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Geo-hydrological and seismic risk awareness at school: Emergency preparedness and risk perception evaluation

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ABSTRACT

One of the targets of the Sendai Framework is to reduce disaster damage to critical infrastructure and the disruption of basic services, particularly in educational facilities, and to develop their resilience. To assess the geo-hydrological and seismic risk awareness in schools in Tuscany (Italy), ad hoc questionnaires were set up. These questionnaires focused on the knowledge of the correct behaviours and procedures during an emergency as well as risk awareness and perception. These questionnaires were different for each school age (from 3 to 19 years old) and were even conceived as a didactic instrument. We distributed 5899 in total (820 to the school staff and 5079 to the students of each school stage), and the analysis shows that, a) as age and responsibilities increase, geo-hydrological and seismic risk awareness and preparation do not increase proportionally, which is almost inadequate for the staff, and b) there is a disconnect between the school evacuation plans and the city civil protection plan. The proposed questionnaires were found to be a good instrument for both disaster education (to increase and improve the level of awareness) and school-resilience evaluation (not only within the Geohazard Safety Classification method) to plan further action and improve it. Therefore, the present study suggests priorities for future school-based emergency management efforts, i.e., to increase school resilience and develop a resilience culture in the community. It is necessary to improve the dissemination of information on the local geo-hydrological and seismic hazards and ensure a link among the different emergency plans.

1. Introduction

Risk, which refers to something that has not happened yet and is related to random chance and possibility, is a complex concept [[1] and references within]. During the ten-year time frame from 2005 to 2015, as a result of disasters, over 700 thousand people lost their lives, over 1.4 million were injured, and approximately 23 million were made homeless [2]. Overall, more than 1.5 billion people were disproportionately affected, and the total economic loss was estimated at more than $ 1.3 trillion [2].

According to the Sendai Framework for Disaster Risk Reduction (SFDRR) 2015–2030, data indicate that the exposure to risk of people and properties in all countries has increased faster than vulnerability has decreased [2]. Thus, new risks and a steady rise in disaster-related losses are generated. Therefore, to achieve a substantial reduction of disaster risk and losses in many fields, the SFDRR outlines seven targets, the first of which is clearly the substantial reduction of the global disaster mortality. The goal of the fourth target is the significant decrease of both damages to critical facilities (as defined in Ref. [3]) caused by disaster and basic services (i.e., health and educational facilities) disruption. The fourth target also considers, as a means to reach the goal, the development of resilience [2].

The update for 2017 of the Comprehensive School Safety (CSS) framework [4] in support of the Global Alliance for Disaster Risk Reduction and Resilience in the Education Sector and The Worldwide Initiative for Safe Schools promoted by the UNISDR Office, brings into focus child-centred and evidence-based efforts to promote disaster risk reduction (DRR) throughout the education sector. Disaster education is actually considered to be an important factor to enhance the quality of education and provide continuous education [5–9]. First, policy-makers

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have moral and legal obligations to fulfil the children's rights to safety, survival, and educational continuity [10]. The symbolic, cultural, economic and political significance of schools as a community centre gives them an importance beyond being just the site for educating children [10]. Schools have to be resilient since they provide a direct link between children and families and are the place where children spent a large amount of time [11,12]. The intangible benefits of schools functioning normally following a disaster include the psycho-social support in the face of loss and change [10]. In addition, they have to provide safer circumstances for students, teachers, parents and community members in normal and disaster situations, being often designated as evacuation centres for disaster conditions [7,8]. Therefore, if schools are not constructed or maintained to be disaster resilient, this can result in lifelong injuries and death for millions of children and adults [13].

An example is the Japanese government, which, after the Great Hanshin-Awaji earthquake of 1995 where almost 4000 schools around the city of Kobe were destroyed, increased the funds and shortened the deadline of a national programme (Japan's Program for Earthquake-Resistant School Buildings) [13]. This programme would make every school resilient to the impact of earthquakes. Thus, in April 2015, earthquake-resistant schools accounted for 95.6%. The addition of most of the remaining percentages of buildings to the programme needed to be postponed due to the planned consolidation or closure of the schools. Additionally, more than 90% of public schools have been designated as evacuation centres in the local disaster management plan [13]. Another example is Nepal, where in 2007, the NGO National Safety for Earthquake Technology (NSET) conducted the School Earthquake Safety Program (SESP) in public schools. This program allowed teachers and students to learn the importance of preparedness and mitigation measures and to take helpful actions for disaster reduction [14].

It is noteworthy that school safety should be multi-risk [15]. Multi-hazard awareness is often lacking. There are many examples of school buildings that fulfil resilience to one hazard, while failing to mitigate against others [16]. The school resilience is not related to a specific hazard and vulnerability, but it takes into account many factors, including the people's geo-hydrological and seismic risk perception and awareness, along with their knowledge and capability of how to behave in an emergency [7]. Therefore, the newer version of the CSS framework has introduced very specific guidelines within the pillar "Risk Reduction and Resilience Education" to develop awareness, knowledge and competencies about risk reduction and resilience in students, staff and households [4]. The expert review process that was part of the "Guidance notes on safer school construction" [17] yielded the list of enabling factors associated with successful and sustained programmes for school structural safety. Awareness is the first factor. Creating and maintaining a safe learning environment means sharing knowledge about hazards, their potentially damaging effects, and most importantly, what we can do about them [17]. A deep understanding of basic disaster awareness and risk reduction education for both adults and children must be seen as a common starting point, applying scientific, technical, local and indigenous expertise [18].

Once again, Japan can be taken as an example. Moreover, even though the Japanese situations could be different from other countries, the disaster education approaches, problems and challenges are widely common [19]. After the 2011 Great East Japan Earthquake (GEJET), the Ministry of Education, Culture, Sports, Science and Technology (MEXT) put an emphasis on promoting disaster education by securing a budget independent from the budget for school buildings reinforcement. Since 2012, this budget has increased every year and is divided into two items: "School safety education project" and "Disaster education project". The establishment of the "Practical Disaster Education Support Project" was also implemented in 2012 for 3 years to develop and disseminate educational methods and approaches to disaster education based on lessons learnt from the GEJET. From 2015, it was known as the "Practical School Safety Support Project," also based on the Five-Year Safety Promotion Plan [7,19].

In Italy, there are laws (Ministry of The Interior Decree of the 26 August 1992 "Norme di prevenzione incendi per l'edilizia scolastica" (Fire prevention rules for school buildings) and D. lgs. 81/2008), that force every Italian workplace, including schools, to create a Risk Assessment Document and an Emergency Plan (DVR and PE are the respective Italian acronyms). The first one is a global and documented assessment of all risks for the health and safety of workers (according to this law, students are considered to be equivalent to workers), while the second is the document that lists all the emergency and evacuation operative procedures. These laws also require every employer (and therefore, every headmaster) to carry out adequate formation and information activities on risks, responsibilities and evacuation procedures and to practice these at least two times a year. Currently, among all the 40,151 school buildings, approximately 55% were built before the first half of the 1970s, i.e., before the first national regulation on specific technical rules for the seismic design of structures [20,21]. More than 40% of the buildings do not have one or more documents that, according to the Italian regulations, indicate the structure safety (i.e., static suitability, static test, compliance with safety standards and fire prevention); but 78.6% of the schools have the PE [20,21]. Moreover, since the whole national territory is a young geological area subjected to endogenous (volcanoes, earthquakes) and exogenous phenomena (landslides, coastal erosion, floods, slope instabilities and sinkholes), 41.6% of the Italian schools are located in areas with a high seismic hazard, 7.2% with a high volcanic hazard, 2.8% with a high geo-hydrological hazard and 1.7% with a high industrial hazard [20,21]. According to Canuti et al. [22], in the following, we will use the term geo-hydrological to refer to both floods and landslides.

Taking into account this international and national framework, we decided to refine the questionnaire that contributes, together with other parameters, to assessing the school-resilience employed in the Geo-hazard Safety Classification (GSC) method [1]. The GSC method and the variable school-resilience are briefly mentioned in subsection 2.2. In this paper, we present the improvements carried out questionnaires and the results of the analysis of 5899 questionnaires (820 administered to school personnel and 5079 to the students of each school stage) tested during school years 2016/2017 and 2017/2018 in 27 schools in Tuscany (Italy), and located in areas of high geo-hydrological and seismic hazards. After a brief reference to the general concept and rationale of the study and the GSC method (section 2), and a concise test sites description (section 3), we introduce the questionnaires and the adopted analysis criteria (section 4). In section 5, we present and discuss the result divided by schools, questionnaire typology (i.e., different school age), and topics.

These questionnaires are a suitable, quick, easy and low-cost tool, even if considered separately from the GSC method. The school headmasters or the local and national educational offices actually could use them a) to evaluate the geo-hydrological and seismic risk knowledge and awareness of students, professors and school personnel; b) to project and design actions needed to improve the school-resilience; c) to verify the goodness of the activities developed at point b); and d) as an educational tool to improve the disaster education, as suggested by the 2017 CSS framework.

2. General concepts and rationale for the study

2.1. Natural risk perception, awareness, and preparedness

The scientific literature provides various notions of risk and currently, it is widely accepted that risks and related damages are not only linked to the entity of natural phenomena but also to the vulnerability of the exposed elements [23]. This concept is synthesized in the well-known equation (1):

$$R = HxVxE \tag{1}$$

where H is the hazard, defined as the probability of occurrence, within a specific period of time and area, of a potentially damaging phenomenon; V is the vulnerability, defined as the degree of loss of a given set of elements at risk resulting from the occurrence of a natural phenomenon of a certain magnitude; and E is the population, properties, economic activities, public services, etc. at risk in a given area. From the perspective of disaster risk reduction, UNISDR [3] defines disaster risk as "the potential disaster losses, in lives, health status, livelihoods, assets and services, which could occur to a particular community or a society over some specified future time period". In general, Renn [24] suggests that there are two general conceptualizations of risk: realist and constructivist. The realist approach assumes that there is an objective risk of an activity or an event that we can recognize, acknowledge and measure [25]. Perception improves with more information and a greater understanding of the risk we have; the risk itself is not questioned [26]. For the constructivist approach, risk is not objective but subjective and socially constructed [27] because likelihoods and probabilities are not considered to be real phenomena.

2.2. Natural risk perception

As for risk in the literature, there is no unique definition of risk perception; it changes from author to author according to the disciplines involved and the context in which risk perception is analysed [28]. Independently from the subject and the context, many authors agree with Renn [29] in assessing that risk perception is influenced by four context levels: i) cultural background, ii) social-political environment, iii) cognitive-affective factors, and iv) general heuristics. Unfortunately, the problem is to find a common vision in which specific aspects fall into the four levels, which weigh more, and how much. A literature review on factors that influence risk perception in natural hazards can be found in Hernández-Moreno [[30], Table 1 at page 354]. For several years, great effort has been devoted to study the risk perception of natural hazards and the processes related to the balancing of risks and benefits as alternative means of hazard adjustment, and quite recently to also study its role in disaster risk management [30]. According to the rationalist view of the construct of risk perception, risk perception of natural hazards can be defined as the subjective evaluation of the likelihood of a future event occurring and of personal and material damage deriving from it. In accordance with the theoretical models proposed in cognitive and emotional psychology, risk perception may be properly conceptualized as a complex process that encompasses both cognitive and affective aspects. In this second view, the emotional processes involved in probability judgements concerning catastrophic events and their possible impact on the adoption of protective behaviours are taken into consideration [31].

There is a growing body of literature on the perception of earthquakes (es [32–35]), volcanic activity (es [36–40]), tsunamis [41–43], floods (es [31,44–46]), hurricanes and tornadoes (es [47–49]) and landslides (es [28,30,50]). The literature on children's natural risk perception is scarce and very recent compared with the literature about adults [[46] and references within]. Indeed, children's perceptions about nature and the environment are truly different from those of adults. The available research mainly concerns the implementation of earthquake emergency measures, while not much is available on flood-risk perception [46] and even less on landslides.

2.3. Natural risk awareness

As for risk and risk perception in the literature, there is no unique definition of natural risk awareness. Risk and risk perception vary according to the disciplines involved, the context in which risk awareness is analysed, and in particular from author to author. Some authors actually call and define as "awareness" the concepts that other authors define as "perception" [44,51,52]. For other authors [53], awareness is the theoretical knowledge of some selected topic related to the risk under analysis. Moreover, a very different way to measure risk awareness exists. Maidl's [54] questionnaire, for instance, investigates the relevance of natural hazards (including concern), the perceived probabilities of different hazard types in the respondents' region, and the perceived threat. Completely different is Pageneux [53], who assesses the awareness with open questions focusing on the number of events, dates, genesis and boundaries of historical events of the hazard in question.

In this work, we focus on the schools' personnel and students' awareness of natural disaster (floods, earthquakes and landslides) that can occur during school-time and can therefore affect the school building. Thus, the survey recipients are both students and school personnel (i.e., headmaster, professor, auxiliary personnel), and the awareness was evaluated, starting from a) the knowledge of the correct behaviour and procedure during an emergency at school, and b) natural risk perception (see subsection 4.1).

2.4. Natural risk preparedness

Once again, in the literature, there is no unique definition of natural risk preparedness and therefore, it is measured in many different ways. The term "preparedness", according to Ref. [3], is defined as "The knowledge and capacities developed by governments, response and recovery organizations, communities and individuals to effectively anticipate, respond to and recover from the impacts of likely, imminent or current disasters." Paton [55] disagrees since a key component of this definition is its allusion to the need for knowledge and capability to be developed, and the emphasis on preparedness as something that needs to be developed is unfounded [55]. This idea derives from recognition that the traditional assumption behind risk communication programmes that advise people of their risk will automatically motivate their comprehensive preparedness [55]. In Miceli [31], disaster preparedness is assessed by means of a questionnaire to identify the type and number of protective behaviours adopted by individuals to cope with a possible disaster. In Maidl [54], the behaviour that was already adopted by the respondents, along with the intention to prepare for an event, is assessed as risk preparedness. Together with the physical dimension of the preparedness, the researcher can consider some other dimensions, such as the psychological one. The physical dimension consists of a series of precautionary measures, such as the securing of property and goods from natural hazards. The psychological dimension refers to a mindset attentive to danger sources and oriented to anticipating and addressing the problems that are likely to appear in future emergency situations, also taking into account personal strengths and weaknesses, including the availability or lack of mutual aid networks [51].

2.5. Relationships among natural risk perception, awareness, and preparedness

The relationship between risk perception, awareness, and preparedness is widely studied, but one again, there is no unambiguous or unique result that depends on the approach and the context. Wachinger [56], after a long literature review, assesses that perception and preparedness are not necessarily linked. According Miceli [31], the link between disaster preparedness and risk perception is based on the rationalist view of the risk perception, and therefore is quite weak or even null. Loewenstein [57] starts from a cognitive and emotional view, and suggests that, at least in part, cognitive and affective evaluations influence the behaviour. Scolobing [51] and Maidl and Buchecker [44], in contrast to many other works, show that awareness and preparedness are not linked. Finally, also Paton [55], who does not take into account the psychological component, considers it to be unfounded that risk communication programmes and advising people of their risk will automatically motivate their comprehensive preparedness.

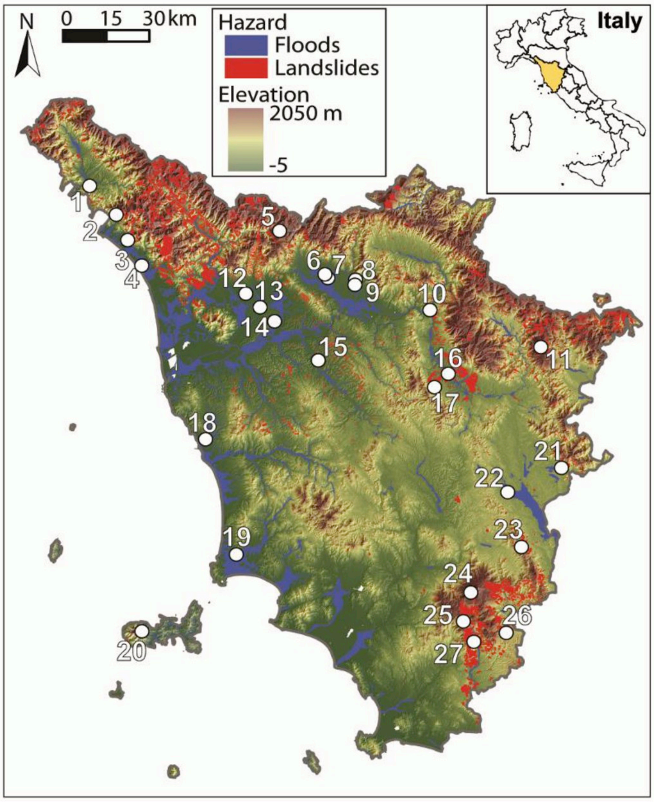

Fig. 1. Localization of the 27 studied schools over an elevation map of Tuscany: in red are the areas affected by landslides hazards and in blue, the valleys prone to floods.

2.6. The GSC method

A wider presentation and discussion of the GSC method is presented in Pazzi et al. [1]. Here, we briefly mention that this method is a useful tool to assess school hazard exposure (landslide, seismic, flood), structural vulnerability (seismic response, dampness, plan configuration) and school-resilience in a non-invasive and fairly quick way. Moreover, (i) it is based on a simple analytic procedure; (ii) it is high speed; (iii) objective in all its processing steps; and (iv) it allows an unambiguous comprehension of results. The GSC is based on the specific risk equation that also takes into account school-resilience as a risk component. The variables (hazard, vulnerability, and school-resilience) can be quantified on the basis of ancillary data (thematic maps), results of field survey data processing (seismic noise measure according to the H/V technique [58], thermographic images [59], GPS surveys [60]), and answers to questionnaires (the focus of this paper). The school-resilience value is obtained by the arithmetic mean of six data: (i) DVR completeness; (ii) integration between the building emergency plan and the municipality civil protection plan; (iii) distance between the school and strategic buildings such as hospitals or fire stations; (iv) state of the path from the school waiting area to the municipal one; (v) presence of people with a handicap, architectural barriers and trained staff; (vi) the answers to the questionnaire for the students and personnel of the school that concern the hazard perception (hydraulic, landslide and seismic). Pazzi et al. [1] defines this variable as school-resilience since it is not related to specific hazards and vulnerabilities, but it takes into account all the above-mentioned data. The re-elaborated version of the questionnaire is the topic of this work. Therefore, the answers to the questionnaire (evaluated as percentage of correct answers as shown in section 4.2) contributes, as in Pazzi et al. [1], to the school-resilience for a sixth.

Table 1
Summary table of the 27 school characteristics: PGA values (in g) for a return time of 475 years (http://esse1-gis.mi.ingv.it), flood and landslide hazard, and student age range. The PGA values in Elba Island where school no. 20 is located have not been calculated (non-existent data).

School ID	PGA [g]	Flood hazard	Landslide hazard	Students age range
S1	0.173	x		14–19
S 2	0.137		x	6–10
S 3	0.133		x	6–10
S 4	0.122	x		3–10
S 5	0.152		x	6–10
S 6	0.162		x	8–10
S 7	0.149	x		11–13
S 8	0.143	x		6–10
S 9	0.143	x		3–10
S 10	0.152	x		6–10
S 11	0.205		x	3–13
S 12	0.117	x		11–13
S 13	0.130	x		11–13
S 14	0.123		x	6–13
S 15	0.136	x		6–10
S 16	0.131		x	11–13
S 17	0.128	x	x	14–19
S 18	0.125	x		14–19
S 19	0.059	x		6–10
S 20	–	x		3–13
S 21	0.156		x	6–10
S 22	0.146	x	x	6–10
S 23	0.144		x	4.5–5
S 24	0.140		x	14–19
S 25	0.138		x	6–13
S 26	0.141		x	3–13
S 27	0.138		x	6–13

3. Test site

The school buildings included in the project were selected from the Tuscany Region (central Italy), which is considered to be a representative set of different geological environments that are actively modelled by exogenous and endogenous forces (Fig. 1). In particular, we have taken into account constructions enclosed in high seismic and geo-hydrological hazard areas, which include (individually or in composite conditions): (i) a significant seismic behaviour of the ground on which the building foundations lay according to the official national classification; (ii) the slope instabilities as recorded by the dedicated agencies; and (iii) all the dangerous hydraulic effects (e.g., floods, excessive surface runoff) as indicated by the authorized local entities. Among the catalogued edifices, 27 were finally selected, taking care to involve a large number of students of all age groups (3–19 years old) in all levels of study (Table 1). The choice of a well-scattered sample distribution for the whole region, including islands, implies not only a high representativeness of the different hazard expressions but also tries to avoid possible inter-territorial cultural influences in the questionnaire responses. Regarding the geo-hydrological danger exposure, 12 of these schools are threatened by flood events, 13 are located in areas prone to landslide, and 2 are simultaneously exposed to floods and landslides (Table 1).

The exact spatial relationship with the slope instability was estimated on the basis of the national landslides inventory, known as the IFFI project and realized by ISPRA (Italian acronym that stands for National Institute for Environmental Protection and Research), that currently counts approximately 615,000 landslides in Italy (http://www.progettoiffi.isprambiente.it/cartanetiffi/). Referring to this inventory, 6 of the selected buildings are arranged (entirely or almost entirely) in landslides areas. Regarding the state of activity classification [61], 3 of them are recorded as dormant, 1 as suspended, and the remaining 2 as stabilised. Instead, the studied buildings that are not too far away from unstable slopes (from a few meters up to approximately 300 m), but which could be involved by their evolutionary dynamics (i.

Table 2
The 7 planned questionnaires taking into account the peculiarity of each student's age (from 3 years to 19 years) and the stage of school (from the preschool to the high school) according to the Italian school system.

ID questionnaire	End user
Q1	School staff (headmasters, teachers, auxiliary personnel)
Q2	Students of high school (age range: 14–19 years)
Q3	Students of middle school (age range: 11–13 years)
Q4	Students of the last three years of primary school (age range: 8–10 years)
Q5	Students of the first two years of primary school (age range: 6–7 years)
Q6	Students of preschool (age range: 4.5–5 years)
Q7	Students of nursery school (age range: 3–4.5 years)

e., by the distribution of activity), are 9 and are positioned both on the above overhanging slopes and along the downstream areas. These landslides are divided between dormant, suspended and stabilised, and they are 3, 5 and 1, respectively.

Concerning the hydraulic hazard issue, there is no unique national or regional zonation to define the exact spatial relationship of schools with flood exposure. Furthermore, the existing classification maps have been edited by each River Basin Authority according to the executive directive of national law 183/1989, which officially designated such institutional entities to the management of the river basins. Therefore, the requested information can be found in different documents called "Piano Stralcio di Assetto Idrogeologico" (PAI), which are characterized by hazard mapping based on an immediate classification of the territory in different areas from "no hazard" to "very high hazard". In this study among the 14 schools exposed to the hydraulic hazard, 28.6% is within low-hazardous areas, the 42.8% is within medium-hazardous areas, and the 28.6% is within high-hazardous areas. Therefore, all the classes are well-represented.

In addition, regarding the seismic exposure, all of the schools are subjected to earthquakes according to the regional and local geological features. Therefore, all the Italian municipalities are classified into four seismic zone according to their Peak Ground Acceleration (PGA) value [62]. As summarized in Table 1, 6 of the selected schools are located within seismic zone 2 ($0.15\,g < PGA \leq 0.25\,g$), 20 within seismic zone 3 ($0.05\,g < PGA \leq 0.15\,g$), and only 1 (the school in the Elba island) within seismic zone 4 ($PGA \leq 0.05\,g$). Moreover, from a structural point of view, the school buildings chosen in such contexts effectively depict the variety of structural typologies that characterize national territory (structures with both regular and irregular distribution of masses as different plant shapes, including linear and compact geometries, and different floor distributions). However, the volume of buildings is reasonably aligned with the number of occupants both in buildings specifically constructed as schools and in historic buildings modified and converted over time.

4. Methodology

4.1. The questionnaires: general description

The questionnaire adopted in Pazzi et al. [1] was designed to evaluate the risk perception of the school staff and of the high school students in reference to their schools and the flood, seismic and landslide risks. The first improvement of the new questionnaires concerns the topic of the questions. In actuality, they also allow the evaluation of risk awareness (see subsection 2.1). The second improvement is the age of the interviewed people: taking into account the peculiarity of each student's age (from 3 years to 19 years) and the stage of school (from the preschool to the high school), we designed 7 different questionnaires, one for the adult personnel (headmaster, professor, auxiliary personnel) and six for the students, subdivided as summarized in Table 2.

These questionnaires were thought through and designed to investigate three main awareness fundamentals: i) school personnel and student knowledge of the correct behaviours and procedure during an emergency that occurs when they are at school; ii) perception of the geo-hydrological and seismic risk of the area where the school is located; and iii) general knowledge of the correct behaviours during a geo-hydrological and seismic emergency (i.e., landslide, flood or earthquake) that occur when they are not at school. Questions concerning point i) were not site dependent, i.e., they were not based on the specific procedures noted in the school DVR or PE, but were focused on general procedures valid everywhere. Awareness fundamentals ii) and iii), which concern contents hard to understand for pupils in the age range of 3–7 (fundamental ii) or could create a sense of anxiety and fear of unsuitableness [63] in such young children (fundamental iii), were investigated only in questionnaires from Q1 to Q4. In Q1-Q4, fundamental ii) is evaluated by means of questions on the natural hazard (landslide, flood and seismic) perception, while in Q1, there are also three questions on the building vulnerability (one for each considered a natural risk). The questions on vulnerability were limited to the school staff to avoid a sense of anxiety and fear of unsuitableness [63]. Fundamental iii), even though not strictly related to the school procedures or local geo-hydrological and seismic risks, gives information on the risk awareness level and therefore, it was considered to be a useful indirect school-resilience indicator [6,64].

Differences among the seven questionnaires not only concern the contents, as just illustrated, but also the employed methodologies. Moreover, each questionnaire, and consequently the approach, was thought through, taking into account the scholastic levels and the development of the cognitive, memory, communicative and social faculties [65]. Nevertheless, all the questionnaires from Q2 to Q7 have six features in common: a) they are based on an active assessment approach (see later in this section); b) they have an enjoyable graphical appearance to increase the students' interest and consequently to enhance their participatory attitude towards the survey; c) they are structured in a way that students cannot understand the answers implicitly expected by the researchers (this is a necessary aspect for the answers reliability) [66]; d) they ask questions paying attention to the reactions of respondents [66] without causing anxiety to students about the investigated topics (emergencies, earthquakes, floods, landslides), with particular attention to younger students; e) they were examined and evaluated by a team of expert school teachers [67] to assess if they were suitable for language, length and graphic aspect for the different age ranges. These teachers came from different schools, not those of the project, and someone was also the responsible for the school security and evacuation procedures. f) Each questionnaire was pre-tested with several classes of students of schools not involved in the project to verify if they were actually comprehensible and feasible [63,65,68]. Moreover, the teachers involved in these pre-tests filled out an evaluation form. Finally, all the questionnaires, included those for the staff personnel, were distributed in paper form to avoid problems related to the technology (the questionnaires described in Pazzi et al. [1] were online and some problems occurred), and filled in during school time.

We mention here that active assessment is a methodology that does not impose the students' knowledge and skills valuation as a rigid quantitative measurement of comprehension. In contrast, it is an integral part of their training and stimulates an active, creative and positive attitude in answering questions. Moreover, the scientist-educator plays an active role in the assessment of his/her educational programmes without using standardized, externally created assessment tools [69]. The proposed questionnaires are anonymous [66] and they are structured so that during the compilation, the students do not feel bored or worried about the results; in contrast, they feel as close as possible to the pleasure of completing a game [63]. The questions are inspired by the Naylor examples of assessment techniques [70] and by "Types of questionnaire items" described in Cohen et al. [66]. Therefore, the questions are structured in different ways: closed question, open-ended question,

Table 3
The five classes of the geo-hydrological and seismic risk and emergency procedures awareness defined on the basis of the percentage of correct answers.

	Awareness level	Percentage of correct answers
A	Very high	85% – 100%
B	High	70% – 84%
C	Medium	60% – 69%
D	Low	50% – 59%
E	Very low	≤ 49%

Table 4
Modulated awareness classes on the basis of the completed questionnaire percentage.

Percentage of complete questionnaires	Modulated awareness class
60%–100%	invariant
31%–59%	−1 class
0%–30%	−2 class

completing table, matching exercise, cartoon strip sequence, graphic organiser, sequencing, graphic open-ended question and graphic closed question (see the supplementary material for some examples).

Thus, to receive the most precise and therefore useful answers for the research, we hope to gain the maximum effort, enthusiasm and correctness of the students in answering the questions. Moreover, to prevent a negative teachers' attitude (which could have led, for example, to not submitting the questionnaire to the students or to help them in the compilation), the questionnaires are set up as a useful tool both for researchers and student training. Consequently, teachers are less inclined to consider the survey as a mere waste of time or a way to evaluate their work with the class.

4.2. Analysis criteria

Three different analyses were carried out on the collected questionnaires: a) school by school; b) questionnaire typology (i.e., different school age); and c) topics (awareness fundamentals i, ii, and iii discussed in subsection 4.1) and questionnaire typology (i.e., different school age). The first analysis allowed us to obtain the answer to one of the six questions employed to calculate the school-resilience variable in the GSC (see subsection 2.2), while the second and third analysis criteria permitted a clearer and more general idea of the student and staff awareness and geo-hydrological and seismic risk perception.

Within the GSC method, i.e., the first analysis criterion, each questionnaire has a total of 100 points, and each question has a weighted score according to its relevance in determining the school-resilience. In particular, these weighted scores range from 1 to 15 and are assigned to correct answers. Wrong or missing answers always receive a score of 0. No fractions of the weighted score are assigned to partially correct answers that, therefore, are considered totally wrong. Higher scores are assigned to awareness fundamentals i) taking into account the role of the interviewed (student or staff personnel), the age and therefore, the scholastic level. Consequently, the sum of the correct answers related to this indicator is 85 in Q1, 60 in Q2 and Q3, 65 in Q4, and 100 in Q5, Q6 and Q7 (these questionnaires consist of just one question focused on marker i; see supplementary material). On the basis of the total score, we classified each school according to a five classes scale, as shown in Table 3. This value indicates the geo-hydrological and seismic risk and emergency procedures awareness.

From the analysis of the questionnaires for each school, we obtained two different geo-hydrological and seismic risk and emergency procedures awareness values/classes (AC); one referred to the students (called in the following, sAC) and one to the staff personnel (called in the following, pAC). Both of them are later modulated on the basis of the percentage of complete questionnaires as specified in Table 4. We provided 5899 questionnaires (5079 to students and 820 to staff) and they returned 4859 (4169 of students and 690 of staff). A low number of completed questionnaires, taking into account the purposes of the project (i.e., disaster education, enhancing the school-resilience and geo-hydrological and seismic risk awareness evaluation), was considered as an indicator of lack of interest, i.e., if people do not have interest in answering the questionnaire, for us it means that they think geo-hydrological and seismic hazards/risks are not a problem for them, so they do not waste time in answering. Therefore, for us, the percentage of completed questionnaires have to be taken into account in evaluating the risk/hazards awareness and perception, which is why we decide to modulate the sAC and the pAC, obtained from the questionnaire analysis, on the basis of the percentage of complete questionnaires, obtaining two new classes: MsAC and MpAC.

The last step of the analysis is to assign to each school the lower class between the MsAC and the MpAC. The behaviours held by the students and the staff during a geo-hydrological and seismic emergency at school

School ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
sAC	B	A	A	B	B	A	B	A	A	B	A	C	B	B	A	B	C	C	A	B	B	B	A	C	C	B	B
MsAC	B	A	A	B	B	A	B	A	A	B	A	C	B	B	A	B	D	C	A	B	B	B	A	D	C	B	B
pAC	C	C	D	C	C	C	D	D	C	C	B	C	C	C	D	C	C	C	D	D	B	D	C	D	D	C	D
MpAC	C	C	D	C	C	C	D	E	C	C	B	C	C	C	D	C	C	C	D	D	B	D	C	E	D	C	D
AC	C	C	D	C	C	C	D	E	C	C	B	C	C	C	D	C	D	C	D	D	B	D	C	E	D	C	D

Fig. 2. Student awareness classes (sAC) and personnel awareness classes (pAC) as obtained from the analysis of the questionnaire, and modulated student awareness classes (MsAC) and modulated personnel awareness classes (MpAC) on the basis of the completed questionnaire percentage (Tables 4 and 5). In the fifth row, the final AC (the lower between the MsAC and the MpAC) is illustrated. A remains for a very high awareness level, B for high, C for medium, D for low, and E for very low, as shown in Table 3.

Table 5
For each school (S1–S27, see Fig. 1 for their location) the students and personnel percentage of answers employed to modulate the sAC and the pAC is indicated, according to Table 4.

School ID	Students answer percentage [%]	Personnel answer percentage [%]
S1	81.4	100.0
S2	92.3	100.0
S3	90.0	77.8
S4	94.0	87.5
S5	90.6	100.0
S6	96.7	100.0
S7	74.6	87.8
S8	86.4	40.0
S9	84.8	80.6
S10	95.1	81.3
S11	97.5	90.0
S12	94.4	93.2
S13	89.2	94.6
S14	72.2	68.6
S15	90.1	98.0
S16	98.3	100.0
S17	57.7	83.8
S18	82.7	73.3
S19	95.3	77.3
S20	68.6	100.00
S21	89.4	95.5
S22	75.0	92.1
S23	80.0	100.0
S24	45.0	33.3
S25	87.0	62.5
S26	77.5	83.0
S27	90.7	94.4

are inevitably connected and in a disaster emergency, younger people look for guidance from supportive adults [71]. Therefore, at school, students look to their school staff expecting to be kept safe, to be reassured and to be reunited with their families [71].

The second analysis criterion, i.e., the analysis according to the questionnaire typology, is carried out in two different ways. The first procedure took into account both the weighted scores described above and the way to modulate the final class according to the completed questionnaire percentage (Table 4). This makes the AC more focused on the interviewed perception of the geo-hydrological and seismic risk emergency procedure at school, given the greater weight assigned to the answer of indicator i). The second method assigns the same score, equal to 1, for each correct answer (and 0 for incorrect or missing answers, as in the previous method), calculates the percentage of correct answers, and assigns the final AC on the basis of Table 2. Therefore, the AC is more general, i.e., indicates the interviewed geo-hydrological and seismic risk awareness and perception.

The last analysis criterion is based on the topics (resilience fundamentals i)-iii)) and therefore on the questionnaire typology. To each correct answer, a score equal to 1 is assigned, and 0 to incorrect and missing answers. Consequently, it is possible to compare the answers of the different age ranges for the same topic.

5. Results and discussion

5.1. Results of the analysis school by school (the values employed in the GSC)

Below, we present the result of the analysis school by school. In Fig. 2, the sAC, MsAC, pAC and MpAC are shown. In the fifth row is the final AC attributed to each school.

In Fig. 2, it is noteworthy that the sAC is at least C (5 schools, i.e., 18.5% of the schools) or higher (B in 13 schools, i.e., 48.1% of the schools and A in 9 schools, i.e., 33.4%), while the pAC is never A, and it is B in only 2 schools, i.e., 7.4% of the schools, C in 15 schools, i.e., 55.5%, and D in 10 schools, i.e., 37.1%. Fortunately, no one is in class E. Moreover, the sAC is always equal (4 schools, those with ID S12, S17, S18, and S21 over 27, which means 14.8% of the schools) or higher (23 schools over 27, which means 85.2% of the schools) than pAC. In 40.7% of the schools (i.e., 11 schools over 27, those with ID S1, S4, S5, S10, S11, S13, S14, S16, S24, S25 and S26), there is just one AC of difference between students and staff, while in 29.6% (i.e., 8 schools over 27, those with ID S2, S6, S7, S9, S20, S22, S23, and S27) there are two classes, and in 14.8% (i.e., 4 schools over 27, those with ID S3, S8, S15 and S19), even three.

If we take into account the percentage of completed questionnaires (Table 5), we note that in 24 schools, the percentages of responders are higher that 60% for both students and personnel, which means no modulation of AC were made (Fig. 2). In one school (S8), the personnel percentage was lower than 60%, and given the value (40% i.e., according to Table 4 means −1 class), the pAC from D was modulated into a MpAC of E (Fig. 2). In another school (S17), the student percentage was lower that 60%, and given the value (57.7% i.e., according to

		Q1	Q2	Q3	Q4	Q5	Q6	Q7
		i, ii, iii	i, ii, iii	i, ii, iii	i, ii, iii	i	i	i
	Delivered questionnaires [adim]	820	553	1374	1619	982	120	92
	Percentage of the total [%]	14.2	7.9	26.9	29.1	17.6	2.4	1.9
	Filled in questionnaires [adim]	690	384	1305	1415	857	117	91
	Percentage of the total [%]	84.1	69.4	95.0	87.4	87.3	97.5	98.9
Weighted score	Total percentage score [%]	60.9	67.5	74.4	81.6	89.6	97.6	90.4
	Awareness class [adim]	C	C	B	B	A	A	A
	Grouped total percentage score [%]	60.9	76.8			90.6		
	Grouped awareness class [adim]	C	B			A		
Not-weighted score	Total percentage score [%]	55.0	71.8	84.6	87.2	86.9	97.6	96.7
	Awareness class [adim]	D	B	B	A	A	A	A
	Grouped total percentage score [%]	55.0	84.2			88.8		
	Grouped awareness class [adim]	D	B			A		

Fig. 3. Results of the questionnaire typology analysis carried out taking into account the weighted scores described in subsection 4.2.

	Q1	Q2	Q3	Q4	Q5	Q6	Q7
Resilience fundamental i_a	62.0	81.3	87.6	93.4	89.6	97.6	90.4
Sub-topic i_a1	48.4	89.6	91.6	94.6	89.6	97.6	90.4
Sub-topic i_a2	83.6	72.9	83.0	92.8	/	/	/
Resilience fundamental i_b	/	57.3	63.5	74.1	/	/	/
Resilience fundamental ii	37.8	56.8	58.0	45.9	/	/	/
Resilience fundamental iii	71.7	67.4	76.9	80.7	/	/	/

Fig. 4. Percentage results of the topic and questionnaire typology analysis carried out taking into account the same score, equal to 1, for each correct answer and equal to 0 for incorrect and missing answers. For topic i-a), the percentage result of two questions common to all the questionnaires is also presented.

Table 4-1 class), the sAC from C was modulated into a MsAC of D (Fig. 2). Finally, in a third school (S24), both the student and personnel percentages were lower that 60%, and given the values (45.0% and 33.3%, respectively, i.e., according to Table 4-1 class), the sAC from C was modulated into a MsAC of D and the pAC from D was modulated into a MpAC of E (Fig. 2). Consequently, we deduce that the MpAC is the worst class in 85.2% of the schools (23 out of 27). In 11.1% of the schools (S11, S18, and S21), the MsAC and MpAC are the same, and only in 3.7% (S17), the worst class is the MsAC. In the last school, only 57.7% of the students completed the questionnaire, but it is plausible to think that they did not fill in the questionnaire because the professors did not distribute them.

The results of this first analysis criterion actually improve the school-resilience evaluation in the GSC method since they provide relevant information on the topic. The undoubtedly more relevant and unexpected information is that the sAC is always proportionally (i.e., the awareness level is assessed in relation to the age and the role of the interviewed) higher, or at least equal, than that of the respective staff. The high percentage of answers reveals that the choices made in the design phase of the questionnaires (see the end of session 3.1) were efficient.

5.2. Results of the questionnaire typology analysis

The questionnaire typology (Q1-Q7) analysis corresponds to an analysis according to the interviewed age ranges (see Table 2). In Fig. 3, the results of the analysis carried out with the two different procedures described in subsection 4.2 are displayed: a) taking into account the weighted scores (described in subsection 4.2) and the modulated awareness classes (Table 4) (in the following method one), and b) assigning the same score to each correct answer (in the following method two). As shown in Fig. 3, all the questionnaire typologies have an answer percentage higher than 59.0% (Table 4), so none of the final classes were modulated. Moreover, we took into account that the student questionnaires Q2, Q3, and Q4 were focused on all three awareness fundamentals (described in subsection 4.1), while the student questionnaires Q5, Q6, and Q7 only focused on the awareness fundamentals i). Therefore, we grouped the student results in two clusters: a) age range 8–19 years, and b) age range 3–7 years. Accordingly, it is also possible to compare the student first cluster results with those of the staff since the questions were focused on the same three awareness fundamentals.

The method one and method two results show that the pAC is C (i.e., 60.9% of correct answers) and D (i.e., 55.0% of correct answers), respectively, while the sAC of the first cluster (8–19 age range) is always B (i.e., 76.8% and 84.2% of correct answers, respectively). From these analyses, it is possible to assess that the sAC is higher than that of the staff, regardless of the pupils age ranges and the two different ways to perform the analysis. While the pAC obtained by means of method one is at least sufficient (60.9%, Class C), that obtained by method two is not sufficient (55.0%, class D). These results confirm those of the analysis school by school (subsection 5.1). It is also noteworthy that the correct answer percentage has an increasing trend as the student interviewed age decreases, regardless of the analysis method and both considering clustered and not clustered questionnaires. Nevertheless, these results do not imply that young children are more prepared than older children or even teachers. By contrast, these results suggest that the disaster education provided by the different typology of the school is perfectly adequate for young pupils, but slightly less appropriate as the responsibilities owed to age or role increase. In particular, these results indicate that the geo-hydrological and seismic risk awareness of staff in charge of the pupils' disaster education is almost inadequate. This last outcome was unexpected and therefore interesting to suggest priorities for future school-based emergency management actions. These results actually identify future strategy action, such as the improvement of the geo-hydrological and seismic hazard dissemination within the entire community.

5.3. Results of the topics and questionnaire typology analysis

In Fig. 4, the percentage results of the topic and questionnaire typology analysis carried out as described in subsection 4.2 are shown. In student questionnaires Q2-Q4, the awareness fundamental i) focused on the knowledge of the correct behaviours during an emergency at school, could be divided into two sub-topics: a) behaviours for which the students are directly responsible (called in the following i-a), and b) behaviours that are the responsibility of the staff (called in the following i-b). Within sub-topic i-a, there are two questions with issues in common with both students and personnel. The first one (i-a1 in the following) is focused on the knowledge of the evacuation procedures, while the second (i-a2 in the following) is on the procedure during an earthquake.

The results of this analysis confirm those of the previous two. Furthermore, they show that students of all age ranges have a suitable awareness and knowledge (i.e., 81.3% or higher) of the correct behaviours during an emergency at school, for which they are directly responsible (topic i-a). In contrast, the staff awareness and knowledge of the procedures under their responsibility is less appropriate (62.0% of correct answers). If we analyse, in-depth, the responses at the i-a1 and i-a2 issues, it is possible to note that the main staff lack concern about the evacuation procedure (only 48.4% of correct answers). In particular, there are two questions, on the i-a1 issue, to which the staff answered the worst. The first asked the staff, where is the safe place for the parents to pick up their children after an emergency (in Italy, this place is regulated by the city civil protection plan, and it is not the safety area near the school), and the second asked them how to reach this safe place. Only 24.2% of the staff answered in the correct way to the first question and 36.1% to the second. Therefore, it is possible to infer that the main

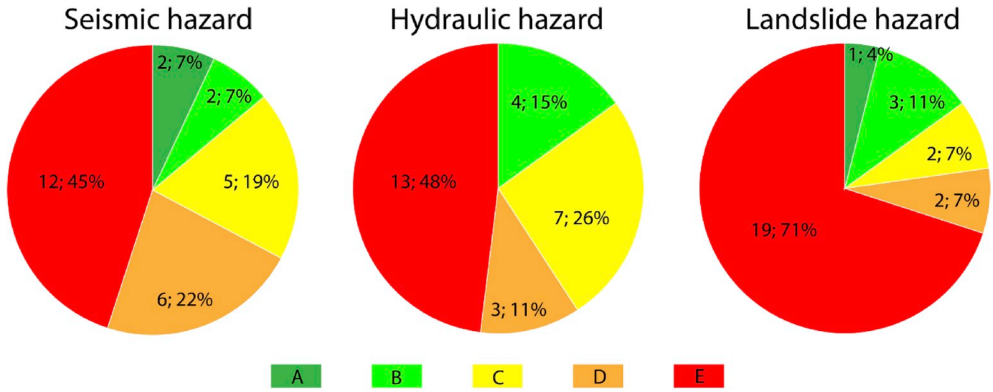

Fig. 5. Seismic, hydraulic and landslide hazard perception of all interviewed people (students and personnel) grouped school by school. Classes refer to the percentage of correct answers indicated in Table 3.

responsibility of the staff lacking results is probably largely caused by a missing link between the school PE and the civil protection plan. Subsequently, this missing link is produced by poor communication between the municipality offices and the school management offices.

Taking into account the percentage of responses for awareness fundamentals ii (the lowest value of correct answers is 37.8% and the highest is 58.0%), it is noteworthy that both the school personnel and the students have a wrong awareness of the geo-hydrological and seismic risk affecting their schools. Once again, the personnel achieved the worst result, which confirms the work of Miceli et al. [31] and Salvati et al. [50], who found that the younger people's perception of flood and landslide risk is higher than older people. In Fig. 5, the seismic, hydraulic and landslide hazard perceptions of the 27 schools are shown, subject to the investigation obtained from the analysis of the answers of the students (age range: 3–19 years) and personnel to three questions (one for each hazard). According to Paton [36], a missing risk awareness leads to underestimating the importance of the prevention actions. However, people are equally unlikely to act if hazard effects are perceived as insurmountable (low outcome expectancy) [36]. The results indicate that, for the landslide hazard, in 78% of the schools (21 schools over 27), less than 50% of people have a correct perception of the hazard of the area; for the seismic hazard, in 76% of the schools (18 schools over 27), less than 50% of people have a correct perception of the hazard of the area; for the hydraulic hazard, in 59% of the school (16 schools over 27), less than 50% of people have a correct perception of the hazard of the area. This result is in agreement with the conclusion of a survey carried out in 2013, according to which, the seismic risk perception in Italy is strongly underestimated [72,73] and is in agreement with Salvati's conclusion [50] that, in Italy, the perception of the threat posed by landslides and floods, in general, does not match the actual risk to the population.

The Italian legislation already underlines the importance of close collaboration between local authorities and educational institutions to promote a resilience culture. The results of this part of the study are useful to identify a strategic action to develop resilience. Furthermore, increasing and developing the geo-hydrological and seismic hazards perception of children and adults is an important factor in developing community resilience and not only in disaster education [33]. To enhance the hazard perception of communities that live in an area with a high geo-hydrological and seismic hazard [38,74–76] is better than only practising evacuation procedures. People actually interpret geo-hydrological and seismic risk information on the basis of their experience, beliefs and expectations [39] and references within]. Therefore, increasing the risk acceptance levels and people's willingness of taking responsibility for their own safety is the right way to enhance the community resilience [39], to ensure the adoption of appropriate levels of planning [42] and therefore the school-resilience. This strategic action has to be planned and carried out by the local administrations [38,39] and cannot be left to the goodwill of the school headmasters [14], even though, by law, they are in charge of personnel and student safety.

6. Conclusions

In the current work, we present the results of the analysis of 7 different questionnaires developed to assess the geo-hydrological and seismic risks awareness in schools and to improve the school-resilience evaluation within the GSC method. With this update, the GSC takes into account the geo-hydrological and seismic risk awareness and knowledge of correct behaviours during an emergency. Moreover, the new questionnaires consider the peculiarity of each student age (from 3 years to 19 years) and therefore stage of school (from nursery school to high school). These questionnaires reveal themselves to be a useful tool even separately from the GSC method. The school headmasters could actually employ them as an easy, detailed and zero-cost tool to assess the geo-hydrological and seismic risk awareness and emergency correct behaviour knowledge of their staff and students. Consequently, on the basis of the results, they can plan resilience improvement actions.

Three different analysis criteria (1. school by school, 2. questionnaire typology and 3. topic and questionnaire typology) were employed to examine 5899 questionnaires distributed in 27 schools in Tuscany (Italy). The results are coherent and show that a) young children's knowledge is perfectly adequate to their age, b) as the age and responsibilities increase, the awareness and preparation do not increase proportionally, and c) the competences of the staff in charge of the pupils disaster education are not sufficient, probably because, among other things, the wrong hazard perception leads to underestimating the importance of prevention actions and disaster education. This last outcome turns out to be unexpected. It is interesting to address the future actions on disaster education to reduce damage to critical infrastructure and the disruption of basic services, as stated by the SFDRR. The analysis of the topics actually revealed two main problems/lacks. The first one is that the school staff does not know the procedure after the school evacuation. The second is the staff and students incorrect geo-hydrological and seismic hazard perception (both underestimated and overestimated). However, both could be attributed to a poor connection between the school evacuation plans and the city civil protection plan and to a lacking communication between local authorities, in charge of the community civil protection, and the educational offices.

Therefore, not only to increase the school resilience but also to develop a resilience culture in the community, it is necessary that the local administrations a) improve the dissemination of the geo-hydrological and seismic hazard of their municipality, b) provide useful tools to link the city civil protection plan with the schools evacuation plans.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijdrr.2019.101280.

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