This level is a side-scrolling world, where the learner faces an

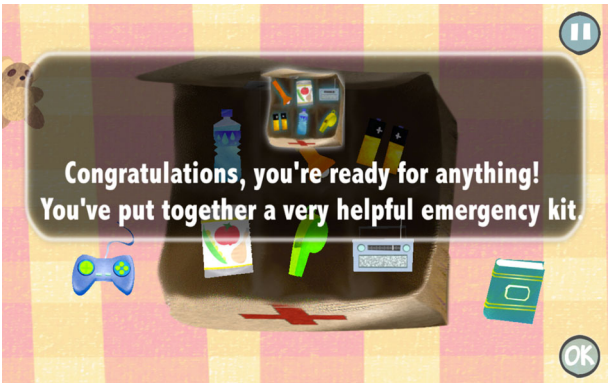

Fig. 1 Level 1: Teaches the children how to build the perfect emergency kit

Fig. 2 Level 2: The learner becomes the centre of attention, and acquires knowledge through a variety of different modalities (e.g., text, pictures, sounds). These enable the player to identify and analyse problems, and to apply past learning

earthquake indoors. To protect themselves from the outcome the damage the earthquake might cause, the players have to find a safe place where they can survive. During the event, the player has to stay calm and wait for the shaking to stop. After the event, the player faces another challenge: a gas leak and dangerous electric wires. These systems have to be turned off to be able to leave the house before any aftershocks strike, with the need to move to the family meeting point in the neighbourhood. Figure 2 shows some screen-shots of the pages that were designed to help users to learn the good practices and procedures that need to be adopted before, during and after an earthquake.

To assess the performance of Treme–Treme, two groups of students from different schools tested it, and commented on its use. This evaluation consisted of a session that involved the playing of the game and then the completion of a final questionnaire that was aimed at being a qualitative assessment of the system. The first test was carried out with a class of third grade students (8–9 years old) with disciplinary and learning problems (14 pupils), as they could not read very well or understand some basic questions. Even so, we were able to gather valuable information from this first test to improve the overall learning experience of the player (Barreto et al. 2014). The second test was carried out with 80 students in the third and fourth grades (8–10 years old). Their answers to the questionnaire confirmed that the goals of this project were achieved (Fig. 3); namely, the development of an interactive system with a user-

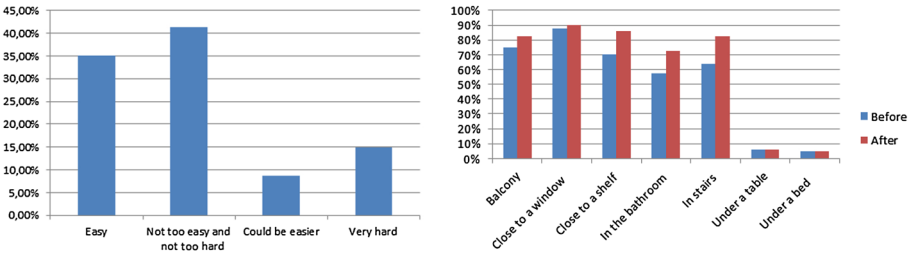

Fig. 3 Evaluating Treme–Treme with the use of specific questionnaires handed out to children (Barreto et al. 2014). Answers to the questions "how did you find the game?" (*left*) "which places participants think are dangerous before and after playing the game" (*right*)

friendly interface that holds the player's attention and curiosity, and that can contribute to the improvement of the player's earthquake risk awareness. In some cases the choice of safe behaviours in case of earthquake resulted in 20 % of improvement after playing the game (Fig. 3).

4 Education and information for the general public

4.1 Types of media used

Lay people include the larger part of the population and represent those who have the potential to urge decision makers and politicians to do their best for risk reduction. It is fundamental to address the general public in a correct and suitable way, to avoid disbelief, attitudes of fatalism and modulate awareness concerning natural hazards even when these do not seem to be a priority among perceived threats.

Audio-visual products and public meetings were used to inform and educate communities on the culture of risk. Videos were designed and made to take into account the link between the inhabitants and their territory, to emphasise such aspects as memory, history, experience and feelings of local communities, while suggesting the need to rely on the reduction of vulnerability.

To promote direct contact between the general public and open houses of scientific institutions, *ScienzAperta* 2013 was devoted to urban disaster prevention strategies (see Sect. 4.4). *ScienzAperta* is meant to be the "spring of science" for the general public. This is a several-week-long period in which pupils, students and families have free access to exhibitions and activities that are designed to raise their awareness of what the Earth Sciences are about. Museums and national and regional parks in areas with high seismic and volcanic risks promoted similar activities for risk education.

4.2 Unstructured interviews

Social research data-collection techniques were chosen to adjust unstructured interviews to the specific aims of video interviewing. In unstructured interviews (Bryman 2001), the main list of topics or issues, which is often called the interview guide, is prepared in advance, but most of the questions are formulated in an informal way during the course of the interview. The phrasing and sequencing of the questions will vary from interview to interview. This type

of interview is usually used for exploratory studies and they do not allow for quantitative data treatment, because of the absence of standardisation of the questions and the respondents' replies. They are usually adopted to explore new areas of research or at the very beginning of a research process, as the first contact with the field of research.

For the conceptual aims of the video, it was important to capture the visions of the lay people and the experts of the problem in a spontaneous way, although around a list of previously selected topics. This implied the construction of an interview guide that was all carried out as street interview, which is presented below.

Specific public places in the city where chosen, and passers-by were invited by the field team to act in the video, with the asking and answering of some questions about earthquake issues. The interviews with lay people related to risk perception, and their knowledge of protective behaviours relied on direct experience of an earthquake. People were asked if they thought that a damaging earthquake might occur where they live, and to express their ideas on the potential that an earthquake has to damage their city, whether the public buildings, like schools, would resist the shaking, and if their own house would be able to resist. A second set of questions concerned the public knowledge of protective behaviours, such as the do's and don'ts during an earthquake, the actions that each individual person can take to prevent earthquake consequences, and the trust that must be put in engineers to improve building safety. Lay people were also asked what question they would most want to ask to an expert if they had the opportunity; the most popular questions were "When will the next earthquake strike?" and "Will my house resist an earthquake?".

The interviews with the experts took into account the ideas that these scientists have on issues that mostly attract lay people and that might be the cause of risk misperception. These included the belief in earthquake prediction, the energy release, and the potential that societies have to reduce the impact of earthquakes. The experts were also asked to suggest advice that can be given to citizens when buying or renting a house, and whether they had actually taken any precautions themselves when they bought their own house. Lastly, the experts were asked to discuss the behaviours that should be adopted during earthquakes.

4.3 Audio-visual products

4.3.1 Guidelines for the audio-visual products

Cognitive aspects of awareness rely on both the correct description of the causative mechanisms of disasters, and their understanding. Tools of scientific dissemination should trigger cognitive aspects, involve emotional intelligence, and keep vivid the memory of past disasters. As audio-visual products can be very effective in raising awareness for the reduction of seismic hazard, it is of paramount importance that they take into account these three dissemination elements. The key message to convey is that every single person can make a contribution to risk mitigation, whatever adequate prevention actions they take, as even actions that appear not to be relevant in their homes can turn out to be fundamental to enhance the safety of the community.The UPStrat-MAFA project has produced five videos with durations from 10 to 29 min, which are targeted at wide audiences, to provide educational material for both schools and the public (Fig. 4). All of these videos are freely available, and can be downloaded from the project website (http://upstrat-mafa.ov.ingv.it/UPStrat/). The four videos were shot in Portugal, Iceland and Italy, to illustrate how seismic hazard is perceived in each of these countries. The interviews have collected different viewpoints, from non-professional to experts. The lay people express their worries and emotions, and confess their fear of earthquakes. The experts describe the

Fig. 4 **a** Screenshots from "Before it's too late". *Left to right* Street interview; a view of Lisbon; the partially ruined Convento do Carmo, once Lisbon's largest convent, but severely damaged by the 1755 earthquake. **b** Screenshots from "Hveragerði… in compliance with nature". *Left to right* Damage during the 2008 earthquake; *black* and *white clips* showing the settlements surrounded by geothermal fields; a child describes his experience of the 2008 earthquake. **c**. Screenshots from "Campi Flegrei". *Left to right* Skyline over the city of Naples; the headquarters of the earthquake monitoring system; tourists at the Solfatara muds. **d** Screnshots from "Mount Etna". *Left to right* Damage related to shallow and low magnitude seismicity; steep slope landscape related to the Timpe fault system; damage related to aseismic creep

progress of scientific research in seismic engineering, explain the basics of the earthquake phenomena in language that the ordinary citizen can understand, and refer to protection measures that people can actually implement.

This represents a way in which science can become a part of the lay person's life, to provide a part of the solution towards the mitigation of the risk.

4.3.2 Voices of earthquake preparedness

"Voices of earthquake preparedness" is a 29-min-long video that outlines the preparedness and security measures in the cases of earthquakes in Portugal, Iceland and Italy. The experts were asked to describe what an earthquake is, not just based on the science behind it, but relying on a truly emotional approach. "I was about 8 or 9 years old when something occurred… I was asleep because I was supposed to go to school the next day. Suddenly a big, tremendous rumbling sound came up all around, and I looked up and I could see the sky, the stars were there… the walls had cracked opened and I could see the sky from the

bed in which I was lying. That was the most terrifying experience I had had, and it is a very serious business. You cannot take an earthquake lightly; it is no joke. It could have killed us." (P. Gülkan). This is the description of a scientist who had experienced a disruptive earthquake as a young child. The emphasis is on the basis that what happened to people as young children might have a greater chance to be imprinted in the mind. The description is about the effects seen through the eyes of a child, while the conclusion is a warning from the voice of an adult. Although the person who talks is a scientist, and an expert in the field, there is nothing that reminds people more about the science behind the urge for preparedness for an earthquake. The video includes the opinions of experts, such as seismologists, engineers, and disaster managers, as voices that express thoughts that rely on memory, fact, and emotion, without the need for lecturing the viewer.

4.3.3 Before it's too late

Portugal "Before it's too late" is a 16-min-long video that focuses on the importance that earthquake preparedness should have in our life. Often it is not easy for the general public to obtain correct information on natural hazards and risk mitigation actions, and so people do not know what to do in the case of an earthquake or other natural event. This film explores the idea that all of us might have an important role, as individuals or as real-estate owners, and how together, the public and the scientific community can influence and push political measures to mitigate the risk.

The first few minutes portray the memories and experiences of lay people, and the cultural views related to seismic risk. The experts address the issue of how to be prepared and how to act during such an emergency, and they share their knowledge of the seismic risk and emergency planning with the viewer. The video ends by addressing the importance of earthquakes in the life of lay people. The images show some Lisbon sites that were affected by the 1755 earthquake (Fig. 4a) that have been imprinted in the collective memory of the Portuguese, where the ruins of the buildings demonstrate the high vulnerability. "Before it's too late" was also presented at film festivals, such as the "2013 European Science TV and New Media Festival" and "*DocLisboa* 2013".

4.3.4 Hveragerði … in compliance with nature: Iceland

"Hveragerði… in compliance with nature" is a 14-min-long educational video in Icelandic that focusses on Hveragerði, which is a small town 45 km from Reykjavik, located south of the Hengill Central Volcano (Fig. 4b). Local geothermal phenomena affect the town, which has also been shaken by volcanic earthquakes due to the nearby Hengill Central Volcano (a seismically prone site) and the South Iceland Seismic Zone. The film explains how the inhabitants in this seismically active place have learnt how to live with earthquakes and their effects. A brief and clear summary on the geodynamic settings of Iceland is followed by video-clips related to the 2008 earthquake that hit the town of Hveragerði strongly, with emphasis on the lack of indoor preparedness of buildings. The inhabitants have got used to both the hot springs and the small geothermal quakes that remind them constantly that they are living in an earthquake-prone area. Over time, this area has been a good choice for settlers, who have built their houses next to the springs, using geothermal energy to cook, wash and heat their houses. Industry has profited from the geothermal energy from the beginning. The use of black and white news clips reflects how the earthquake threat has been continuous from past to present times, and should be expected to prevail into the foreseeable future. This requires the inhabitants, as grown-ups as well as

children, to participate in risk reduction measures to decrease the indoor vulnerability of the buildings.

The Mayor of the city of Hveragerði and the Police Commissioner are involved in the film, and they express their participatory attitude towards safety, pointing out the need for preparedness of all of the components of the rescue system. The monitoring system of the area is introduced by the local news and described by scientists. Details on the crucial vulnerability points of buildings with respect to ground motion are presented by scientists, as well as the lessons learnt during the last two major quakes that hit south Iceland. Outstanding research on risk assessment is explained with reference to the Disruption Index (Ferreira et al. 2014), which takes into account the failure of the infrastructure elements that can be caused by a major earthquake, which will strongly affect the daily operations of any society. Finally, having an earthquake monitoring and research centre inside a high-risk area gives lay people the opportunity to directly interact with the scientists. Such communication is expected to strengthen both risk awareness and the sense of security within the community.

4.3.5 Campi Flegrei: Italy

"Campi Flegrei" is a 10-min-long video that gives information on the cutting-edge monitoring system of the caldera as well as its inhabitants. Until about 10 years ago, people living in the caldera would ask for information on Vesuvius Volcano (Fig. 4c). Indeed, they had to experience the bradyseisms to raise their awareness of the hazard they were next to. History shows how the inhabitants have related to the volcano: for example the Solfatara muds were known because of their potential positive effects towards the healing of skin diseases. The video also describes how the beauty of the landscape, the hot-springs, and the richness of soil overwhelm the awareness of past earthquakes and the climactic eruptions they heralded.

4.3.6 Mount Etna: Italy

"Mount Etna" is a 13-min-long video, for which the shooting took place in the town of Catania and in a few municipalities in its surroundings, which are located along the southeastern flank of the volcano (Fig. 4d). The monitoring system of the area is described to enhance the trust that the lay people should have in the scientific experts. Video sequences of the main consequences of living nearby Etna volcano are shown. The urge to raise awareness of the hazard related to small, yet shallow, earthquakes is pointed out by the scientists, who describe the damage related to the well-known Timpe fault-system. Images of the steep-slope landscape and damaged buildings are shown. The high social cost of this kind of hazard depends on the continuous need for reconstruction due to the short-recurrence time of the damage. As shallow seismicity usually results in high damage in restricted areas, the lay people might completely underestimate the potential of knock-on effects on the surroundings, which might thus suffer increased, and unexpected, yet unattended vulnerability because of recurrent shaking. This is explained in the video.

4.4 Public outreach venues: *ScienzAperta* (open science)

Earthquakes are topics that are often dealt by the media, because of their tragic effects. Their high cost is dramatically evident, in terms of loss of human lives, damage, and the

Fig. 5 Images of school groups participating at *ScienzAperta* at the Catania INGV *Osservatorio Etneo* in 2013, where the achievements of the UPStrat-MAFA project were presented

process of recovery. With a growing population in urbanised regions, disastrous earthquakes result in pressing requests to seismologists and engineers worldwide about the strategies that can be adopted to mitigate the risk associated with similar catastrophes. Scientific dissemination tools are therefore devoted to increase awareness of seismic hazard, and the improvement of building resilience. In doing so, open-door initiatives that can be used to explain earthquakes and their effects through seminars and hands-on activities are very effective.

ScienzAperta is a yearly outreach event that has been organised by the *Istituto Nazionale di Geofisica e Vulcanologia* (INGV; National Institute for Geophysics and Volcanology) in Italy since 2011. This event aims to promote awareness of seismic and volcanic hazards, and to bridge the gap between the scientific community and society. The INGV *Osservatorio Etneo* (Etna Observatory) has contributed with enthusiasm and competence to this open-door initiative, to support and consolidate a face-to-face link between the public and the INGV staff. Tours of the institute (located in downtown Catania) have included guided walks with posters, exhibits, and multimedia presentations to pupils, students, and the public. In addition, all of the visitors have seen the 'operation room', which monitors Sicily (southern Italy) with multidisciplinary sensors. With about 1100 visitors in 5 days, the 2013 edition of *ScienzAperta* put particular emphasis on the progress in the monitoring and research of earthquakes and volcanoes. The programme of the event encompassed seven seminars, one of which dealt with the activities of the UPStrat-MAFA project (Fig. 5). This seminar described examples of seismic prevention in urban areas of Portugal, Iceland, Italy and Spain (Zonno and The UPStrat-MAFA Working Group 2013). Throughout the outreach event, various educational items were distributed, along with leaflets about the project.

5 Conclusions

Disaster prevention strategies represent a bottom-up approach that must encompass both child and adult education. People often have the idea that natural hazards will strike others, and not them. In part, this is connected with education itself: textbooks often present 'horrible' cases from far away, compared to which any local disaster might appear trivial. Consequently, there is a lack of risk perception in people's lives, in the community, in the State development planning, in the educational curriculum, and in the media priorities.

The compulsory school curricula of three European countries, namely Portugal, Iceland and Italy, where seismic hazard is a part of daily life were analysed: for Portugal, Iceland and Italy. The results show that the State education plans are not prepared in terms of seismic hazard education, in line with worldwide studies relating to natural disaster education (Komac et al. 2013). The most crucial issues are that education of earthquake hazards does not start at an early age, and that there is no appropriate in-depth approach at later ages.

Nevertheless, education is of paramount importance for earthquake disaster prevention, and we believe that a bottom-up strategy can be effective to achieve this goal. In this paper, we describe how education to seismic hazard can find support from scientific dissemination based on tools and initiatives targeted to a broad audience. To comply with the need to take action towards training and education at an early age, we describe a prototype of a hands-on tool and a learn-by-playing approach in an informal environment. A video-game has also been produced, on the basis that serious games have the potential to become significant tools for achieving the educational purposes of earthquake risk reduction and prevention. Finally, the audio-visual products were found to represent the best way, at the lowest cost, to promote the risk awareness and education of the general public. Five videos were produced that address the different topics, regions and cultures, with the motivation and ideas behind each product described in detail.

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