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A protocol to communicate seismic risk in schools: design, test and assessment in Italy

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Abstract

The best chance to achieve a future disaster-resilient society is through risk education in School: it has a great potential to strengthen capacity of communities to mitigate risks. The KnowRISK (Know your city, Reduce seISmic risK through non-structural elements) project took this opportunity and implemented a risk communication campaign for schools in Portugal, Italy, and Iceland. The idea was that suitably changes in people's knowledge and attitude can trigger best practices. Crucial to reach such target is the raise of awareness on meaningful issues. The main challenge of the campaign was how to effectively address the mitigation of the vulnerability to earthquakes of non-structural elements, which is an issue considered to be of low priority even in the building regulations of many countries around the world.
The campaign stood on a communication strategy that was systematized within a protocol, for 13-15 years old students, that specifies goals, contents, learning strategy, support material, and relies on face-to-face intervention of scientists in the classroom. This protocol had training sessions bounded by assessment sessions, ex-ante and ex-post, that allowed to validate its efficacy. The training made large use of flipped learning and Episode of Situated Learning (EAS) strategy to raise student's motivation and increase achievements. To ensure its replicability, the protocol was tested in zones matching a wide range of seismic hazard in Italy. The assessment showed the protocol be effective and ready for a wide dissemination.

Keywords: Seismic risk communication; Non-structural elements; Schools; Seismic risk prevention.

1. Introduction

Nowadays, the achievement of disaster-resilient societies is an imperative issue that cannot be addressed by simply increasing scientific knowledge and technological provisions. Rather, it is necessary to efficiently transfer strategic knowledge to citizens, raise awareness, change the way risk are perceived and stimulate a preventive attitude. To this aim, the Sendai Framework for Disaster Risk Reduction 2015-2030 (*https://www.undrr.org/publication/sendai-framework-disaster-risk-reduction-2015-2030*), adopted at the Third UN World Conference held in 2015 in, Sendai, Japan, provides guiding principles for the Nations to implement action oriented to disaster risk reduction, as outcome of stakeholder's consultations and inter-governmental negotiations.

Low risk awareness is among the main causes of an insufficient level of prevention and preparedness, and of an inadequate response to disasters [Grothmann and Reusswig, 2006; Miceli et al., 2008; Terpstra et al., 2009; Maidl and Buchecker, 2015]. It often couples with the willingness to adopt precautionary measures [Neuwirth et al., 2000; Floyd et al., 2000; Scolobig et al., 2012]. The link between low-risk awareness and low preparedness has also been highlighted recently by Baldecchi et al. [2019]. By bridging the gap between science and society, risk communication can raise awareness on meaningful issues, change perception, mitigate fatalist attitudes and has the potential to reduce the impact of the so-called natural disasters, which indeed have natural triggering causes, but are socially constructed events [Castro et al., 2017].

A fundamental prerequisite to prevention and preparedness the raise of awareness on meaningful issues. The proper understanding of the difference between *hazard* and *risk* relates to such prerequisite. The improper and often interchangeable usage of the two words in the daily practice of most common languages significantly contributes to a misplaced approach to damage mitigation. People might be turning act against the hazard and miss the opportunity to reduce vulnerability. In turn, the fight against hazard might look overwhelming and led to fatalist attitudes that discourage communities towards preventative actions [McClure et al., 2001; McClure et al., 2015]. Turner et al. [1986] found that California residents who endorsed the attitude that "There is nothing I can do about earthquakes, so I don't try and prepare for that kind of emergency" were in fact less likely to be prepared to earthquakes than other citizens. Similar relationships have been shown for climate change, in that people who felt they were powerless to affect climate change were less likely to take actions towards risk mitigation [Aitken et al., 2011; Lee et al., 2015]. In recent years, starting from M. Douglas' Cultural Theory [Douglas and Wildavsky, 1982], social attitudes to fatalism have been connected to religions [Gaillard and Texier, 2010]. However, it should be noted that further risk cultures should be considered in addition to the fatalistic approach. In these regards, Dressel [2015] proposed a general framework, in which three different ideal-typical risk cultures can be individuated: individual-oriented, state-oriented, and fatalistic.

The KnowRISK (Know your city, Reduce seISmic risK through non-structural elements) project had the task to facilitate the access of local communities to knowledge that helps citizens cope with seismic hazard. KnowRISK conducted a risk communication campaign in pilot areas located in Portugal, Italy, and Iceland on the mitigation of seismic damage to the non-load bearing components of building, commonly referred as Non-Structural Elements (NSE). Damage to NSE is among the most diffuse and a yet wide underestimated effect of earthquakes. It occurs even in case of moderate-to-small magnitude events – more frequent that those strong – because measures to reduce NSE vulnerability are often not included in most countries' regulations. It is spread over a large area occurring even far away from the earthquake epicentre. It is also the ground for a challenging paradox in which the relatively low cost/benefit ratio required for mitigation is at odds with the low attention towards the associated vulnerability.

This paper describes the design, implementation, and evaluation of a protocol of intervention in schools (*The Protocol* from now on) within the framework of a communication campaign – "*Know your school: be safe!"*- addressing such paradox. It reports a lesson learned and provides insights to future applications of such protocol countrywide. Schools in Italy for which *The Protocol* was designed are at lower secondary level (here referred as middle school and corresponding to ISCED level 2). *The Protocol* includes a training session and an evaluation session. The latter was accomplished by means of a specifically designed questionnaire that can be used for quantitative assessment of given parameters, within a risk communication campaigns in other European countries [Crescimbene et al., 2019; Platt et al., 2019].

2. Background framework: challenges for the campaign

Italy is one of the countries at highest seismic hazard in the Mediterranean area, for the number and the magnitude of earthquakes that have affected its territory over time. Seismicity results from its peculiar location at the boundary between the African and Eurasian tectonic plates, where ongoing convergence occurs. In 2.500 years, Italy was affected by more than 30.000 earthquakes with medium to high macroseismic intensity (I>IV-V Mercalli-Cancani-Sieberg) and by about 350 seismic events with I>=VIII [Boschi et al., 1995]. In the twentieth century, Italy experienced

8 earthquakes with Mw 6.4 and macroseismic intensity up to X (Figure 1). At least 6 destructive (M_W=5.9, 2002, Molise; M_W=6.3, 2009, L'Aquila; M_W=5.8 and 6.1, 2012, Emilia; M_W=6.2, 2016, Amatrice, M_W=6.6, 2016 Norcia) earthquakes occurred in Italy in the last 20 years. The shaking for some of them was felt even in areas where seismic hazard is mapped as low. They had a large media coverage and triggered public debates [Musacchio and Piangiamore, 2016].

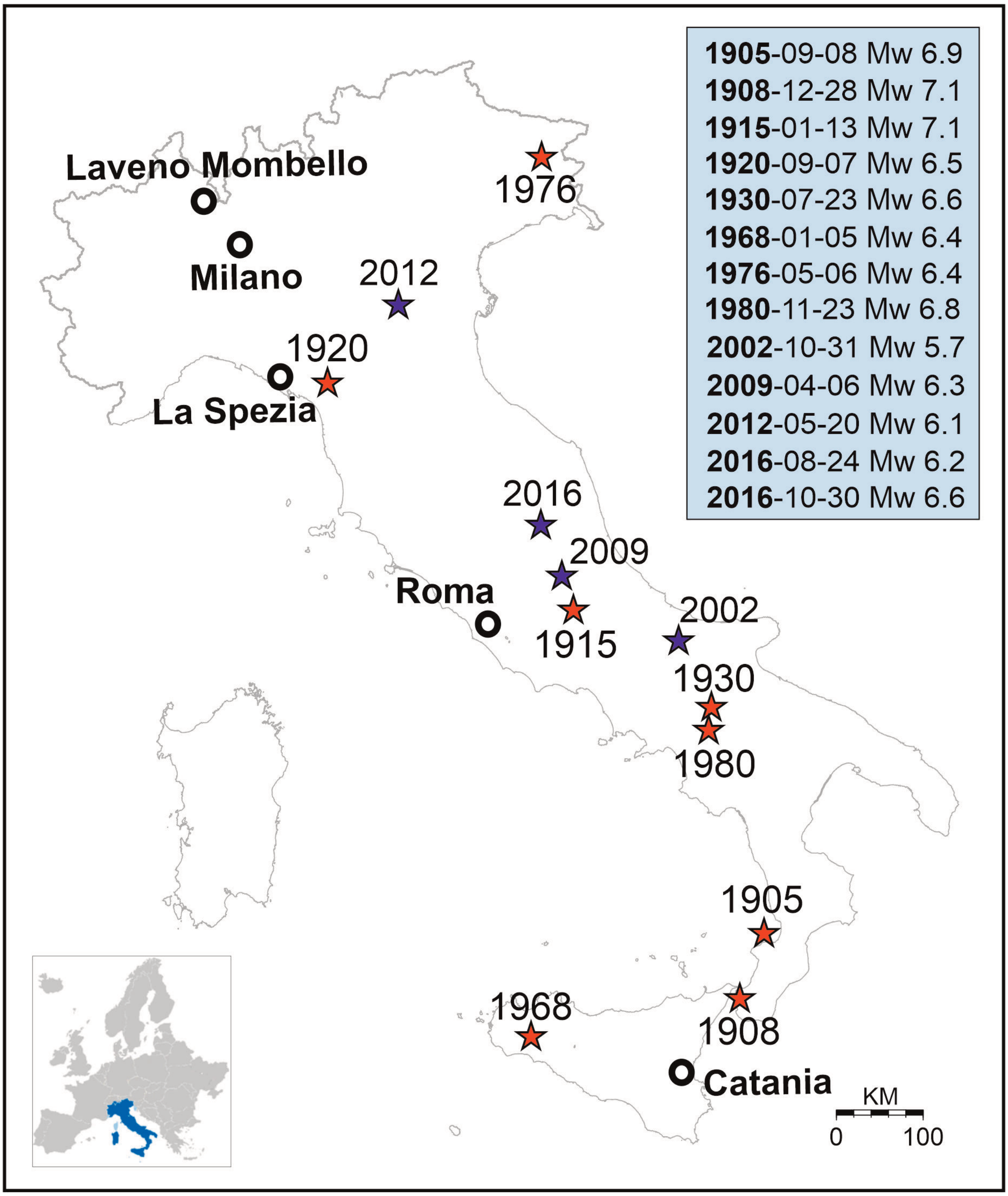

Figure 1. Major seismic sequences occurred in Italy since 1900. The Legend lists the earthquake with the highest magnitude for each sequence. Red: maximum magnitude M≥6.5 sequences occurring in the XX century [CPTI15; Locati et al., 2015]. Blue: maximum magnitude M≥5.5 damaging sequences occurring in the last 20 years [http://bollettinosismico.rm.ingv.it/; Margheriti et al., 2017; Rossi et al., 2017].

Despite the frequent occurrence of destructive earthquakes, most of the Italian citizens do not have a correct perception of the seismic hazard. A survey on a national statistical sample of more than 4,000 people, carried out in 2015 by a group of researchers of INGV (Istituto Nazionale di Geofisica e Vulcanologia) in collaboration with the CNR-IRPPS (Consiglio Nazionale delle Ricerche-Istituto di Ricerche sulla Popolazione e le Politiche Sociali) and the OGS (Istituto di Oceanografia e Geofisica Sperimentale) of Trieste, allowed to assess the hazard perceived across Italy [Crescimbene et al., 2015]. It was found that the perceived hazard highly underestimates the so called "hazard by law" [Crescimbene et al., 2015] that is shown in the Italian hazard map, which the Italian Building Code refers to, and for which buildings are required be compliant. Among people living in areas where the "hazard by law" ranges from high to very-high (Figure 2), only 6% have a proper perception of the hazard they are exposed to. Considering a 1-to-7 Likert scale, Crescimbene et al. [2015] assumed that a perception score of 5.5 fairly represents the "hazard by law" in these zones and showed that the perceived hazard underestimates the "hazard by law" everywhere across the country: perceived hazard scores 3.20 in the North, 3.39 in the Centre and 3.70 in the South of Italy [Crescimbene et al., 2014; Crescimbene et al., 2015].

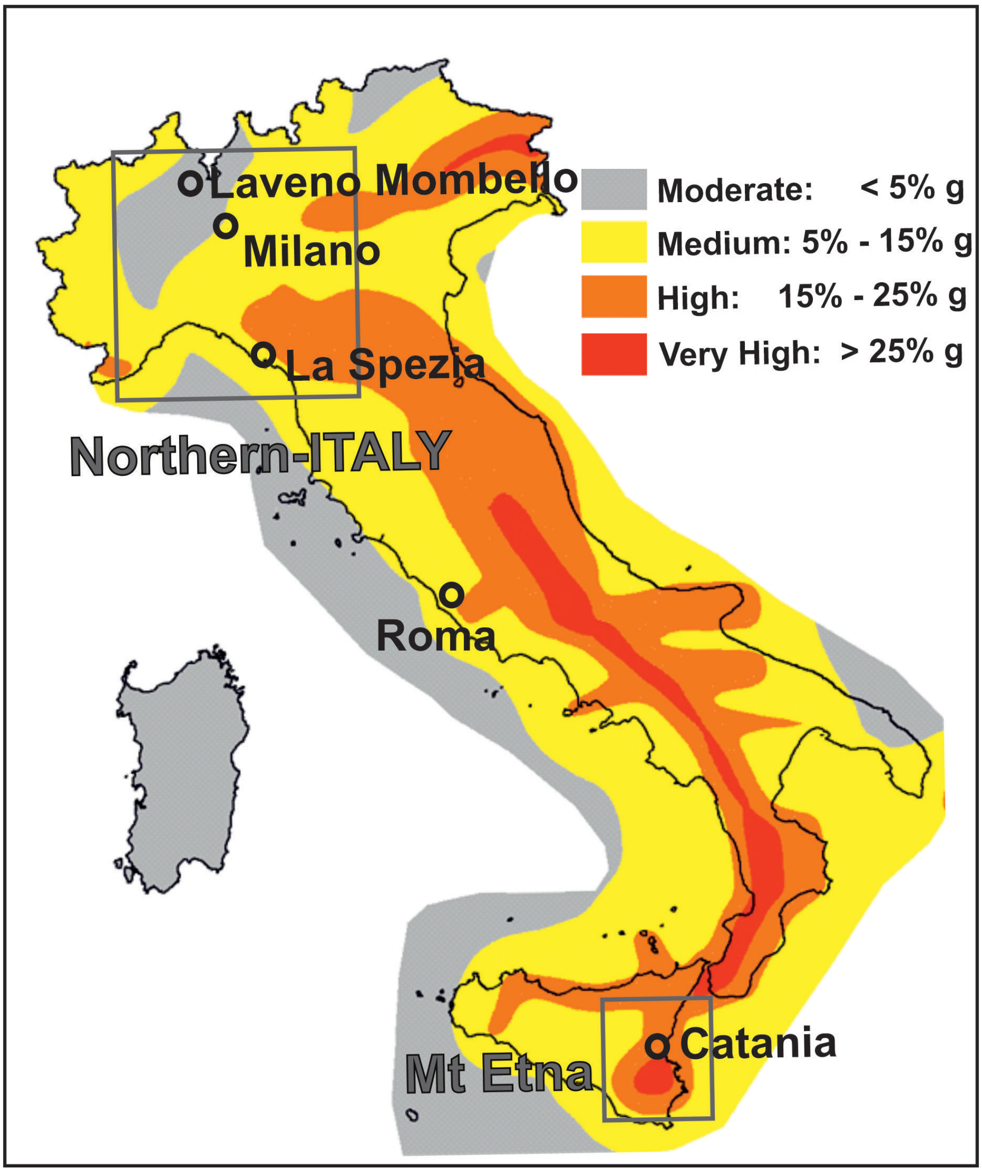

Figure 2. Seismic hazard map of Italy [MPS04, Stucchi et al., 2004]. Peak Ground Acceleration values, expressed as a percentage of g (gravity acceleration), were grouped, colour coded and plotted to be specifically used for science communication purposes. Laveno Mombello, La Spezia and Catania are the cities within the KnowRISK project's pilot areas where the campaign in schools was undertaken. They brace three different level of seismic hazard.

Beside hazard misperception, the public debate concerning risk reduction is set mostly over structural vulnerability and efforts are put essentially to building-code compliance and upgrading to safety level. Non-structural damage mitigation has to face three major challenges that add on to the hazard misperception: the widespread lack of a proper knowledge, the fatalist attitude and the underestimation.

Only after the Emilia seismic sequence in 2012, the need to reduce vulnerability of non-structural elements of buildings began to be more pressing so much so that Building Code published in 2018 finally included compliance requirements for some of the main non-structural elements.

Heavy damaging earthquakes force buildings' reconstruction and should prompt reduction of global vulnerability [Valensise et al., 2017]. However, they have hidden, yet remarkable drawbacks: they might represent an obstacle to prevention by reinforcing fatalist attitudes that drive community to abandon land (De Lucia et al, 2020); they might support an underestimation of minor damage – such that occurring to NSE – which, compared to deaths and collapses, seems to have a much lower relevance. In some sense the fear towards heavy structural failure is an obstacle to the prevention of non-structural damage [Musacchio et al., 2019b].

Where NSE are known they are either underestimated or addressed as a low relevance issue. To face this, the KnowRISK campaign deliberately choose to implement a strategy including areas of middle-to-low seismic hazard. Pilot areas were therefore the towns of Laveno Mombello (moderate seismic hazard) and the city of La Spezia (middle seismic hazard), in Northern Italy, and Mt Etna area with the city of Catania (high-seismic hazard) in Southern Italy (Figure 2).

3. School system: gaps and opportunities

State education plans are a mirror of what any society considers to be valuable for its growth. This is specifically relevant for compulsory education. Recent studies reveal that there are a very few State-backed plans addressing in an efficient way earthquakes-related topic, even in countries at high seismic risk [Musacchio et al., 2015a]. This fact is even more relevant if we consider that preservation of the memory of a hazard, a major issue in support of risk mitigation, can be achieved through provision of information that is enhanced by school education [Wisner, 2006; Biernacki et al., 2008; Komac, 2009; Komac et al., 2013]. The societal underestimation of the seismic hazard is one of the reasons why in the Italian school education system earthquakes have not been subject of any specific class or syllabus, teachers do not have high-level and up-to-date training in geosciences, and textbooks do not provide the needed support neither to teaching nor to learning. The subject of "Citizenship Education" added to school programs in 2020, addresses the issue of risk education. This is just a first step that likely reflects an upcoming general interest towards risks mitigation.

School represents a great opportunity to provide proper knowledge, attitude, and practice towards earthquake damage prevention to the future society. In Italy, such opportunity is emphasized by the fact that school system, acknowledge the fruitful interaction with the world of science by hosting special projects integrating in a few hours teachers' and textbooks' gaps [Musacchio et al., 2014a; Piangiamore at al., 2015]. These projects normally have a length that should not be too intrusive of the school planning. They may include experts in the classroom or have the class group hosted by, for instance, a science centre [Musacchio et al., 2015b]; they rely on hands-on activities that should normally have a high capability to be reproduced by the students themselves [Musacchio and Pino, 2014].

However, since the weight of NSE in risk mitigation is highly underestimated a challenge that the campaign in school "*Know your school: be safe*!" had to face was indeed topic's intrusiveness in official syllabus. This was the reason for which we implemented protocols of intervention that could be incorporated in the regular curricula. Such protocols enable to approach schools by strengthening existing knowledge, using teaching strategy as communication asset, providing cross disciplinary suggestions, and presenting the intervention as a resource for the thesis due for the exam at the end of the year. We also supported the school with specific tools and face-to-face intervention of experts and provided a learning methodology that could be attractive by the school community. The schools were selected among those located in specific test sites, namely in Northern Italy and in Mt Etna pilot areas, and with networking contacts established by past experiences.

4. Method

The campaign "*Know your school: be safe*" relied on protocols of intervention specifically designed according to needs of schools in the three countries. These protocols had conceptual frameworks, learning approaches, and contents chosen strategic in raising students' awareness and eventually changing their attitude and knowledge towards preventative actions to mitigate earthquakes' damage. They all included scientist's interaction with the students and the assessment of effectiveness of the communication by mean of a specifically designed questionnaire. In this paper we discuss *The Protocol* that was implemented for Italian schools.

4.1 Conceptual framework: the KAP concept

The KnowRISK communication campaign stood on the idea that by suitably changing people's *Knowledge* and *Attitude* it is possible to trigger best *Practices*. This concept is summarized by the KAP [NSET, 2017], where *Knowledge* refers to the understanding of earthquakes and the associated risks; *Attitude* is related to feelings and preconceived ideas towards hazard and risk; *Practice* is the ways in which communities demonstrate their knowledge and attitudes through the actions they undertake. The quantitative assessment of effectiveness of the campaign were based on the KAP trilogy.

4.2 Strategic contents

A proper understanding of the meaning of *hazard* and *risk* that was deemed strategic to raise awareness on meaningful issues. Therefore, before the starting of the risk communication campaign, we assessed what the students knew or thought about hazard and risk to eventually address gaps in *The Protocol*. The assessment was based on a short survey that could suggest us to what extent students' knowledge was based on misconceptions. We asked students' opinions on four attributes that we thought relevant to implant a proactive attitude towards risk mitigation: size, certitude, threat, and damage. To avoid that answers could be influenced by the way the questions were asked, we followed distinct procedures to submit the questions to two distinct groups of students, group-A (Figure 3a) and group-B (Figure 3b). Most of the students correctly answered that risk is the possibility to suffer damage and that hazard is the phenomena that cause damage. However, students seemed to be quite puzzled when they were asked to choose if it is possible to reduce hazard or risk (respectively 57% and 42% in Figure 3b). This evidences that they actually did not know the meaning of hazard and risk, or at least not at the extent that could effectively trigger an efficient proactive attitude. They might think one should put efforts in reducing hazard and not risk.

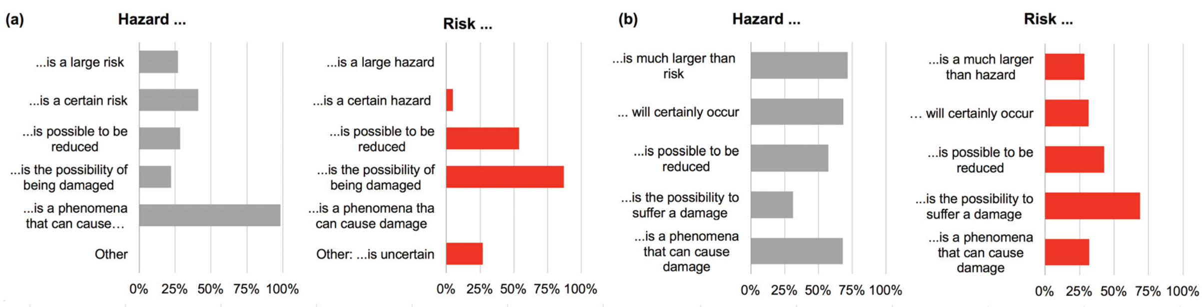

Figure 3. Opinions on hazard and risk derived interviewing two groups of students (164 total answers). Group-A: all questions about hazard were asked first (a); group-B: for each question, respondents choose either it referred to a hazard or a risk attribute (b). Questions are listed in the y axis.

When coupled with the experience that heavy damage occurs even with moderate magnitude earthquakes, this knowledge gap is crucial, possibly reinforcing people thoughts that buildings are intrinsically vulnerable no matter the level of seismic action and, therefore, associating damage to hazard, rather than vulnerability. Therefore, a strategic content for *The Protocol* was the understanding of the difference between hazard and risk, and specifically of which could be reduced, a basic step to trigger preventative actions on NSE vulnerability more efficiently.

In high seismic hazard we had to consider that schools were mostly interested and were actually expecting preparedness actions. We took these as a starting and reference point in highlighting the efficacy of preventative measures regarding the reduction of NSE. In moderate seismic hazard schools had little knowledge and experience on earthquakes; here we included more lectures on the subject. To make more appealing *The Protocol* we reinforced the cross disciplinary (i.e., History, Geography, Technology, Arts, Language) contents.

4.3 A strategic learning approach: the flipped learning strategy

The flipped-learning [Bergmann and Aaron, 2014; Jamaludin and Osman, 2014; Kong, 2014] is a pedagogical strategy in which the conventional notion of classroom-based learning is inverted: students are introduced to the learning material before class and classroom time is instead used to deepen understanding through discussion with peers as well as activities of problem-solving that are facilitated by teachers. Discussion, cooperative learning and the fact the students are encouraged to solve problems independently by the teacher, are crucial aspects when applied to issues that pertain to their living environment [Rivoltella, 2014]. Flipped-learning has been implemented primarily in math and science [e.g., Bergmann and Sams, 2012; Hamden, McKnight, 2013) and it showed a great potential in engaging Digital Native generation. Episode of Situated Learning, [EAS; Rivoltella, 2014] is a teaching strategy based on flipped-learning. It breaks up the learning process into three steps.

The EAS-*preparation* is when the tutor provides the students with the necessary information to operates on their own by mean of a brief and situated (i.e., constrained in space, time and contest) stimulus.

The EAS-*activity* is the core of the EAS, and it can be run either at home or at school. It is when students build their knowledge and rework concepts researching for information on their own, in small groups, to prepare products suitable to present what they have found.

The EAS-*debriefing* is the conclusion of the EAS, and it is run at school within a participatory framework. It is when products are presented and discussed, misconception are eventually corrected and they key concepts are defined.

The EAS strategy has already been applied to risk education [Piangiamore et al., 2016]. In *The Protocol* (Figure 4) three EAS were implemented: the "KR-EAS | Hazard & Mobility" (Table 1) was aimed at understanding that seismic hazard is not only a local threat; the "KR-EAS | Risk" (Table 2) was aimed at understanding the concept of exposure to hazard; the KnowRISK-EAS ("KR-EAS | NSE", from no on) (Table 3), was aimed at understanding those preventative actions that mitigate vulnerability to NSE.

5. A protocol to communicate seismic prevention in schools

The conceptual framework, the strategic contents and the learning approach have been used for *The Protocol* that systematizes objectives, actions, durations, times and tools and includes 2 assessment phases bouning the whole training. Moreover, the training is fully managed by scientists interacting face to face with students (Figure 4).

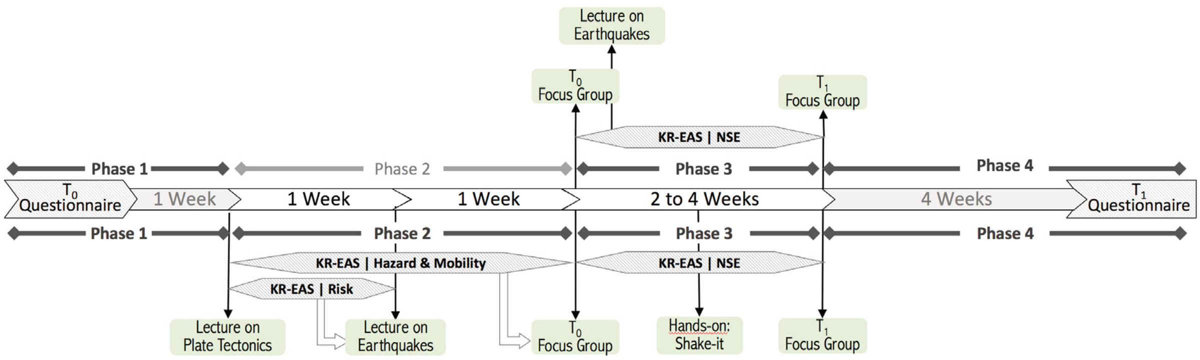

Figure 4. Synopsis of *The Protocol* of intervention in schools within the communication campaign "*Know your school: be safe*". The training sessions are bounded by the submission of a questionnaire ex-ante and ex-post. In the upper part of the figure, above the timeline, the short version of *The Protocol* is shown. It essentially includes only one of the two training phases (phase 3) with 3 face-to-face interventions by scientists (green filled boxes). In the lower part of the figure, below the timeline, the full version of *The Protocol* is shown. It includes 5 face-to-face interventions by scientists (green filled boxes). Grey empty arrows show that the output of one EAS is the incipit for the next activity.

5.1 Assessment: Phase 1 and Phase 4

In these phases, the KnowRISK Questionnaire (KR-Q) [Crescimbene et al., 2019; Platt et al., 2019], specifically implemented to assess *The Protocol*'s effectiveness, is submitted: in phase 1, at T_0, before the training begins and in phase 2, at T_1, after the training's end. The procedure has a quasi-experimental design [Cook and Campbell, 1979] in which the same group of respondents are interviewed before and after an event, which in our case, is the training session of *The Protocol*, and a control group was interviewed but did not participate to the training. Respondents are essentially a whole class of students who filled in the questionnaire some days or a week before the training began and at least one month after the end of it. The time between the two sumbissions ranges between a minimum of 7 to a maximum of 10-12 weeks (Figure 4). The questionnaire was filled-in on-line at school and the teacher was asked to make sure that students did not exchange each other information concerning their answers.

5.2 Training: Phase 2

This phase is aimed at building knowledge and is part of the full-size protocol. Two lectures, on plate tectonic and earthquakes, and two EASs support knowledge that is not part of the usual syllabus. The lectures are highly recommended for application of *The Protocol* in geographical areas of moderate seismic hazard, where the level of knowledge on the phenomena and related risks are presumably low. In other areas, we suggest applying it depending on the results of the questionnaire at T_0.

The lectures required face-to-face intervention in the classroom by a scientist. Major topic of the two lectures should be the scientific framework of the phenomena causing the hazard, which in case of seismicity is the Plate Tectonic theory, and details on how and when the phenomena occur. They should always have an interactive session and be combined with the "KR-EAS | Hazard & Mobility" and the "KR-EAS | Risk" that will be described further on. These face-to-face interventions should occur one week apart, to give the students enough time to accomplish the EAS-*activity*. The total length of each intervention should highly depend on the interaction with the classroom. It is recommended to warn the school board that the time needed might range between 1 to 2 hours. The tools used in support of the lectures and EAS can be slide presentations, hands-on activities or games for the interactive session of the lecture; they should address specific issues of the general topic.

5.2.1 The KR-EAS | Hazard & Mobility

This EAS (Table 1) is placed at the beginning of phase 2. It is aimed at emphasizing that people living in a moderate seismic zone might be even less prepared to face an earthquake than others. It is the incipit and the framework of the whole protocol. The EAS-*preparation* is very short and is essentially the presentation of the topics that will be addressed within *The Protocol*. Students might wonder why it is necessary to discuss about earthquakes in a zone where they might think there were not any: they will get the answer in the EAS-*debriefing*.

For the EAS-*activity* students are asked to interview their peers on “where have you been in Italy last year for at least 3 days?”. Data collected are plotted on the hazard map and charted against the number of respondents. At this stage students have not been introduced to the concept of seismic hazard yet. They essentially use the map just as a thematic map, without knowing what was representing. It is possible that some of them begin to autonomously search for information on seismic hazard.

Two weeks later at school, within the EAS-*debriefing*, students present the results of their work to the classroom. They eventually verify that most of them have been staying for a few days in a zone with higher seismic hazard level with respect to where they live. They therefore have a data-driven conclusion that in Italy hazard is a generalized problem, and that living in a moderate seismic hazard zone does not exempt them from learning what to do to be safer. The ending of this EAS can be taken as the incipit of the discussion of T_0-focus group within the KR-EAS | NSE in the phase 3 of *The Protocol*.

KR-EAS | Hazard & Mobility			
STEPS	WHAT	TIME	SUPPORT MATERIAL/SHARING RESOURCES
Preparatory	Stimulus	10 min	Slide presentation
Activity	Assignment: “Communicate prevention of damage to NSE”	2 weeks	Excel sheet with ready formula Seismic Hazard map
Debriefing	Discussion of the results (incipit of KR-EAS | NSE)	15 min	Diagrams with students results

Table 1. KR-EAS | Hazard & Mobility.

5.2.2 The KR-EAS | Risk

This EAS (Table 2) intends to trigger students’ reflective thinking on the fact that if you live on a plate boundary you should expect earthquakes to affect your life. It is the assignment at the end of Lecture 1, before talking about earthquakes, hazard and risk. The ending of this EAS is taken as the incipit for Lecture 2, on earthquakes, and is intended to introduce exposure to hazard. In the EAS-*preparation* students, after choosing one of the major tectonic plates, are provided with internet links where they can find the following items concerning that plate:

- a plate tectonic world map
- the populations of major cities
- major earthquakes occurred in the past.

In the EAS-*activity* they are assigned to:

- plot major cities on the chosen tectonic plate and the closest to the plate boundary; write a table with population of cities, distance from the plate boundary and from a recent earthquake.
- suggest, just based on these data, where on the chosen tectonic plate an earthquake could cause more damage.

One week later, in the EAS-*debriefing* they will discuss at school why an earthquake can cause damage.

KR-EAS | Risk			
STEPS	WHAT	TIME	SUPPORT MATERIAL/SHARING RESOURCES
Preparatory	Stimulus	15 min	Activity "The plate tectonic puzzle"
Activity	Assignment: "Where do earthquakes cause more damage?"	1 week	Link to: plate tectonic world map populations of major cities major earthquakes occurred in the past
Debriefing	Discussion of the results	15-30 min	Students' presentations

Table 2. KR-EAS | Risks.

5.3 Training: phase 3

This phase is aimed at building students' capacity to predict and act over consequences of hazards. It is the core of *The Protocol* and it is essentially the training part of its short version (see Figure 4). The training in this phase is essentially done with one EAS and eventually one lecture. The KnowRISK-EAS on NSE [Musacchio et al. 2019a] that is described further on is bounded, at the beginning and at the end, by two focus groups aimed at providing an additional, yet qualitative, assessment of the efficacy of the communication. This EAS has the peculiarity of a *preparation* more extensive than normally required [Rivoltella, 2014]. It includes, beside the usual EAS's stimulus, the T_0-focus group and one lecture.

5.3.1 The KR-EAS | NSE

This is the risk communication EAS specifically devoted to NSE. The incipit of the EAS-*preparation* includes a T_0-focus group (Table 3) that is essentially a discussion/debate about the concepts of hazard and risk that is performed before the students deepen their knowledge. Images from daily life and videos were used as support material to trigger a debate that could retrieve students' opinions, help them to make spontaneous observations, and ask new questions. In low hazard zone, where the full version of *The Protocol* is applied, the output from the KR-EAS | Hazard & Mobility can be recalled within this focus group. The lecture following the T_0-Focus group addresses why earthquakes occur in each area, what are the mechanisms that cause them and general concepts on seismic waves propagation. The game "Find the difference: be safer!" [Solarino et al., this issue] or the Move-Secure-Protect video spot (https://www.youtube.com/channel/UCQng71zMIJE0PeVHP9ktWIQ), can be used as stimulus for the EAS *activity*. In the game "Find the difference: be safer!" students are asked to spot the difference in damage on a bedroom and a classroom contents, with and without solutions to mitigate NSE vulnerability. The aim is to help them focus on the assignment. The video spot shows vulnerability of NSE and the key concept to mitigate it.

In the EAS-*activity* the students are assigned a risk communication homework: they should prepare a communication tool on NSE vulnerability addressing young people as target public. Specific weblinks showing NSE, vulnerability, and solutions for mitigation [Solarino et al., this issue] should be given to the students to allow them retrieve validated information for their assignments. Students can have about 4 weeks' time to prepare their products. The EAS-*debriefing* is essentially the T_1-Focus group, that is centred on risk communication. Students present their products to the class and take up the role of risk communicators. The expert moderates the discussion, analyses students' products and workouts misconceptions.

KR-EAS | NSE			
STEPS	WHAT	TIME	SUPPORT MATERIAL/SHARING RESOURCES
Preparatory	T_0-Focus group	30 min	Slide presentation Output from KR-EAS | Hazard & Mobility
	Lecture on earthquakes	30 min	Slide presentation
	Stimulus	10-15 min	https://www.youtube.com/channel/UCQng71zMIJE0PeVHP9ktWIQ
Activity	Assignment: "where have you been in Italy last year for at least 3 days"	2-4 weeks	Downloads from: https://knowriskproject.com/wp-content/uploads/2018/02/pg-it-1feb.pdf https://knowriskproject.com/wp-content/uploads/2017/11/Guida-Casa-ita.pdf https://knowriskproject.com/wp-content/uploads/2017/11/Guida-Scuola-ita.pdf
Debriefing	T_1-Focus group	1-2 hours	Students' presentations Slide presentation by the scientist Game: https://knowriskproject.com/wp-content/uploads/2018/01/KR_PG_Game-IT.pdf

Table 3. KR-EAS | NSE.

5.3.2 Hands-on activity: Shake it!

This activity helps students to pin down concepts related to buildings' resistance to earthquake. It should be done within the class-time of the technology subject. Students build spaghetti and marshmallow structures that are placed on shake-table cardboard models (Figure 5). The vibration of the shake-table models well couples to the structure of spaghetti and marshmallows and visually exemplify the seismic action and resistance of real buildings. Students can test buildings' response to shakingand test solutions to reinforce buildings and have them more resistant to earthquakes shaking.

6. Testing the protocol

The Protocol was tested over three years (Table 4), each time with a different group of students. The activities underwent changes that were rated necessary to have it more effective and yet less intrusive of the school's planner. The analysis of the questionnaires at T_0 and T_1 allowed to assess in a quantitative manner if changes in *The Protocol* from one year to the next were effective.

The general structure of *The Protocol* and the learning strategy was first tested in the city of La Spezia for which the assessment was performed only qualitatively by means of student's products within the KR-EAS | NSE [Piangiamore et al., this issue]. The choice of starting in La Spezia was based on operational reasons, belonging to a well-established collaboration network. Later, when communication tools, more focussed on the NSE target, and the questionnaire for the assessment specifically implemented by the project were ready, we conducted *The Protocol* in the schools of two pilot areas, Laveno Mombello and Catania (Table 4) with the purpose of testing in a moderate and a high seismic hazard zone, respectively.

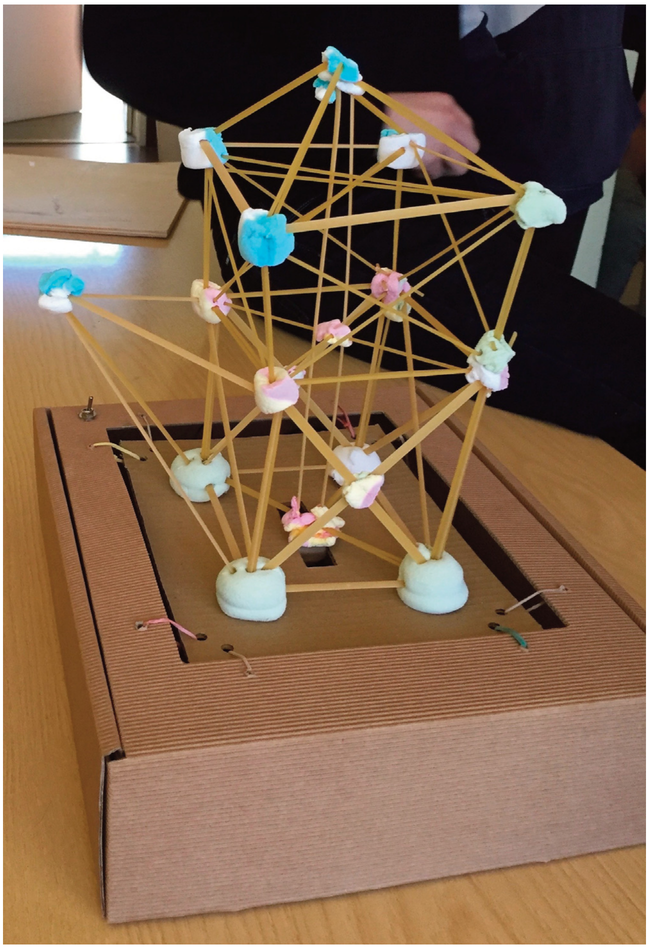

Figure 5. A spaghetti and marshmallow house model on a cardboard shake-table. The model has diagonal structures to increase seismic resistance. These diagonals will be broken one-by-one to verify what happens in response to shaking of the cardboard table. The tetrahedron on the left side of the structure represents a NSE architectural component. The spaghetti and marshmallow structure was build by a student of the IC Monteggia in Laveno Mombello, school year 2018.

SCHOOL YEAR	PILOT AREA AND CITIES	SCHOOL NAME	N° CLASSES	N° STUDENTS
2017-2018	Northern Italy: Laveno Mombello area	IC G. B. Monteggia IC Campo dei Fiori	5	120
	Mt Etna: Catania	IC San Domenico Savio	3	70
2018-2019	Northern Italy: Laveno Mombello area	IC G. B. Monteggia	4	98
2019-2020	northern Italy: Laveno Mombello area	IC G. B. Monteggia	4	96

Table 4. Schools that participated in the communication campaign “Know your school: be safe” from school year 2017 to 2020.

6.1 The training session in the Mt Etna Pilot Area: Catania

In Catania we tested the short version of *The Protocol* (Figure 4) that included only the two assessment phases (1 and 4) and the KR-EAS | NSE in phase 3. Catania's schools are in the Mt Etna pilot area, a zone with a high seismic hazard where low- to moderate-magnitude earthquakes; with shallow seismic foci and can cause heavy damage. The discussion within the T_0-Focus group draw an unexpected picture of the situation. We were expecting that at least some students had felt earthquakes' shaking, while it was clear that they were not even aware they were living in an area with high seismic hazard. We could speculate that the presence of an active volcano may likely overwhelm their awareness: tremors and eruptions of volcanic ash are more frequent than tectonic earthquakes. The discussion with the students highlighted that they could not distinguish between hazard and risk. They considered natural disasters as something that cannot be changed, and they believed that behaviours alone cannot save lives, a sort of fatalist attitudes.

The approach to the concept of hazard and risk was stepwise: it begun addressing the general concept in familiar contests (for example in relation to sunburns), and later it switched to earthquakes. The discussion was also set progressively on seismic hazard is in the surrounding area, in the whole Sicily, and in Italy, and on what can be done to reduce seismic risk. The students were guided to speculate whether there are simple actions able to reduce seismic risk by operating on the non-structural elements of their homes. Sometimes the discussion/debate among the students allowed them to understand concepts that even for adults can be difficult. Finally, the products presented by the students provide insights on student's point of view towards risk and the way they think it could be communicated [Piangiamore et al., this issue]. Brief video-reports, interviews, semi-serious games, hand shaken non-structural damage models, video scribing, comics, music.

6.2 The training session in Northern Italy Pilot Area: Laveno Mombello area

The Laveno Mombello area allowed to test *The Protocol* for schools located in a zone with a moderate seismic hazard. Here communities' preparedness to earthquakes and preventative measures are perceived as a low priority. Only some of the students felt earthquake shaking: they remembered the Emilia seismic sequence in 2012, when they were 7-to-9 years old. They talked about being in the classroom while the shaking occurred and apply drop-cover-hold actions, having never done any earthquake drills before. In Italy earthquake drills are not mandatory in medium hazard seismic zone, and they usually are included in or mistaken by fire-drills [Bernharðsdóttir et al., 2015]. Other students felt the earthquakes that occurred in the summer of 2016 in Central Italy, where they were spending their holidays.

Here we tested the full version of *The Protocol*. We addressed needs of people living in a low hazard zone surrounded with higher seismic hazard, like it is in this pilot area. We stressed that the actual hazard that people are exposed to is also depending on their mobility. The EAS | hazard & mobility showed that most of the students have been staying in a zone with higher seismic hazard than what they are used to (Figure 6).

Students of the Laveno Mombello area also participated to the hands-on activity describing building resistance to seismic action (Figure 5). They spontaneously include NSE like tiles, chimneys, eaves/parapets, architectural ornamentation (internal or external objects) which are among the most damaged elements in Italy (Ferreira et al., this issue) to see what happens during the shaking. *The Protocol* also activated interdisciplinary participation and involved science and geography teachers, technology and history and it was used to provide additional suggestions for the thesis the students prepared for their final examination at the end of the year.

7. Assessing the effectiveness of the protocol

A major novelty introduced by *The Protocol* is the implementation of the KR-Q, a questionnaire to assess the effectiveness of the training sessions. The KR-Q was inspired by a more general questionnaire, used to assess seismic hazard perception all over Italy in a survey conducted in 2015 [Crescimbene et. al. 2015]. Within *The Protocol* framework hazard perception is considered as the starting point to frame the participant individual background about risk and to prompt a proactive attitude towards seismic risk best practice.

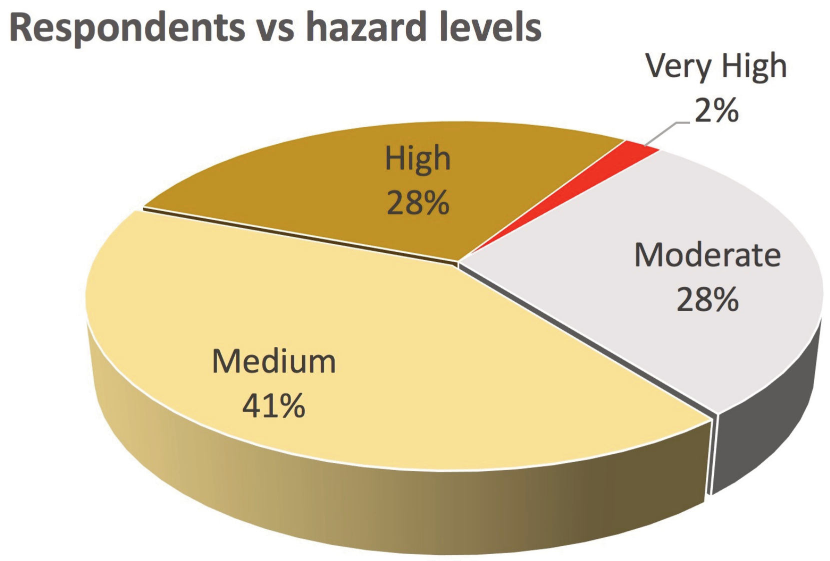

Figure 6. Results from the KR-EAS | hazard and mobility. Answers to the question "where have you been in Italy last year for at least 3 days?". The diagram is used as incipit from the KR-EAS I NSE. The survey had 164 respondents.

The KR-Q questionnaire's conceptual framework is based on the KAP trilogy and includes three main sets of questions. In particular, the first set refers to the assessment of efficacy concerning the *Knowledge*: it inquires whether fundamental concepts concerning earthquakes and the associated risks have been acquired. The second set refers to the assessment of *Attitude* which represents perception towards hazard and risk. Last set is aimed to verify whether *The Protocol* was capable to trigger changes in actions and behaviours of respondents, that is in the concept of *Practice* [NSET, 2017]. Most of the questions relied on the semantic differential method and the Likert scale [Likert, 1932], a psychometric scale commonly used to derive the attitude towards the given object, event or concept. Respondents make a choice on a numerical scale that we set from 1 to 7 with two dichotomous adjectives: "hardly (1) - highly (7)"; "unlikely (1) - likely (7)".

To compare results ex-ante and ex-post, we firstly verified the Cronbach alpha [Cronbach, 1951], a parameter measuring the internal consistency of data and retrieve how closely related is a set of variables of as a single indicator. It ranges between 0 and 1: Cronbach alpha>0,70 indicates a large correlation and large consistency. In our dataset, the Cronbach alpha showed a good level of both correlation and consistency between the indicators. This allows us to work with the mean values of the Likert scales to compare the results at T_0 and at T_1. To verify whether the average value at T_1 distribution significantly differs from that at T_0 we used the t-test [Student, 1908]. The statistical correlation of the answers before and after the training sessions clearly describes the students have assimilated the basic concepts proposed to them. The assessment for the schools located in Catania and Laveno Mombello are illustrated further on by discussing results concerning the three dimensions of the KAP conceptual framework: *Knowledge*, *Attitude* and *Action*. The t-test with 95% probability and 97 degrees of freedom corroborates the significance of all the mean values of the answers before and after the training section of *The Protocol*.

7.1 Results of the assessment: Mt Etna Pilot Area: Sicily, Catania

Knowledge is assessed by 8 questions. Here we discuss those explicitly asking about earthquakes and risk (Figure 7). Before the training session of *The Protocol*, (at T_0 in Figure 7), the question "Do you know the earthquakes in your area?" scored 2.31. However, students' self-assessment on knowledge of seismic risk showed a better background situation than the one for hazard: at T_0 mean scores were 3.78, meaning that on average students thought they had a sufficient knowledge (57% of the maximum) on the risk they are exposed to. This could be related to the earthquake drills regularly performed at school. The training session of *The Protocol* increased more knowledge on risk (Δ=

+1.09) than on hazard (Δ= +0.9). Similarly, the scores at T_1 were higher for risk (4.58) than for hazard (3.40) and on the 1-to-7 Likert scale, correspond to 65% and 48% of the maximum score, respectively. Although *The Protocol* was effective in rising knowledge, the final scores are still very low for people living in a high hazard zone.

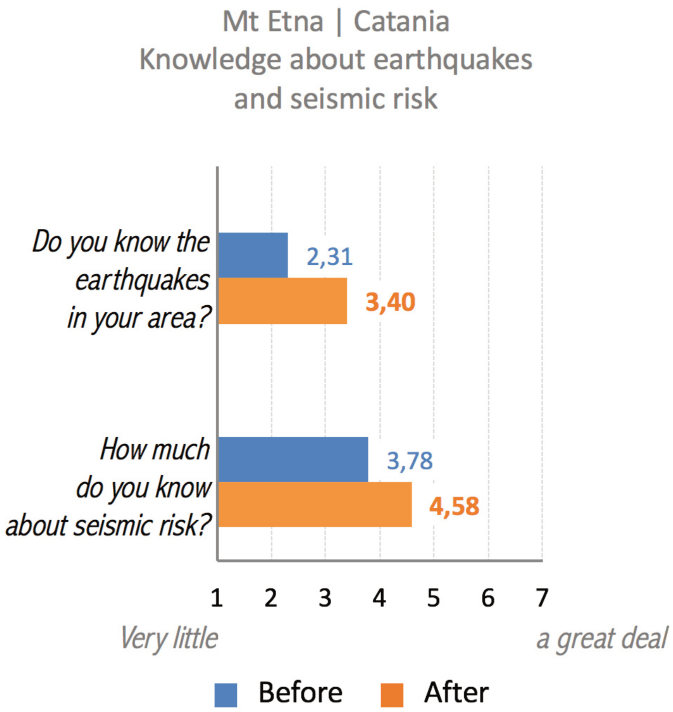

Figure 7. Mt Etna pilot area: Catania. Graph showing the dimension *Knowledge,* on a 1-to-7 Likert scale, before (T_0) and after (T_1) the training session of *The Protocol*. Students are asked to rate their knowledge on earthquakes and seismic risk.

Perception and *Attitude* are retrieved by studying the part of the questionnaire concerning attitude to hazard and risk. The question "how would you describe an earthquake in your area?" is associated with six perception indicators (Figure 8), ordered on the Likert scale so that 1 matches *unlikely*, *weak*, *not dangerous*, *low-risk* and *infrequent* and 7 matches *likely*, *strong, big, dangerous, high risk, frequent*. Before the training session of *The Protocol,* the group of students living in Catania perceived earthquakes *likely*, *dangerous* and posing a *high-risk* (mean scores mean greater than 4). After the training session, all the perception indicators have an increase of scores with a high level of consistency (high Cronbach alpha=0.94). The students' most concern was *Likelihood* and *danger,* being the items that gained the highest scores (Figure 8). However, the perceived hazard still underestimates the "hazard by law" (red dashed in figure 8). It is worth of notice that in an area of high seismicity, students think, at T_0 and T_1, that earthquake is a phenomenon infrequent (score at T_0 = 2,78 and at T_1=2.88). This information coupled with the low scores for knowledge on earthquakes, might suggest that these students never had the experience of earthquakes. (Figure 8).

The dimension *Practice* is assessed with questions on preparedness and actions that strictly refers to non-structural elements (Figure 9). Students are asked to rate each action as *not-important* by flagging 1 to *important* by flagging 7. The answers are correct the higher the average values of the Likert scale are, except for the "run out of the house" which, being an unwanted behaviour, must be evaluated as not important. At T_0 most of the actions and behaviours scored more than 4, suggesting that students were already acquainted with these issues or that they intuitively guessed the correct answers. It is worth of notice that actions concerning mitigation of vulnerability to building contents (grey shaded in Figure 9), which are the specific issues upon which the whole campaign stood, were

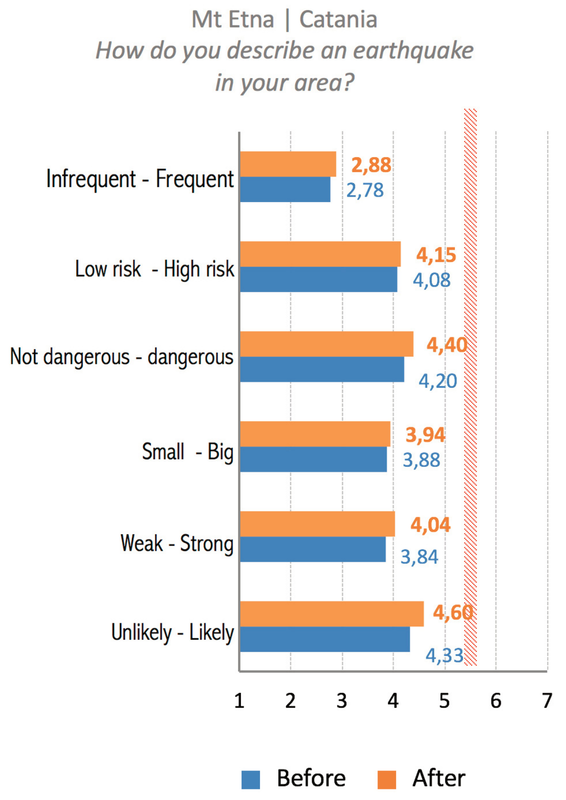

Figure 8. Mt Etna pilot area: Catania. Graph showing the dimension *Attitude,* on a 1-to-7 Likert scale, before (T_0) and after (T_1) the training session of *The Protocol*. The six indicators allow to derive students' hazard perception. Dashed red is the perception score considered appropriate with respect to the "hazard by law" in the Catania area [Crescimbene et al 2015].

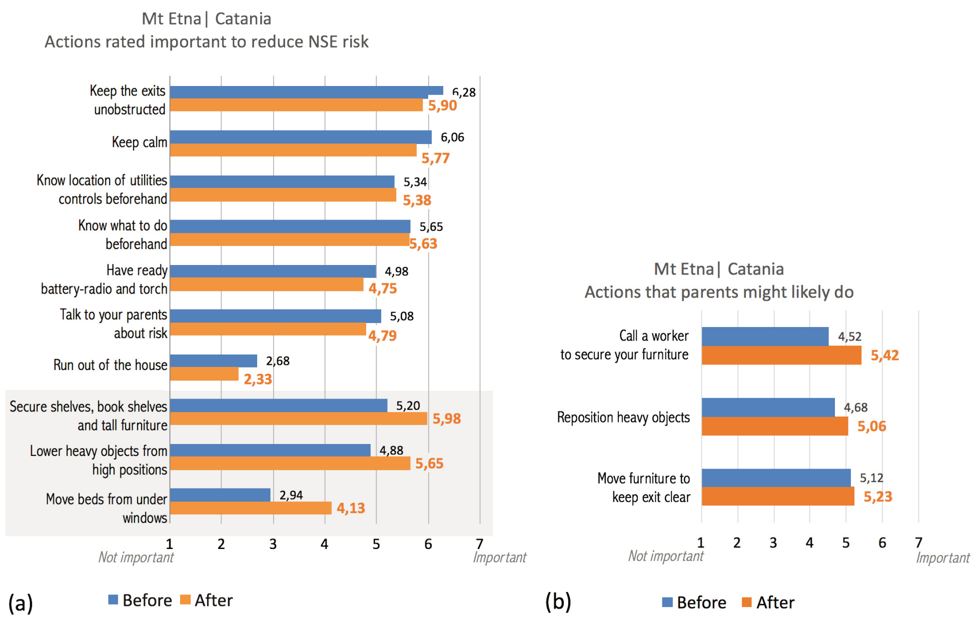

Figure 9. Mt Etna pilot area: Catania. Graphs showing the dimension *Practice,* on a 1-to-7 Likert scale, before (T_0) and after (T_1) the training session of *The Protocol*. Preventative actions rated important (a) and the likelihood these actions would be undertaken by the parents (b) are plotted. Score 1 is for *not important*; score 7 is for *important*. Shaded area is for actions that strictly refer to NSE.

well received, being the changes, from before (T_0) to after (T_1) the training session of *The Protocol*, quite high. The highest change was triggered the on the action of "*move the beds from under the window*" (Δ=+1.19) possibly as a result from the discussion we had with the students during the T_0-focus group. As a matter of fact, students found the action initially not pertinent (they thought it was a joke), as it is also shown by the answers at T_0 but, by the end of the discussion, they agreed it was a worthwhile action to substantially increase safety with a relatively low effort. The action of "Secure shelves, bookshelves and tall furniture", that scored Δ= +0,78, and the action of "Lower heavy objects from high positions", that scored Δ=+ 0.77, bring answers to score mean Likert all above 5.0. However, the likelihood preventative actions will be undertaken by student's parents increases only slightly from T_0 to T_1 . This shows that students, although they learned what to do, they might find obstacles in undertaking actions at home.

7.2 Results of the assessment: Northern Italy Pilot Area: Laveno Mombello (VA)

Knowledge at T_1 shows in Laveno Mombello a trend similar to that in Catania: scores have a low mean values, whereas they are higher for risk (3.21) than for hazard (2.28) (Figure 10 and Figure 7). A large increase of knowledge at T_1 (Figure 10) proves the training session of *The Protocol* be effective. Such increase was larger for knowledge about risk (Δ= +1,67) than hazard (Δ= +1,04). Similarly, the final scores were higher for risk (4.88) than for hazard (3.32), corresponding to 70% and 47% of the maximum score, respectively, on the 1-to-7 Likert scale. The training session of *The Protocol* was more effective rising knowledge on risk that on hazard and brought final scores to a satisfactory level for risk, while those on hazard are still quite low.

Perception and *Attitude* for students living in the Laveno Mombello area shows increased mean values at T_1 on all the considered indicators and have a high Cronbach alpha (=0.86) (Figure 11). These scores underestimate the "hazard by law" although the difference is less pronounced than in Catania.

The results on the dimension *Practice* are quite like what described for Catania (Figure 9 and Figure 12). The high scores at T_0 could likely be justified with the fact that students in Laveno Mombello had recently experienced the Emilia 2012 earthquake sequence when they saw shaking and falling heavy objects on the floor. Nonetheless, the training was effective in reinforcing the experience they had with additional knowledge. The highest mean scores are reached for items describing common sense behaviours such as: *"keep the exit unobstructed"* and "*keep calm*". The latter remains unchanged between before and after the training. It shows that students' behaviours strictly linked to the emotional sphere has a low capacity to be modified just by raising the awareness. The items concerning preventative actions towards the mitigation of vulnerability to NSE show a strong increase from T_0 to T_1. The likelihood that preventative actions will be undertaken by student's parents has also a large increase (Figure 8b). By reaching mean scores larger than 4 shows that students think they might find support by the parents in implementing actions to increase their safety. Here the message concerning the do-it-yourself since it is easy to implement was successful.

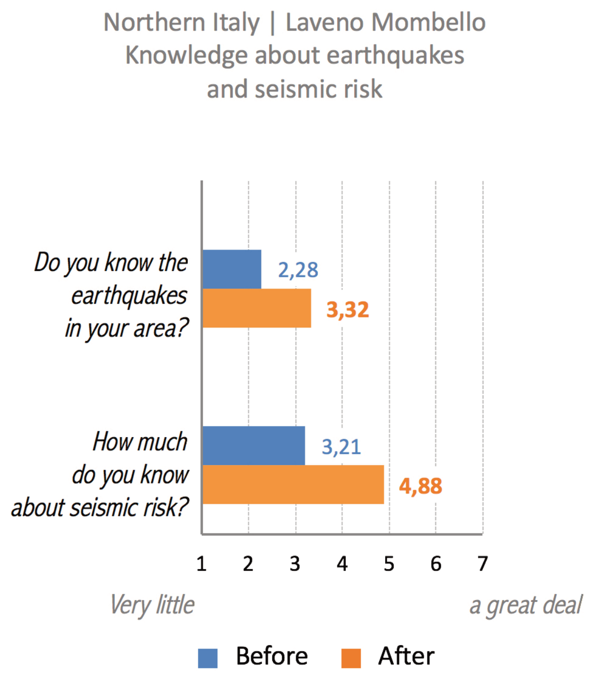

Figure 10. Northern Italy pilot area: Laveno Mombello. Graph showing the dimension *Knowledge,* on a 1-to-7 Likert scale, before (T_0) and after (T_1) the training session of *The Protocol*. Students are asked to rate their knowledge on earthquakes and seismic risk.

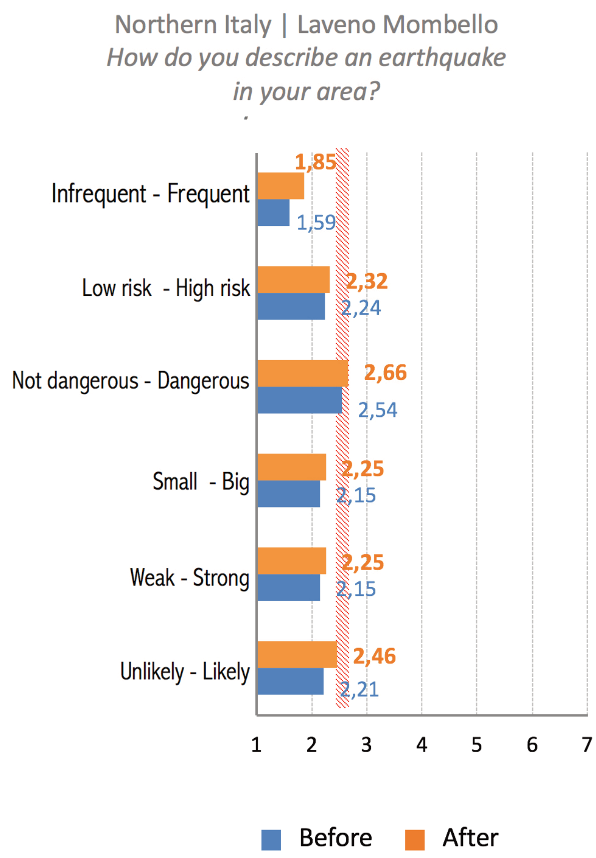

Figure 11. Northern Italy pilot area: Laveno Mombello. Graph showing the dimension *Attitude*, on a 1-to-7 Likert scale, before (T_0) and after (T_1) the training session of *The Protocol*. The six indicators allow to derive students' hazard perception. Dashed red is the perception score considered appropriate with respect to the "hazard by law" in the Laveno Mombello area [Crescimbene et al 2015].

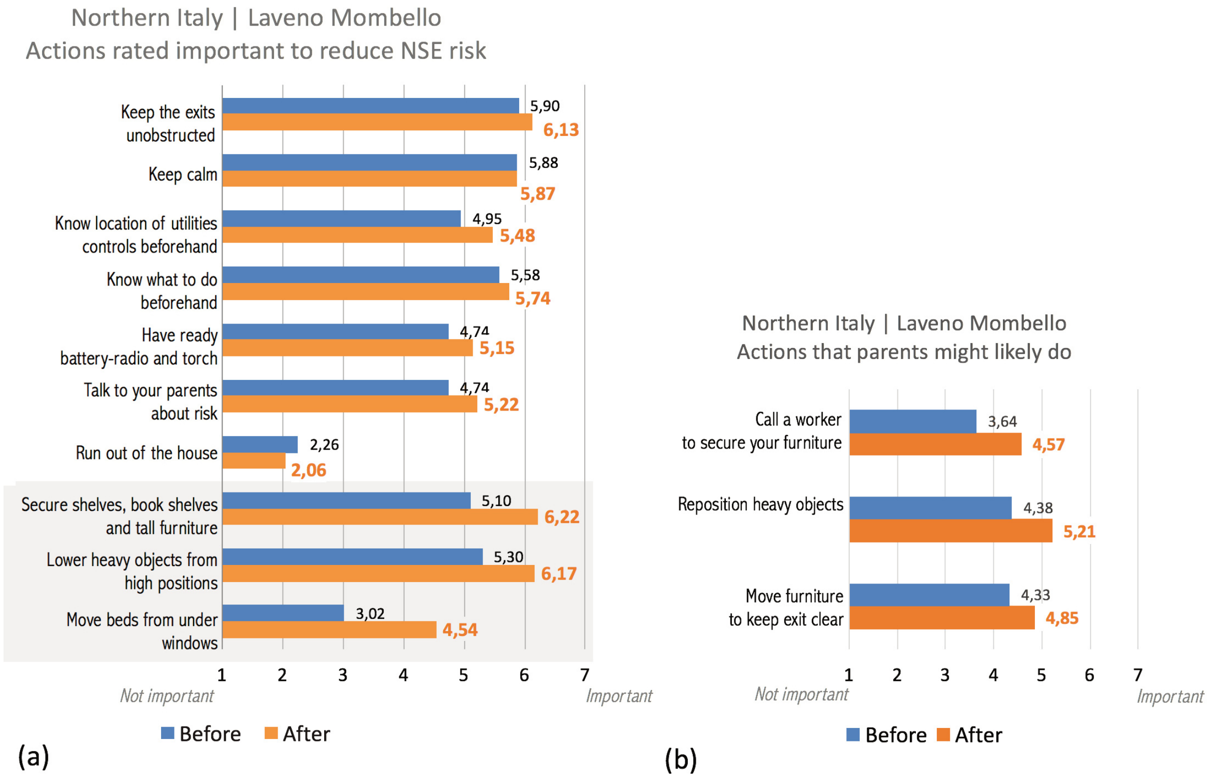

Figure 12. Northern Italy pilot area: Laveno Mombello. Graphs showing the dimension *Practice,* on a 1-to-7 Likert scale, before (T_0) and after (T_1) the training session of *The Protocol*. Preventative actions rated important (a) and the likelihood these actions would be undertaken by the parents (b) are plotted. Score 1 is for *not important*; score 7 is for *important*. Shaded area is for actions that strictly refers to NSE.

7.3 Comparison between interventions carried out in 2017, 2018 and 2019 in Laveno Mombello

The intervention carried out in Laveno Mombello over three years, to different group of students but always in the same age, is an opportunity to compare the effectiveness of changes in the design of *The Protocol*. If we consider the dimension *Knowledge* on the two key concepts of hazard and risk, we can see the difference between scores reached before (T_0) and after (T_1) the training session of *The Protocol* is always positive and high (Figure 13). It is worth notice that there is a general improvement of scores across the three years that can be signalize the effectiveness of changes applied to *The Protocol*. In year 2017 *The Protocol* included only the "KR-EAS | NSE" for which no support material for the stimulus and for the activity of the EAS was implemented, yet. In year 2018 and 2019 *The Protocol* was refined, reaching its present configuration (Figure 4 and Table 1-3): the "KR-EAS | NSE" could profit by specifically implemented support material for [Solarino et al., this issue]; two more EAS, "KR-EAS | hazard & mobility" and "KR-EAS | Risk", were included. The improvements shown in Figure 13 were likely related to the aforementioned changes in *The Protocol*. The "KR-EAS | hazard & mobility" was strategically placed at the beginning of the intervention in school to catch attention and motivate students. The "KR-EAS | Risk" was a way to introduce risk to students. The two EASs might have allowed students to understand that an earthquake can be more damaging if it occurs close to a densely populated area, therefore that it is not the earthquake itself the cause of damage. It also helped students distinguish between hazard and risk. It is worth of notice that while knowledge on earthquakes remained close to the value expected by the real hazard, risk got a major improvement.

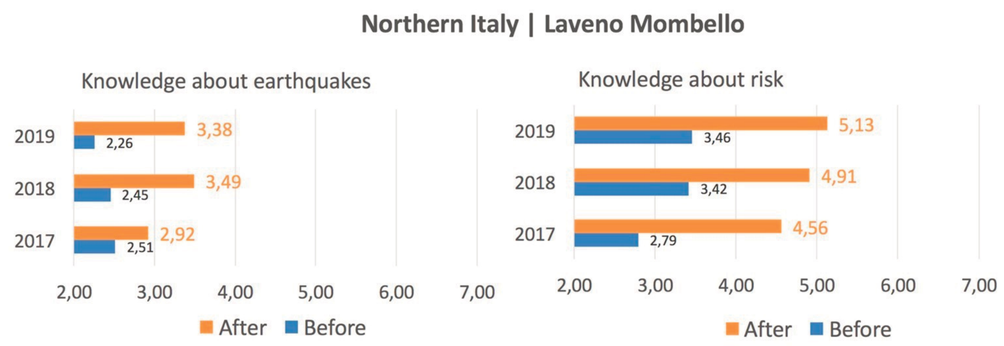

Figure 13. Northern Italy pilot area: Laveno Mombello. *Knowledge* about earthquakes and risk are graphed against the three years of intervention. They reveal the efficacy of The Protocol with time.

8. Conclusive remarks

Communication bridges science and society and has great potential for implanting a culture of risk.

The School is one of the institutions that play a crucial role in the construction of the future society. Communicating risk through school could therefore be one of the most effective ways to reduce the impact of future disasters. This was the rationale behind *"Know your school: stay safe!"* risk communication campaign, undertaken in schools as part of the KnowRISK project (https://knowriskproject.com/). The project aimed at empowering communities to mitigate the vulnerability of non-structural elements to earthquakes, an issue normally considered to be of low priority even in the building regulations of many countries around the world. The campaign was based on intervention protocols, implemented in Portugal, southern Iceland and Italy, each with specify objectives, actions, durations, timelines and tools. They all underwent assessment of effectiveness to be replicated.

The protocol implemented in Italy included training sessions that made extensive use of the flipped Learning and Episode of Situated Learning strategies. The robustness of *The Protocol* was assessed both qualitatively and quantitatively. Two focus-groups at the beginning and at the end of KR-EAS | NSEs were an opportunity to qualitatively evaluate the effectiveness of training. However, a questionnaire was specifically implemented for the quantitative assessment of *The Protocol* and demonstrated its effectiveness in increasing knowledge, changing attitudes and implementing best practices.

The survey conducted through the questionnaire was an opportunity to investigate the perception of seismic risk by students in age 13-14 living in Catania (Sicily) and Laveno Mombello (Lombardy), two areas with extremely different level of seismic hazard, and highlights significant aspects that could be useful for future work. Students living in Catania perceive earthquakes as being probable, dangerous and high-risk (Figure 8). The scores' improvement brought the hazard perceived by the students to scores higher than the average computed for the whole South Italy [Crescimbene et al., 2015] although still underestimating the "hazard by law" for that area. Such "hazard by law" is that the Italian Building Code refers to and for which buildings are required be compliant. This suggests that significant and stable changes in hazard perception are very slow to achieve and need a long-term perspective, through repeated and long-lasting activities. Although living in a high- hazard area, Catania students perceive earthquakes as infrequent even after *The Protocol* (Figure 8). This could be related to the well-known misperception of the probability of a hazardous event [Becker et al., 2019; Doyle et al., 2014 a and b; McClore et al., 2014]. Additionally, students may only associate damage with strong earthquakes that are less frequent.

The Protocol was very effective regarding preventative actions. However, in Laveno Mombello, an area with moderate seismic hazard, the students' scores for responses on actions to mitigate NSE vulnerability were already high before *the Protocol*. The students that participate to the campaign felt the 2012 Emilia earthquake sequence; they personally saw heavy objects shaking and falling on the floor. This earthquake has engulfed the public debate and had a great resonance in the media, probably influencing the perception of local communities living in the north of the country and likely helped students to choose the right answers to the questionnaire.

Although the students understood what can be done to reduce vulnerability to NSEs, they are not convinced that these actions would be taken at home. It is worth noting this detail for the future development of *The Protocol* and in general for risk communication campaigns which should have a broad parental involvement with workshops, discussions within a framework of public engagement.

The results presented in this paper allow us to be confident on the efficacy of *The Protocol* we have implemented, and it can be replicated countrywide and in Europe. We are aware that *The Protocol* described in this paper is demanding in terms of time and efforts for both the scientists and the students, but we have proved that this is a way that should be pursued to achieve good results.

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