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Preparing children to cope with earthquakes: Building emotional competence

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Abstract

Natural disasters, including earthquakes, can have a traumatic impact on children's psychological wellbeing and development. The efficacy of interventions aimed at enhancing children's socio-emotional learning has been documented in the literature. At the same time, these techniques are the key for training children for possible future disasters by enhancing their knowledge about behavioural preparedness and emotional competence. However, research on evidence-based training programs on earthquakes combining digital and traditional activities is scarce. We tested the efficacy of a 10-unit training program for primary school children, developed within the Emotional Prevention and Earthquakes in Primary School (PrEmT) project. The program aimed at increasing knowledge of and metacognition about earthquakes, safety behaviours, emotions, and coping strategies, through digital (using the web-application HEMOT®, Helmet for EMOTions, developed ad-hoc) and traditional activities (completing paper-and-pencil tasks). The participants were 548 second and fourth-graders from Italian schools. They were divided into an experimental group (participating in the training program) and a control group. Both groups participated in pretests and posttests to evaluate changes in their knowledge of training-related contents. For ethical reasons, we also measured children's wellbeing. Generalized linear mixed models indicated an improvement in the experimental group's knowledge and metacognition about earthquakes, safety behaviours, emotions, and coping strategies after the training program, compared to the

This article is based on a project described in an Italian book (Raccanello, Vicentini, et al., 2021), one paper (Raccanello et al., 2019), and three conference presentations (Vicentini et al., 2019, Vicentini, Raccanello, et al., 2022, Vicentini, Raccanello, Rocca, et al., 2022).

control group. Children's general wellbeing did not deteriorate during participation in the project. The results documented the efficacy of the evidence-based training program developed within the PrEmT project. The program provides a preventive method for enhancing earthquake-related resilience that could be generalized to other kinds of disasters.

KEYWORDS

children, earthquake, emotional competence, evidence-based intervention, prevention

BACKGROUND

Emotional competence enables individuals to better cope with life demands. Like other natural disasters, earthquakes have the potential to disrupt everyday life and to overcome people's emotional resources for dealing with emergencies. Enhancing children's emotional competence together with training them about how to behave in the event of an earthquake before an earthquake occurs can make the difference between survival or injury and death. Nevertheless, little attention has been given to implementing and testing the efficacy of psycho-educational actions designed to foster children's resilience in the event of a disaster. Therefore, within the Emotional Prevention and Earthquakes in Primary School project (PrEmT, in Italian *Prevenzione Emotiva e Terremoti nella Scuola Primaria*, https://www.hemot.eu) we developed an evidence-based intervention aimed at promoting knowledge and metacognition of earthquakes, as well as the understanding of related emotions and emotion regulation, among primary school children.

Disasters can be defined as collective traumatic events that impact many people or a whole community (McFarlane & Norris, 2006). They can be conceptualized as having a sequence of phases, i.e., a nondisaster phase, a predisaster phase, an impact phase, an emergency phase, and a reconstruction phase (Noji, 1997). Ideally, programs designed to increase emotional resilience are carried out in advance of a disaster – during the 'nondisaster' phase – when people are not under threat or feeling high levels of stress that would interfere with knowledge acquisition (Ford & Nichols, 1991; Maslow, 1970). We conducted the research described here during a period in which the threat of earthquakes was relatively low but using contents focused on the impact, emergency, and reconstruction phases that typically occur during an earthquake.

Impact of natural disasters on children

Natural disasters are events that have serious negative consequences for people's life, possessions, and environment (Shaluf, 2007). They have a negative impact on the safety and health of communities, interrupting their normal functioning and resulting in an imbalance between people's resources and the demands placed upon them by the disaster (UNISDR, 2009). As in other natural disasters, earthquakes may have traumatic effects on the psychological functioning of people who experience the event (Fergusson & Boden, 2014; Galambos, 2005). This is particularly true for children, whose vulnerability depends on their level of cognitive, metacognitive, emotional, and social development (Kar, 2009; Masten & Narayan, 2012; Masten & Osofsky, 2010).

Several studies describe the traumatic consequences of various kinds of disasters in terms of deterioration of physical health, increased psychopathology, and negative emotional impact (Dai et al., 2016; Furr et al., 2010; Hong & Efferth, 2015; Hopwood & Schutte, 2017; Lai et al., 2014; Neria et al., 2008;

Tang et al., 2014; Wang et al., 2013). These events may affect victims directly exposed to disasters and victims indirectly exposed, for example through the mass media (UNDRR, n.d.-a). Some researchers have documented increases in post-traumatic stress disorder (PTSD), depression, anxiety, fear, and other traumatic symptoms among children (An et al., 2013; Celebi Oncu & Metindogan Wise, 2010; Goenjian et al., 2011; Gökçen et al., 2013; Karairmak & Aydin, 2008; Kolaitis et al., 2003; Tian et al., 2013; Wang & Gan, 2011; Yang et al., 2014; Zhang et al., 2014; Zheng et al., 2012; Zhou et al., 2015, 2016, 2018; Zhou & Wu, 2016). Examining the narratives authored by children exposed to earthquakes and reports by adults, shows that fear and anxiety are the emotions most frequently associated with earthquakes, followed by sadness (Raccanello et al., 2017, 2021). Nevertheless, some studies give hints about children's resilience, indicating for example that, 2 years after an earthquake, there were no differences in the development of the abilities to understand and regulate emotions between direct victims and a control group (Raccanello et al., 2017).

Emotional competence in children

The abilities to express and understand emotions, together with the ability to regulate them, are basic components of emotional competence (Denham, 1998).

According to Pons et al. (2004), the understanding or knowledge of emotions includes nine subcomponents grouped into three dimensions, pertaining to the nature of emotions, their causes, and their regulation. The first dimension comprises understanding the nature of emotions by, for example, the correct recognition and categorisation of emotions based on facial expressions. This ability is central for non-verbal communication of emotions, while mastering a psychological lexicon plays a key role for the corresponding verbal expression of emotions (Lewis, 2016). The second dimension involves understanding the causes of emotions including external events such as earthquakes, tornados, or tsunamis that can provoke similar emotions (e.g., fear and anxiety). The third dimension concerns understanding the ability to regulate emotions. Children develop the skills to recognize a range of emotions at about 2/3 years; an understanding of the causes of emotions at about 3 years; and an understanding of the ability to regulate emotions at about 8 years. They gradually refine these abilities during development.

Emotion regulation refers to the processes through which individuals moderate their emotions (Gross, 1998). Initially, young children mostly regulate their emotions extrinsically with interindividual support; gradually, they become better at using intrinsic and intraindividual resources (Phillips & Power, 2007; Rothbart & Bates, 2006; Sroufe et al., 2005). In parallel, they become more able to use cognitive as well as behavioural emotion regulation strategies (Dennis et al., 2009; Gross, 2008; Thompson & Goodvin, 2007). Moreover, at least for adults, thinking that one can change one's own emotions can be an important element in emotional control (De Castella et al., 2013). When facing traumatic events, people resort to coping strategies to reduce the negative impact of the events (Lazarus & Folkman, 1984; Skinner et al., 2003; Skinner & Zimmer-Gembeck, 2007) – for a discussion on analogies and differences between emotion regulation and coping see Compas et al. (2014). Zimmer-Gembeck and Skinner (2011) argued that uncertain or challenging events can threaten three basic human needs, i.e., the needs for competence, relatedness, and autonomy (Deci & Ryan, 1985). They presented a taxonomy which classified coping strategies into three categories focused on meeting these three basic human needs. For each category, they identified two adaptive and two maladaptive strategies. The adaptive strategies were, for competence: problem solving and information seeking; for relatedness: self-reliance and support seeking; and for autonomy: accommodation and negotiation. The two maladaptive strategies were, for competence: helplessness and escape; for relatedness: delegation and social isolation; and for autonomy: submission and opposition. These strategies are typically activated in the face of perceived challenges or threats (for a more detailed description, see Zimmer-Gembeck & Skinner, 2011; for applications, see Burro et al., 2021; Raccanello, Vicentini, Rocca, et al., 2020, Raccanello et al., 2021; Vicentini, Burro, et al., 2022). A meta-analysis of data on natural disasters indicated that for children and adolescents, strategies such as problem solving and support seeking are positively associated with indicators of wellbeing, while strategies such as escape, delegation, social isolation, and opposition are positively associated with traumatic symptoms (Raccanello et al., 2023). A study using a sample of adults as reporters, indicated that the most effective strategies that children can use to cope with earthquakes are problem solving, information seeking, self-reliance, support seeking, and accommodation (Raccanello et al., 2021).

In summary, previous literature indicates that emotion recognition, understanding, and regulation improve as age increases, however, less is known about how these changes pertain to emotion and emotion regulation concerning natural disasters, and in particular earthquakes (Johnson et al., 2014). Understanding these relationships is a necessary precursor for planning the content of disaster preparedness programs so that they are appropriate for the participants, considering their level of cognitive and emotional development, along with the extent of their existing topic knowledge.

Disaster-related interventions for children

Two pivotal concepts for disaster-related coping are preparedness and prevention. The United Nations Office for Disaster Risk Reduction defines disaster-related preparedness as the knowledge and the ability of governments, organizations, communities, and people to 'effectively anticipate, respond to, and recover from the impacts of likely, imminent, or current disasters' (UNDRR, n.d.-b). Prevention refers to 'activities and measures to avoid new disaster risk' and to reduce 'vulnerability and exposure in such contexts' where disaster risks cannot be eliminated (UNDRR, n.d.-c). These concepts can be applied to children by fostering their knowledge about the nature of earthquakes and the related safety measures, together with an understanding of emotions and emotion regulation. These interventions can help limit secondary consequences, such as psychological traumatic reactions and the development of psychopathologic symptoms, of a stressful event.

While recognizing the importance of preparedness and prevention, many disaster risk management programs underestimate the relevance of psychosocial factors in disaster-related preparedness, response, and recovery (Pacheco et al., 2021). Addressing this problem is key to enabling children (and their families) to prepare physically and psychologically for future or imminent disasters (Ronan et al., 2008). Schools can be an ideal environment in which to implement appropriate programs for children (Elangovan & Kasi, 2015; Pacheco et al., 2021; Ronan et al., 2008). Elangovan and Kasi (2015) described an intervention consisting of four modules that integrate psychosocial aspects and physical preparedness concerning disasters conducted by trained teachers with sixth and eighth-graders. Compared to a control group, children participating in the training program showed an improvement in their knowledge from the pretest to the posttest session. Moreover, involving children in such initiatives has several advantages for family and community preparedness (Ronan et al., 2008). In fact, from a motivational perspective, children are participants full of enthusiasm and this leads them to talk about the interventions with families and friends, disseminating content and consequently helping increase preparedness at a community level (Ronan & Johnston, 2005).

It is important to note that most of the evidence-based psychological interventions aimed at helping children deal with natural disasters took place after their occurrence. Some meta-analyses and systematic reviews have provided support for a variety of interventions – which included school-based programs – as reducing PTSD, anxiety, and depression (Brown et al., 2017; Fu & Underwood, 2015; Pfefferbaum et al., 2017, Pfefferbaum, Nitiéma, et al., 2019, Pfefferbaum, Nitiéma, Newman, et al., 2019). Moreover, some researchers have explored approaches aimed at reducing earthquake-related fear (Karairmak & Aydin, 2008). Nevertheless, little is known about the value of interventions designed to develop children's emotional competence for coping with the psychological trauma associated with future earthquakes.

The psychological literature has amply documented the efficacy of interventions using socio-emotional learning (SEL) on children's emotional competence in the context of a wide range of outcomes such as social interactions and school performance (Durlak et al., 2011, 2022; Qualter et al., 2017). These programs integrate cognitive, emotional, and behavioural processes to increase awareness, responsible decisions, and management of behaviours (Brackett & Rivers, 2014).

A meta-analysis including more than 200 studies with primary to lower secondary school students, indicated that SEL programs positively influence a wide range of abilities, comprising both social and emotional skills, school success, social relations, and problematic behaviours (Durlak et al., 2011). Recently, a review of meta-analyses confirmed the overall efficacy of these interventions worldwide for improving students' personal and social skills, attitudes, positive social behaviours, and academic performance, while reducing negative behaviours and emotional distress (Durlak et al., 2022). However, interventions conducted before disasters rarely complied with the standards for evidence-based research (Flay et al., 2005; Gottfredson et al., 2015), which include comparing pre and post-intervention measures, using rigorous statistical procedures and data gathering methodologies, and carrying out long-term follow-up.

Novel technologies and games play an increasing role as tools to facilitate learning and, given their attractiveness, they can be a potent resource for teaching about disaster preparedness (D'Amico, 2018) and for fostering children's motivation, autonomy, engagement, and problem solving abilities (Sung et al., 2016). Nowadays, the Internet is a dominant medium for widely disseminating information in the field of disaster management. Web and mobile-based resources can be useful means for increasing preparedness. Verrucci et al. (2016) reviewed the role of digital media for preparing for earthquakes and fires. In the case of earthquakes, they found more than 70 websites and more than 150 mobile applications that provided information about correct safety behaviours and household preparedness. However, they highlighted that only few of them were directed at children. More recently, a review described the contents of earthquake-related mobile applications free to download from the Google Play Store (Raccanello, Vicentini, et al., 2020): Among the 20 identified applications, none really addressed psycho-emotional issues, giving more attention to information about the characteristics of seismic events and safety behaviours.

Knowledge and psycho-education about disasters

Psycho-educational interventions are rarely based on specific theoretical models that elucidate the psychological mechanisms underlying the phenomena at issue. Within the PrEmT project, we developed a preliminary theoretical model describing the psychological processes related to the responses in the face of a disaster, i.e., the Psychological Functioning in Disaster model (PFD; Raccanello, Vicentini, Florit, et al., 2020, Raccanello, Vicentini, Rocca, et al., 2020). The model postulates that training on emotional preparedness has a particular relevance in helping individuals encode the declarative and procedural knowledge about safety behaviours and emotion regulation strategies that needs to be retrieved during and just after an emergency. When a disaster occurs, people in the immediate area can be exposed to a wide range of unusual stimuli generated by other people and/or environmental events. Knowing how to respond in this situation can be critical for safety and survival. This process can be facilitated if knowledge of the likely attributes of the disaster is encoded before the disaster occurs and retrieved from long-term semantic, episodic, and/or procedural memory (Squire, 1986; Tulving, 2012).

The PrEmT training program is designed to facilitate an understanding of what the experience of an earthquake would be like and what kinds of actions are likely to maximize safety. Knowledge about the nature of an earthquake, emotions that might be experienced, and coping strategies can be learned. The process of training is aimed at optimizing the way the information is stored in memory. The recollection of the training activities can be encoded mostly as episodic memory, while knowledge of activities such as school evacuation drills can be stored primarily in the procedural memory. These stimuli can also enter the autobiographical memory, i.e., the collection of events significant for a person, which has a key role for defining oneself, adapting to the demands of a particular context (Fivush, 2019), and interpreting what is happening (Bruner, 1991). The direct experience of a traumatic event has, for example, been revealed as one of the factors underlying the more complex conceptualisation of earthquakes held by Italian second and fifth-graders compared to children who had not experienced one (Raccanello et al., 2017).

The retrieval of all this information impacts the later decision making processes (Kahneman & Tversky, 1979; Zhang et al., 2018), which in turn influence the repertoire of responses to the disaster. Within the whole process, emotions play a paramount role, influencing perception, memory, decision making, and responses, and in turn being influenced by them through a complex pattern of intertwined and bidirectional relations (Barrett et al., 2016; Christianson, 2014).

Improving disaster risk awareness is considered a precondition for disaster risk reduction (Prevention Web, n.d.). To reach this objective, the UNDRR claims as fundamental the need to make research-based knowledge easy to understand and available for a variety of users. A large body of studies on disaster psychology indicates that there is a certain distance between how experts and lay people perceive risk (Ho et al., 2008; Paton et al., 2008), and that such distance is frequently at the basis of misunderstanding, miscommunication, and failure of policy implementation (Drennan, 2018). However, involving a large sample of 11 to 14-year-olds in Nepal and Turkey, Yildiz et al. (2022) found that their risk perceptions were in line with their country-specific objective risks, but there was room to improve their knowledge about safety behaviours. Therefore, it is important to design actions to align people's knowledge about disaster risks with the knowledge of experts. This is particularly so in the case of young people (Midtbust et al., 2018).

While at least 30 years of scientific research has clarified our knowledge of how natural disasters occur, little attention has been paid to the developing of usable materials and interventions to help lay people understand the mechanisms of natural disasters and how to mitigate the personal risks involved (Prevention Web, n.d.). We are aware of the so-called 'knowledge–behaviour gap' arising from the observation that, in the context of disaster interventions, an improvement in knowledge does not necessarily lead to an increased capacity to act correctly when needed (Nakano & Yamori, 2021). However, current research reports contradictory findings about this presumed gap (Grolnick et al., 2018). On the one hand, a review of disaster education programs developed for children indicated that there is little empirical evidence supporting the likelihood that such programs transform into appropriate protection behaviours (Johnson et al., 2014). On the other hand, other studies suggest that prior knowledge on earthquakes promotes actions mitigating the subsequent damage, at least in adults (Hurnen & McClure, 1997; Tekeli-Yeşil et al., 2010). This is supported also by some data on the COVID-19 pandemic indicating that students' quality of life was higher for those students who, before its outbreak, were better at describing their emotions and had access to a larger range of emotion regulation strategies (Panayiotou et al., 2021). Moreover, not much is yet known about the mechanisms explaining how disaster education facilitates coherent protective behaviours (Johnson et al., 2014). According to some authors, the outcome of disaster risk education, including the presence of a knowledge–behaviour gap, could depend on the nature of the teaching format. There may be poorer outcomes from (a) having an active instructor and passive learners; (b) being based on a pedagogical approach focused on the mere transmission of knowledge; and (c) comprising short-term evaluation methodologies. Therefore, educational actions focusing on active learning processes, cooperative learning with a community of practice approach, and long-term commitment evaluations (Nakano & Yamori, 2021) should constitute viable ways to increase the probability that acquired disaster-related knowledge will transform into appropriate behaviours during and after disasters.

While ethical constraints make it difficult to conduct experimental studies testing the efficacy of interventions on establishing preparedness for earthquakes, we can investigate whether training on emotional competence and preparedness increase children's knowledge, and the underexplored differential effects of age (Johnson et al., 2014). This is particularly relevant given the urgent need for conducting rigorous scientific evaluations of interventions aimed at developing disaster-related emotional competence (Qualter et al., 2017).

The current study

Within the PrEmT project, we developed and tested the efficacy of an evidence-based intervention aimed at enhancing primary school children's knowledge and metacognition of earthquakes, related emotions, and emotion regulation. We conducted the intervention in Italy, which is among the countries with the highest seismic risk in the Mediterranean area, given its geographical position at the intersection of the African and Eurasian clusters. In particular, Italy is characterized by a medium to high level of seismic hazard, a very high vulnerability, and a very high exposure to earthquakes (Dipartimento della Protezione Civile, n.d.-b).

Students in an experimental group experienced the intervention. We assessed the children's knowledge and metacognition before and after the intervention and compared the findings with those from a control group. In designing the study, we sought to avoid five problems we observed in the current literature on disaster-related interventions with children. First, previous literature focused on evidence-based interventions conducted after disasters and rarely on interventions preceding a disaster. Second, few of the studies were carried out according to the standards of evidence-based research. Third and fourth, respectively, to our knowledge no evidence-based intervention focused on both earthquake preparedness and emotional competence or combined traditional and technology-based activities. Fifth, interventions were not often based on theoretical models related to earthquake-related preparedness.

Our first aim was to demonstrate increases in children's knowledge on three different content areas, i.e., earthquakes, earthquake-related emotions, and earthquake-related emotion regulation, exploring possible school class level differences. Given that general knowledge about emotions and emotion regulation is a prerequisite for mastering domain-specific knowledge about earthquake-related emotions and emotion regulation, the intervention included also general contents about the two constructs (e.g., emotion recognition and emotional lexicon for emotions). Moreover, we examined differences between second and fourth-graders.

We hypothesised that:

> **Hypothesis 1a.** Children in the experimental group would increase their knowledge about earthquakes and earthquake-related safety behaviours, compared to the control group.

> **Hypothesis 1b.** Second-graders would have less knowledge about earthquakes and earthquake-related safety behaviours, compared to fourth-graders.

> **Hypothesis 1c.** Children in the experimental group would show improvements in their emotion recognition and emotional lexicon, compared to the control group.

> **Hypothesis 1d.** Second-graders would have lower scores for emotion recognition and emotional lexicon, compared to fourth-graders.

> **Hypothesis 1e.** Children in the experimental group would expand their knowledge of earthquake-related emotion regulation strategies, compared to the control group.

> **Hypothesis 1f.** Second-graders would have less knowledge of earthquake-related emotion regulation strategies, compared to fourth-graders.

Our second aim was to examine whether the intervention was associated with increases in children's metacognitive awareness concerning earthquakes, emotions, and emotion regulation strategies, and beliefs about the malleability of emotions. We hypothesised that:

> **Hypothesis 2a.** Children in the experimental group would increase their earthquake-related metacognitive awareness, concerning the characteristics of earthquakes, safety behaviours, earthquake-related emotions, and earthquake-related fear regulation strategies, compared to a control group.

Hypothesis 2b. Children in the experimental group would modify their beliefs about the malleability of emotions, considering them more changeable and controllable, compared to a control group.

We also explored possible differences in metacognition related to the school class level.

Our third aim was, for ethical reasons, to monitor whether the intervention negatively impacted children's wellbeing and to see whether there were differences in wellbeing across school class levels.

METHOD

Research design

Following the standards for evidence-based research (Flay et al., 2005), we used a quasi-experimental design with longitudinal data collected in a pretest and a posttest. We divided the sample into two groups, randomly assigning the classes within each of the schools where the study was conducted. The experimental group took part in a 10-unit intervention aimed at increasing knowledge of earthquakes, emotions, and emotion regulation, while the control group did not have the same experiences.[1] Before and after the intervention, the students in the experimental group filled in a questionnaire that evaluated their knowledge on earthquakes, emotions, and emotion regulation. The control group completed the same two questionnaires at the beginning and end of a 3-month period that corresponded to the duration of the experimental intervention.

Participants

The final sample comprised 548 students. There were 272 second-graders and 276 fourth-graders from 34 classes in nine primary schools located in middle class socioeconomic areas in Northern Italy. The students were divided into an experimental group ($n = 321$; second-graders: 11 classes, $n = 178$, $M_{age} = 7.35$, $SD = 0.40$, range: 6.36–9.66, 45% females; fourth-graders: 9 classes, $n = 143$, $M_{age} = 9.36$, $SD = 0.42$, range: 8.54–10.67, 50% females) and a control group ($n = 227$; second-graders: 6 classes, $n = 94$, $M_{age} = 7.48$, $SD = 0.33$, range: 6.78–8.87, 39% females; fourth-graders: 8 classes, $n = 133$, $M_{age} = 9.37$, $SD = 0.34$, range: 8.67–10.84, 56% females). In Italy, students attending second grade are typically 7 or 8 years old, while the students attending fourth grade are 9 or 10 years old.

A small number of children had experienced at least one earthquake directly (experimental group: $n = 45$, 17%; control group: $n = 55$, 27%). For 82 children this information was missing. In the experimental group, experiencing earthquake tremors had resulted in emotional damage to one child and to emotional damage to the relatives in another case, and there was economic damage for four participants; in the control group, one of the affected students had experienced both emotional damage to relatives and economic damage.

See Appendix for further characteristics of the sample.

Procedure

We began the project by consulting with the head teacher responsible for each school to gain permission to work within the school. We then organized meetings with teachers and parents to present

[1]For ethical reason, we had planned to provide a short version of the intervention for the children in the control group during the final phase of the whole project (wait list design), but it was not possible to implement it due to the outbreak of the COVID-19 pandemic and the related restrictions.

the project. It was explained to the parents that we were conducting a research project aimed at (1) understanding children's knowledge and beliefs about both earthquakes and emotions, and then (2) teaching them how to react both behaviourally and emotionally in the event of an earthquake. The study followed the American Psychological Association (APA) ethical guidelines and was approved by the Ethical Committee of the Department of Human Sciences, University of Verona (protocol numbers 479971, 134535, and 226153). At the end of the project, we organized debriefing sessions for heads of schools, teachers, and parents on the one hand and students on the other hand. We provided the adults with an overview of the project findings, and we delivered guidelines about how to conduct a similar training program. For the children, we described the results in language appropriate for their cognitive level, prompting them to provide feedback and encouraging them to use the materials given during the training program (e.g., badges, puzzles) in the future, to help them consolidate what they had learned.

All the program units were guided by experts in educational psychology (i.e., the first three authors of this paper), with the support of at least one collaborator (Durlak et al., 2011). The first two units were conducted with the assistance of an expert in geology. The first author conducted the first wave of the intervention; the second and the third author (who had the role of collaborators during the first wave), conducted the second wave. The first wave intervention was videorecorded and the videorecords were used for training all the collaborators of the second wave.

The children belonged to two cohorts and were divided into two waves. We administered the intervention and the pre/posttest between February 2019 and May 2019 for the first cohort and wave ($n = 124$), and between September 2019 and January 2020 for the second cohort and wave ($n = 424$). Pretest and posttest were administered about one week before and one week after the intervention. Whenever a student missed one unit, we gave him/her an opportunity to participate in the activities as soon as possible. The CONSORT flow diagram (Figure 1) shows the recruitment process and the attrition rates. Detailed description about attrition information, implementation fidelity, transparency and openness are reported in Appendix.

Intervention

The experimental group participated in the 10 units (i.e., the PrEmT training program; Raccanello, Vicentini, et al., 2021) during school time: Each unit was presented weekly and lasted 1 hr.

The intervention focused on three content areas, i.e., knowledge of earthquakes, emotions, and emotion regulation. The first two units had the objective of enhancing knowledge about the nature of earthquakes (Unit 1) and safety behaviours (Unit 2). Then, there were two units focused generally on emotions, promoting the ability to express/understand emotions through facial expression (Unit 3) and psychological lexicon (Unit 4); these were followed by a unit about the emotions that might be experienced during/after an earthquake (Unit 5). This unit was followed by four units on emotion regulation, fostering knowledge about the intensity of emotions (Unit 6), the different types of emotion regulation strategies (Unit 7), and possible strategies that can be effective during (Unit 8) and after an earthquake (Unit 9). The final unit (Unit 10) consisted of a review of the previous contents. We ordered the units such that the information built logically from Unit 1 to Unit 10.

Each unit of the intervention combined an initial digital activity, using tablets and headphones, with some traditional activities (two for each unit, with the only exception being Unit 9). The digital activities consisted of 10 levels of the web application HEMOT®, Helmet for EMOTions, developed ad-hoc (Raccanello, Vicentini, et al., 2020, Raccanello, Vicentini, Florit, et al., 2020; Vicentini et al., 2020). In the first nine levels there were from 24 to 48 written items (read by a software voice to help students with reading difficulties), associated with images and/or sounds, to which students had to respond using a dichotomous scale. The last level requested the users to

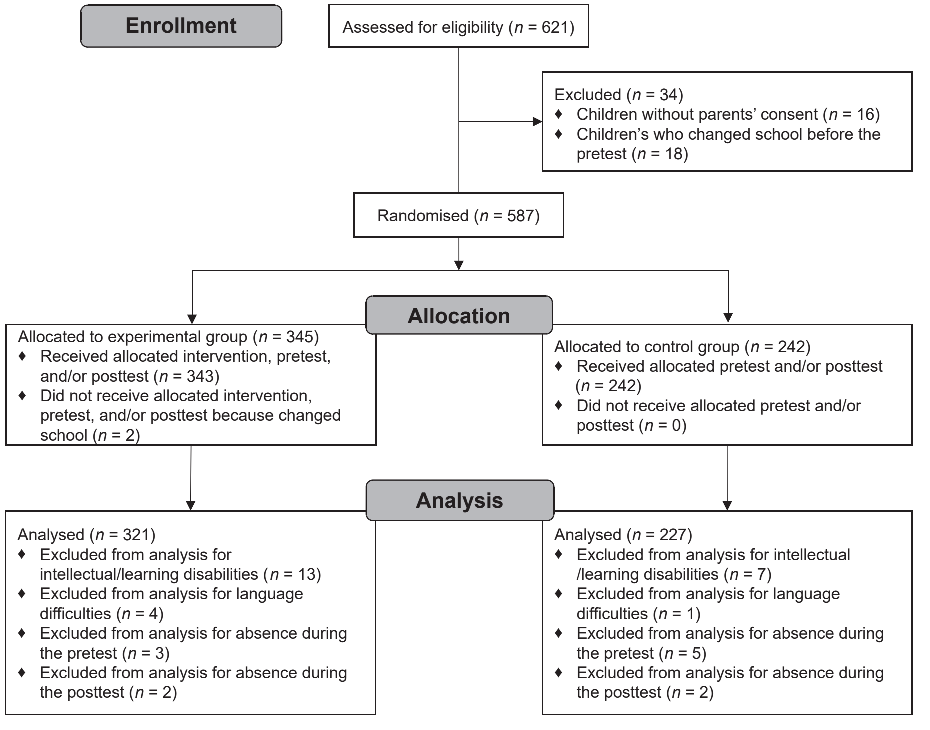

FIGURE 1 CONSORT Flow Diagram.

solve four summary puzzles. The traditional activities comprised different methodologies (i.e., instructor-presented lessons, pencil-and-paper activities, poster activities, and mimic-gestural activities), employing various levels of cooperative learning (Johnson & Johnson, 2009; Slavin, 1991). For ethical issues, all the drawings of faces representing emotions were balanced for gender (male, female) and ethnic origin (European, Asiatic, African). See Table 1 for a detailed description of all the activities.

We conducted the intervention using sequenced, active, focused, and explicit (SAFE) training procedures typical of SEL programs (Durlak et al., 2011). Sequenced procedures employ a range of activities coordinated to achieve the objectives of the programs; active techniques refer to participants' proactivity emerging in cooperative learning settings; focused and explicit programs include at least some activities about personal and specific, rather than only general, social and emotional skills. We described all the instructions and materials of the intervention within a manual, developed during the first wave and used during the second wave.

Measures

For pre and post-intervention measures we administered a questionnaire to assess students' knowledge about earthquakes, emotions, and emotion regulation. We also used two metacognitive instruments and measured children's general wellbeing.

To assess the reliability of our instruments, a first rater coded all the open-ended answers, and an independent second rater coded the 20% of the answers. We evaluated the interrater agreement using Cohen's k (for categorical data) or percentage of agreement (for numerical data). Any disagreement was resolved through discussion with a third rater. The levels of agreement varied from substantial to

TABLE 1 Description of the 10 units of the intervention.

Unit	Title and description of the activities
1	Unit 1 – What are earthquakes?
	Digital activity: Level 1
	The level presented 32 written items, associated with images or sounds, that described events that were (e.g., *The earth shakes*) or were not (e.g., *The walls of the house are always still*) related to an earthquake; possible answers were *Yes* or *No*
	Traditional activity 1.1: Frontal lesson
	The expert in geology conducted an interactive frontal lesson about the main components of the Earth and the characteristics of earthquakes
	Traditional activity 1.2: Summary questions
	The expert in geology asked orally some questions to sum up the most important contents. At the end, the students received a paper sheet with a summary of the questions with the correct answers
2	Unit 2 – How can we be safe?
	Digital activity: Level 2
	The level presented 36 written items, associated with images, that described behaviours that were (e.g., *Looking for shelter under a table inside the house*) or were not (e.g., *Getting under a tree*) useful to be safe during/after an earthquake; possible answers were *Yes* or *No*
	Traditional activity 2.1: Frontal lesson
	The expert in geology conducted an interactive frontal lesson about the adequate safety behaviours to be used before, during, and after an earthquake
	Traditional activity 2.2: Safety behaviours
	In pairs, the students worked with a paper sheet containing a list of adequate safety behaviours: For each of them, they had to choose if it was useful during and/or after an earthquake
3	Unit 3 – How can we recognize the facial expression of emotions?
	Digital activity: Level 3
	The level presented 36 written items, associated with images, that requested to choose if the verbal description of the emotion corresponded to the drawn facial expression (e.g., *Is she happy?*); possible answers were *Yes* or *No*
	Traditional activity 3.1: Emotional selfies
	Individually, using a tablet, the students had to take a photo of their own faces while imitating the facial expression associated with enjoyment, surprise, calm, fear, sadness, and anger
	Traditional activity 3.2: Striped faces
	Individually, the students used two paper sheets on which they had to reconstruct the images corresponding to the facial expression of enjoyment, surprise, calm, fear, sadness, and anger
4	Unit 4 – How can we call the emotions?
	Digital activity: Level 4
	The level presented 36 written items that requested to choose if two words pertaining to the psychological lexicon were (e.g., *Does to be AMAZED mean to be SURPRISED?*) or were not (e.g., *Does to be TERRIFIED mean to be SAD?*) synonyms; possible answers were *Yes* or *No*
	Traditional activity 4.1: Emotional synonyms
	In small groups, the students used a paper sheet on which they had to list as many synonyms as they could to describe the emotions represented in six images (corresponding to the facial expression of enjoyment, surprise, calm, fear, sadness, and anger)
	Traditional activity 4.2: Emotional hangman
	The expert in psychology conducted the hangman game using some of the words pertaining to the psychological lexicon learned through the previous activities

(Continues)

TABLE 1 (Continued)

Unit	Title and description of the activities
5	Unit 5 – Which emotions can we experience during and right after an earthquake? *Digital activity: Level 5* The level presented 36 written items, associated with images, that requested to choose if the emotion, expressed both verbally and visually, was related to a positive (e.g., *Do you FEEL GOOD if you are HAPPY?*) or a negative feeling (e.g., *Do you FEEL BAD if you are ANGRY?*); possible answers were *Yes* or *No* *Traditional activity 5.1: Seismic emotions* In pairs, the students used a paper sheet on which they had to list some emotions that could be felt during and right after an earthquake (adaptation from Raccanello & Hall, 2021) *Traditional activity 5.2: Coloured emotions* Individually, the students used two paper sheets with three shapes of children: The students had to colour them using six different colours corresponding to six different emotions (enjoyment, surprise, calm, fear, sadness, and anger; the correspondence between colours and emotions was defined on the basis of scientific literature, e.g., Kaya & Epps, 2004; Sutton & Altarriba, 2016). They had to calibrate the use of each colour thinking to how frequent the corresponding emotion could be felt during and after an earthquake, for the first two shapes, and during the activity they were doing, for the third shape (this last shape was inserted for ethical reasons)
6	Unit 6 – How can we control the intensity of the emotions? *Digital activity: Level 6* The level presented 48 written items, associated with images, that requested to choose if the two drawn facial expressions expressed a certain emotion with the same intensity (e.g., *Are they SURPRISED in the same way?*); possible answers were *Yes* or *No* *Traditional activity 6.1: Mime of emotions* The expert in psychology chose six volunteers that, one by one, had to mime with the face one of six emotions (enjoyment, surprise, calm, fear, sadness, and anger), at the beginning showing a very low intensity, and then with a very high intensity. The other students had to guess the mimed emotion *Traditional activity 6.2: Emotiometer* Individually, the students used two paper sheets with the drawing of six thermometers, one for emotion (enjoyment, surprise, calm, fear, sadness, and anger), scaled on three different levels of intensity (from *Not at all* to *Very much*). The students had to match the facial expression, choosing from a pack of images, and the correct emotion and intensity reported in the thermometers (adaptation from Di Pietro & Dacomo, 2007)
7	Unit 7 – How can we feel better? Do or think, alone or with others *Digital activity: Level 7* The level presented 24 written items, associated with images, that described possible strategies to feel better. In the first part, the user had to choose if the strategy was behavioural (e.g., *Sheltering in a safe place*) or cognitive (e.g., *Remembering that the earthquake is a natural event*); possible answers were *Do* or *Think*. In the second part, the user had to choose if the strategy was intra (e.g., *Breathing deeply*) or inter-individual (e.g., *Calming down people who are with you*); possible answers were *Alone* or *With others* *Traditional activity 7.1: Shield for emotions* The expert in psychology presented a poster representing the 'shield for emotions' as a metaphor for introducing the importance of coping strategies (the shield was divided into four quadrants, deriving by the intersection of two axes: *Do/Think* and *Alone/With others*; adaptation from Whitehouse & Pudney, 1999). Then, in pairs, the students used a paper sheet to write possible strategies to cope with negative emotions (fear, sadness, and anger) *Traditional activity 7.2: Sticky strategies* The students received a sticky card to write their favourite strategy, individually. Then, they had to classify their strategy according to the two dimensions represented in the shield (*Do/Think* and *Alone/With others*) and to stick their card on the correct quadrant of the poster (adaptation from Vicentini et al., 2020)

TABLE 1 (Continued)

Unit	Title and description of the activities
8	Unit 8 – How can we feel better during an earthquake? *Digital activity: Level 8* The level presented 24 written items, associated with images, that described adaptive (e.g., *Staying near others to help calm down*) or maladaptive (e.g., *Thinking that there is nothing you can do to save yourself*) strategies to cope with the fear that can be experienced during an earthquake; possible answers were *Yes* or *No* *Traditional activity 8.1: Seismic strategies* In pairs, the students used a paper sheet to list some strategies that could be useful to cope with fear during an earthquake (adaptation from Raccanello & Hall, 2021) *Traditional activity 8.2: Safe child badge* The students received a badge with the trademark of the project and the summary sentence 'Protect yourself and your emotions. In case of earthquake, behave safely and be calm!' (adaptation from Raccanello & Hall, 2021)
9	Unit 9 – How can we feel better right after an earthquake? *Digital activity: Level 9* The level presented 24 written items, associated with images, that described adaptive (e.g., *To get rid of sadness, Talking about how you feel*) or maladaptive (e.g., *To get rid of anger, Hitting someone*) strategies to cope with the fear, the sadness, or the anger that can be experienced right after an earthquake; possible answers were *Yes* or *No* *Traditional activity 9.1: Emotional coding* Individually, the students used three paper sheets with three paths to be completed following some instructions. Each path started with an image representing the facial expression of a negative emotion that could be experienced right after an earthquake (fear, sadness, and anger) and finished with an image representing the facial expression of a positive emotion (enjoyment or calm); an intermediate cell of the path requested to the students to write possible coping strategies useful to feel better right after an earthquake (adaptation from Raccanello & Hall, 2021)
10	Unit 10 – Putting the pieces back together *Digital activity: Level 10* The level presented four 3 × 3 puzzle images to be put back together. The four resulting images contained a verbal and a visual summary of what to do and how to feel better, both during and after an earthquake *Traditional activity 10.1: Content reconstruction* The expert in psychology conducted an interactive frontal lesson to summarize the contents of the previous units and the learning methodologies used during the intervention *Traditional activity 10.2: Puzzle* Individually, the students had to put back together the pieces of a summarizing puzzle. The resulting image corresponded to a collage of some images and written descriptions focused on what to do and how to feel better, both during and after an earthquake At the end of this unit, each student received a personal certificate that attested his/her participation to the intervention and had the possibility to take home the portfolio containing all the sheets used during the activities

almost perfect (Landis & Koch, 1977). We used McDonald's omega (ω) to assess the reliability of the scales. See Table 2 for the list of measures, questions, examples of answers to the open questions of the questionnaire, and reliability indexes.

Knowledge about earthquakes

Earthquake definition

We assessed the knowledge about the characteristics of earthquakes through an open-ended question. We coded each answer considering the variety of contents in terms of the number of content categories

(Raccanello et al., 2017, 2019) to which the children referred: natural (e.g., *The earthquake is when the Earth shakes*), man-made (e.g., *The floor trembles, things fall, the shops and the houses fall*), behavioural (e.g., *You have to stay away from the buildings*), biological (e.g., *People can get hurt*), and psychological (e.g., *It makes people panic but they have to stay calm*). The total score, resulting from summing the numbers of cited categories, ranged from 0 to 5.

Earthquake-related safety behaviours

We asked the children to list appropriate safety behaviours (e.g., *Taking away a backpack with water, a radio, and a torch*) through two open-ended questions. The appropriateness of the responses was established by consulting reliable sources (e.g., Dipartimento della Protezione Civile, n.d.-a). We counted the number of appropriate behaviours mentioned.

Knowledge about emotions

Emotion recognition

We assessed the ability to recognize the facial expression of emotions through a labeling task (Denham, 1986; Izard et al., 2003; Pons & Harris, 2000; Raccanello & Bianchetti, 2014). The students had to write a plausible label under each of six images, representing the faces of children experiencing enjoyment, surprise, calm, fear, sadness, or anger (the gender of the child in each drawing was the same as that of the respondent to facilitate the identification). The faces had been drawn ad-hoc following Ekman's guidelines (Ekman, 1992, 1993). We had tested them for validity in a pilot phase (Raccanello, Vicentini, Florit, et al., 2020, Raccanello, Vicentini, Rocca, et al., 2020) which involved 233 second and fourth-graders. Students in the pilot study participated in a naming task in which we showed six faces and asked them to produce a label describing the illustrated emotion. Most children had reported an appropriate label for the basic emotions (enjoyment: 95.7%; surprise: 71.2%; fear: 75.1%; sadness: 90.1%; anger: 98.7%), while the percentage of correct responses was lower for calm (59.2%). This is consistent with the fact that calm is not a basic emotion with a unique correspondence between facial expression and emotion (Ekman, 1992, 1993). For the emotion recognition task, we coded the answers counting the number of plausible labels, ranging from 0 to 6.

Emotional lexicon

We evaluated children's knowledge of the psychological lexicon for emotions by asking them to respond with synonyms (Raccanello & Hall, 2021) describing how the individuals feel while experiencing enjoyment (e.g., *Excited*), surprise (e.g., *Astonished*), calm (e.g., *Quiet*), fear (e.g., *Frightened*), sadness (e.g., *Unhappy*), and anger (e.g., *Irritated*). We calculated the total number of plausible synonyms.

Knowledge about emotion regulation

Earthquake-related emotion regulation strategies

We used two open-ended questions (Raccanello & Hall, 2021) requesting a list of strategies that can be effective for regulating earthquake-related fear (e.g., *Thinking that everything will be fine*) to assess understanding of emotion regulation. We counted the number of plausible strategies to create a measure for this concept.

Metacognition

Earthquake-related metacognitive awareness

We assessed earthquake-related metacognitive awareness using five self-report ad-hoc items based on previous measures (Schraw & Dennison, 1994; Sperling et al., 2002). We measured both declarative and procedural knowledge. Children evaluated each item on a 5-point scale (1 = *nothing*, 2 = *few things*, 3 = *some things*, 4 = *many things*, 5 = *a lot of things*).

Beliefs on malleability of emotions

We assessed the beliefs on malleability of emotions through eight self-report items based on the Implicit Theories of Emotion Scale adapted for children (Tamir et al., 2007; Raccanello et al., 2022). We distinguished beliefs regarding positive (four items; e.g., *I can learn to change the positive emotions that I have*) and negative (four items; e.g., *If I want, I can control the negative emotions I feel*) emotions. Children evaluated each item on a 5-point scale (1 = *not at all true*, 2 = *slightly true*, 3 = *somewhat true*, 4 = *moderately true*, 5 = *extremely true*).

Wellbeing

General wellbeing

To assess children's wellbeing, we administered an adaptation of the School-Related Well-being scale (Raccanello, Trifiletti, Vicentini et al., 2021; Loderer et al., 2016, 2018; Putwain et al., 2020). It comprises six self-report items (e.g., *I feel good*) to be evaluated on a 5-point scale about how true each sentence is (1 = *not at all true*, 2 = *slightly true*, 3 = *somewhat true*, 4 = *moderately true*, 5 = *extremely true*). It is worth noting that while for this scale there are no norms for distinguishing adequate vs. poor wellbeing, some information about children's levels of wellbeing can be drawn by examining the end points of the scale.

Data analysis

We used the R software for all the analyses, version 4.1.1 (R Core Team, 2022). We ran five generalized linear mixed models (GLMM) and four linear mixed models (LMM). We considered group (experimental, control) and class level (second-graders, fourth-graders) as the categorical fixed between-subject effects; phase (pretest, posttest) as the categorical fixed within-subject effect; and participants, gender (male, female), and class (34 classes) as the random effects. The participants were considered as nested in classes. The dependent variables were, respectively for each of the nine models:

1. The variety of contents in earthquake definitions, in terms of proportion of the number of reported content categories on the total number of possible categories, i.e., five (proportion variable; GLMM);
2. The number of adequate earthquake-related safety behaviours (count variable; GLMM);
3. The proportion of adequate labels in the emotion recognition task on the total of possible adequate labels, i.e., six (proportion variable; GLMM);
4. The number of plausible synonyms of emotions (count variable; GLMM);
5. The number of plausible earthquake-related emotion regulation strategies (count variable; GLMM);
6. The level of earthquake-related metacognitive awareness (rating variable; LMM);
7. The score of beliefs on malleability of positive emotions (rating variable; LMM);
8. The score of beliefs on malleability of negative emotions (rating variable; LMM);
9. The score of general wellbeing (rating variable; LMM).

For the GLMM, respectively for proportion and count variables, we utilized the binomial family and logit link-function, and the Poisson family and log link-function, and we performed mixed-model ANOVA tables using likelihood ratio tests. For the LMM, which involved rating variables, we used the Gaussian family and identity link-function; and we calculated the analysis of deviance tables using chi

TABLE 2 List of measures, questions, examples of answers to the open questions of the questionnaire, and reliability indexes (k = Cohen's kappa, percentage of agreement, ω = McDonald's omega), distinguishing the phase of administration (PRE = pretest, POST = posttest) and the group (EX = experimental, CO = control), translated in English (adaptation from Raccanello, Vicentini, et al., 2021).

Measure	Question	Examples of answers	Reliability
Earthquake definition	What is an earthquake? Write all you think could be useful to explain to a child what an earthquake is	The earthquake is when the earth shakes abruptly and breaks the roads, the palaces and the houses (PRE, EX) A shake of earth that is provoked because of tornados, very strong air movements (PRE, CO) The earthquake is a shake of the terrain and it happens when the huge rocks that 'navigate' on the underground magma crash and provoke the shake that can be strong and disruptive or soft and mild; the earthquakes can happen also at the sea provoking, besides the shake, huge wave (tsunami) (POST, EX) In my opinion an earthquake is a natural thing, that makes wabble all (POST, CO)	k = 0.83
Earthquake-related safety behaviours	During an earthquake, what do you have to do if you are in class at school?	I panic. I start screaming. I run as fast as I can toward the exit together with all the class. (PRE, EX) Getting under the desk. Going to the yard. Calling the firemen. (PRE, CO) Putting the backpack on the head. Going under a door. Not taking the elevator. Going under the table. Going under the desk. Not going where there is glass otherwise it can fall on you. Calling the first aid. Escaping within the car. Escaping using the stairs. Putting an empty basket on the head. (POST, EX) Respecting the teachers' orders. Getting under the desk. (POST, CO)	Agreement: 88%
	During an earthquake, what do you have to do if you are at home?	Hiding under the table. Hiding under the bed. Exiting. (PRE, EX) Exiting immediately from the house. Not carrying away anything. (PRE, CO) Keeping calm. Under the tables. Staying in a safe place. Getting away from the full shelves. (POST, EX) Going under the bed. Going under the table. (POST, CO)	
Emotion recognition	Write which emotion is expressed by each of the following faces	–	k = 0.95
Emotion lexicon	Write at least a synonym for each emotion. If a child is happy/surprised/calm/afraid/sad/angry, you can also say that s/he is…	Happy: Content, cheerful, joyful (PRE, CO) Surprised: Stunned, astonished, amazed (PRE, CO) Calm: Tranquil, relaxed, peaceful (PRE, CO) Afraid: Terrified, scared, frightened (POST, EX) Sad: Unhappy, displeased, down in the dumps (POST, EX) Angry: Furious, mad, raging (POST, CO)	Agreement: 94%

TABLE 2 (Continued)

Measure	Question	Examples of answers	Reliability
Earthquake-related emotion regulation strategies	If during an earthquake a child is afraid, how can s/he get rid of the fear?	Saying to his/herself that all is going well. (PRE, EX) Hugging your teddy bear. (PRE, CO) You can take deep breaths. Think to things you like. Stay with people you love. Going to a safe place. Repeating that all is well. (POST, EX) It is impossible to get rid of the fear. (POST, CO)	Agreement: 90%
	If after an earthquake a child is afraid, how can s/he get rid of the fear?	Not thinking to what happened before. (PRE, EX) Hugging a mate. Thinking that all is returning normal. (PRE, CO) Going to the mum. Doing beautiful things. Hugging a peluche. Cuddling with daddy. Thinking to beautiful thing. Being careful so that other thing does not fall. (POST, EX) Thinking happy thing. Thinking that you are saved. (POST, CO)	
Earthquake-related metacognitive awareness	How many things do you know about earthquakes/emotions during an earthquake/emotions after an earthquake? How many things do you know about safety behaviours/getting rid of earthquake-related fear?	–	$\omega = 0.821$
Beliefs on malleability of emotions	–	–	Positive emotions: $\omega = 0.603$ Negative emotions: $\omega = 0.696$
General wellbeing	–	–	$\omega = 0.807$

square tests. For each model we reported the conditional R^2, which is the variance explained by the entire model including both fixed and random effects (Johnson, 2014; Nakagawa et al., 2017; Nakagawa & Schielzeth, 2013). Such index is considered small when $0.02 \leq R^2 < 0.13$, medium when $0.13 \leq R^2 < 0.26$, and large when $R^2 \geq 0.26$ (Cohen, 2013).

We reported in Table 3 all the significant effects and interactions and the key *post-hoc* tests related to all of them; in Table 4 means, standard deviations, and 95% confidence intervals (CI) for the pretest and the posttest by group (experimental, control), for the whole sample, and by class level; and in Figure 2 means and 95% CI concerning the interaction between group and phase.

Based on the conditional R^2 index (Johnson, 2014; Nakagawa et al., 2017; Nakagawa & Schielzeth, 2013) – reported in the Results – the *post-hoc* power analysis indicated that our sample size was adequate. Specifically, for each of the nine models it revealed that a sample size of $N = 548$ approximated to a power of 0.99% with alpha = 0.05.

TABLE 3 Chi square (with degrees of freedom) and level of significance for significant effects and interactions, and key Bonferroni tests and effect sizes, for all dependent variables.

Variables	Significant effects or interactions	χ^2 (df)	*p*	Bonferroni *post-hoc* comparisons	*z*	*p*	*d*
Earthquake definition	Class level	8.36 (1)	.004	Second-graders versus fourth-graders	3.09	.002	0.30
	Phase	9.38 (1)	.002	Pretest versus posttest	3.06	.002	0.20
	Group × Phase	5.36 (1)	.021	Experimental group: pretest versus posttest	4.23	<.001	0.35
				Control group: pretest versus posttest	0.48	n.s.	0.05
				Pretest: experimental group versus control group	1.14	n.s.	0.13
				Posttest: experimental group versus control group	1.50	n.s.	0.17
	Class level × Phase	4.10 (1)	.043	Second-graders: pretest versus posttest	3.37	.005	0.33
				Fourth-graders: pretest versus posttest	0.79	n.s.	0.07
				Pretest: second-graders versus fourth-graders	3.63	.002	0.43
				Posttest: second-graders versus fourth-graders	1.42	n.s.	0.16
Earthquake-related safety behaviours	Group	7.31 (1)	.007	Experimental group versus control group	2.89	.004	0.19
	Class level	25.87 (1)	<.001	Second-graders versus fourth-graders	6.24	<.001	0.40
	Phase	284.51 (1)	<.001	Pretest versus posttest	16.89	<.001	0.52
	Group × Phase	142.97 (1)	<.001	Experimental group: pretest versus posttest	23.66	<.001	0.90
				Control group: pretest versus posttest	3.07	.013	0.15
				Pretest: experimental group versus control group	2.51	n.s.	0.19
				Posttest: experimental group versus control group	8.10	<.001	0.56
	Group × Class level × Phase	8.14 (1)	.004	Experimental group, pretest: second-graders versus fourth-graders	5.16	<.001	0.50
				Control group, pretest: second-graders versus fourth-graders	2.75	n.s.	0.31
				Experimental group, posttest: second-graders versus fourth-graders	3.85	.003	0.32
				Control group, posttest: second-graders versus fourth-graders	4.41	<.001	0.49

TABLE 3 (Continued)

Variables	Significant effects or interactions	χ^2 (df)	*p*	Bonferroni *post-hoc* comparisons	*z*	*p*	*d*
Emotion recognition	Group	26.53 (1)	<.001	Experimental group versus control group	6.27	<.001	0.96
	Class level	27.57 (1)	<.001	Second-graders versus fourth-graders	6.35	<.001	0.97
	Phase	306.23 (1)	<.001	Pretest versus posttest	14.28	<.001	1.64
	Group × Phase	80.04 (1)	<.001	Experimental group: pretest versus posttest	12.88	<.001	2.54
				Control group: pretest versus posttest	6.33	<.001	0.74
				Pretest: experimental group versus control group	0.37	n.s.	0.05
				Posttest: experimental group versus control group	8.06	<.001	1.86
	Group × Class level × Phase	10.86 (1)	<.001	Experimental group, pretest: second-graders versus fourth-graders	4.06	.001	0.73
				Control group, pretest: second-graders versus fourth-graders	5.38	<.001	1.14
				Experimental group, posttest: second-graders versus fourth-graders	3.81	.004	1.51
				Control group, posttest: second-graders versus fourth-graders	2.09	n.s.	0.49
Emotional lexicon	Group	5.25 (1)	.022	Experimental group versus control group	2.42	.016	0.151
	Class level	39.88 (1)	<.001	Second-graders versus fourth-graders	9.19	<.001	0.58
	Phase	113.37 (1)	<.001	Pretest versus posttest	10.71	<.001	0.36
	Group × Phase	22.89 (1)	<.001	Experimental group: pretest versus posttest	12.95	<.001	0.52
				Control group: pretest versus posttest	3.66	.002	0.20
				Pretest: experimental group versus control group	0.14	n.s.	0.01
				Posttest: experimental group versus control group	4.59	<.001	0.31
	Class level × Phase	8.99 (1)	.003	Second-graders: pretest versus posttest	8.39	<.001	0.46
				Fourth-graders: pretest versus posttest	6.68	<.001	0.26
				Pretest: second-graders versus fourth-graders	9.19	<.001	0.68
				Posttest: second-graders versus fourth-graders	6.95	<.001	0.48

(Continues)

TABLE 3 (Continued)

Variables	Significant effects or interactions	χ^2 (df)	*p*	Bonferroni *post-hoc* comparisons	*z*	*p*	*d*
Earthquake-related emotion regulation strategies	Group	20.80 (1)	<.001	Experimental group versus control group	5.34	<.001	0.40
	Class level	20.80 (1)	<.001	Second-graders versus fourth-graders	5.40	<.001	0.41
	Phase	107.41 (1)	<.001	Pretest versus posttest	10.68	<.001	0.36
	Group × Phase	229.95 (1)	<.001	Experimental group: pretest versus posttest	22.98	<.001	0.87
				Control group: pretest versus posttest	2.82	.029	0.16
				Pretest: experimental group versus control group	1.40	n.s.	0.12
				Posttest: experimental group versus control group	11.25	<.001	0.91
	Group × Class level × Phase	20.90 (1)	<.001	Experimental group, pretest: second-graders versus fourth-graders	3.89	.003	0.41
				Control group, pretest: second-graders versus fourth-graders	3.00	n.s.	0.38
				Experimental group, posttest: second-graders versus fourth-graders	1.24	n.s.	0.12
				Control group, posttest: second-graders versus fourth-graders	5.35	<.001	0.71
Earthquake-related metacognitive awareness	Group	15.36 (1)	<.001	Experimental group versus control group	4.14	<.001	0.61
	Phase	67.00 (1)	<.001	Pretest versus posttest	8.41	<.001	0.52
	Group × Phase	65.75 (1)	<.001	Experimental group: pretest versus posttest	13.07	<.001	1.04
				Control group: pretest versus posttest	0.06	n.s.	0.01
				Pretest: experimental group versus control group	0.55	n.s.	0.09
				Posttest: experimental group versus control group	7.07	<.001	1.12
Beliefs on malleability of positive emotions	Phase	9.10 (1)	.003	Pretest versus posttest	3.02	.003	0.19
	Group × Phase	5.62 (1)	.018	Experimental group: pretest versus posttest	4.20	<.001	0.34
				Control group: pretest versus posttest	0.42	n.s.	0.04
				Pretest: experimental group versus control group	0.66	n.s.	0.08
				Posttest: experimental group versus control group	1.94	n.s.	0.22

TABLE 3 (Continued)

Variables	Significant effects or interactions	χ^2 (df)	p	Bonferroni *post-hoc* comparisons	z	p	d
Beliefs on malleability of negative emotions	Phase	11.69 (1)	<.001	Pretest versus posttest	3.43	.001	0.21
	Group × Phase	6.26 (1)	.012	Experimental group: pretest versus posttest	4.63	<.001	0.37
				Control group: pretest versus posttest	0.60	n.s.	0.06
				Pretest: experimental group versus control group	1.66	n.s.	0.22
				Posttest: experimental group versus control group	0.72	n.s.	0.09
General wellbeing	Phase	18.96 (1)	<.001	Pretest versus posttest	4.38	<.001	0.27
	Class level × Phase	3.97 (1)	.046	Second-graders: pretest versus posttest	4.38	<.001	0.40
				Fourth-graders: pretest versus posttest	1.74	n.s.	0.15
				Pretest: second-graders versus fourth-graders	1.78	n.s.	0.22
				Posttest: second-graders versus fourth-graders	0.20	n.s.	0.03

Note: χ^2 = Chi square; *df* = degrees of freedom; *p* = level of significance; *z* = *z*-ratio; *d* = Cohen's *d*; n.s. = not significant. For *z* and *d*, we reported the absolute value.

TABLE 4 Mean (*M*), standard deviation (*SD*), and confidence interval (CI) for the dependent variables, for the experimental and the control group, at each time point (pretest, posttest), and for the whole sample and by class level. We reported data concerning the whole sample before the first slash, concerning second-graders before the second slash, and concerning fourth-graders after the second slash.

Variable	Pretest *M*	Pretest *SD*	Pretest 95% CI	Posttest *M*	Posttest *SD*	Posttest 95% CI
Earthquake definition						
Experimental group	0.21/0.18/0.25	0.17/0.16/0.18	[0.19, 0.23]/[0.16, 0.20]/[0.22, 0.28]	0.28/0.27/0.28	0.15/0.15/0.16	[0.26, 0.29]/[0.25, 0.29]/[0.26, 0.31]
Control group	0.25/0.20/0.28	0.18/0.16/0.19	[0.22, 0.27]/[0.16, 0.23]/[0.25, 0.31]	0.25/0.22/0.27	0.16/0.16/0.15	[0.23, 0.27]/[0.19, 0.25]/[0.25, 0.30]
Earthquake-related safety behaviours						
Experimental group	3.08/2.38/3.94	2.18/1.76/2.34	[2.84, 3.31]/[2.12, 2.64]/[3.56, 4.33]	7.47/6.37/8.84	3.33/2.86/3.38	[7.11, 7.84]/[5.95, 6.79]/[8.28, 9.40]
Control group	3.78/3.14/4.23	1.90/2.01/1.69	[3.53, 4.03]/[2.73, 3.55]/[3.94, 4.52]	4.53/3.34/5.38	2.32/1.96/2.19	[4.23, 4.84]/[2.94, 3.74]/[5.00, 5.75]
Emotion recognition						
Experimental group	0.80/0.75/0.85	0.21/0.22/0.18	[0.77, 0.82]/[0.72, 0.78]/[0.82, 0.88]	0.97/0.96/0.99	0.08/0.09/0.04	[0.96, 0.98]/[0.94, 0.97]/[0.98, 1.00]
Control group	0.80/0.70/0.87	0.23/0.28/0.14	[0.77, 0.83]/[0.65, 0.76]/[0.85, 0.89]	0.89/0.86/0.91	0.15/0.17/0.13	[0.87, 0.91]/[0.82, 0.89]/[0.89, 0.93]
Emotional lexicon						
Experimental group	3.17/2.21/4.36	2.45/1.85/2.57	[2.90, 3.43]/[1.93, 2.48]/[3.93, 4.78]	5.22/4.11/6.61	3.43/3.04/3.38	[4.85, 5.60]/[3.66, 4.56]/[6.05, 7.17]
Control group	3.45/2.23/4.30	2.18/1.73/2.07	[3.16, 3.73]/[1.88, 2.59]/[3.95, 4.66]	4.01/3.00/4.73	2.42/1.83/2.53	[3.70, 4.33]/[2.63, 3.37]/[4.30, 5.16]
Earthquake-related emotion regulation strategies						
Experimental group	3.00/2.46/3.67	2.17/1.73/2.46	[2.76, 3.24]/[2.21, 2.72]/[3.26, 4.08]	7.15/6.82/7.57	5.51/5.67/5.30	[6.55, 7.56]/[5.98, 7.66]/[6.69, 8.44]
Control group	3.59/2.77/4.17	2.57/2.54/2.44	[3.25, 3.93]/[2.25, 3.29]/[3.76, 4.59]	3.30/2.01/4.20	3.07/1.93/3.39	[2.89, 3.70]/[1.62, 2.41]/[3.62, 4.78]
Earthquake-related metacognitive awareness						
Experimental group	2.86/2.81/2.92	0.98/1.13/0.77	[2.75, 2.97]/[2.65, 2.98]/[2.80, 3.05]	3.51/3.45/3.58	0.82/0.91/0.68	[3.42, 3.60]/[3.32, 3.59]/[3.47, 3.69]
Control group	2.83/2.74/2.90	0.89/1.04/0.75	[2.71, 2.95]/[2.53, 2.95]/[2.77, 3.02]	2.82/2.83/2.81	0.78/0.87/0.71	[2.72, 2.92]/[2.66, 3.01]/[2.68, 2.93]
Beliefs on malleability of positive emotions						
Experimental group	2.94/2.99/2.89	0.96/1.03/0.87	[2.84, 3.05]/[2.83, 3.14]/[2.74, 3.03]	3.21/3.21/3.20	0.92/0.99/0.83	[3.11, 3.31]/[3.07, 3.36]/[3.07, 3.34]
Control group	2.99/3.01/2.98	0.90/1.08/0.74	[2.87, 3.11]/[2.79, 3.24]/[2.85, 3.10]	3.01/3.11/2.95	0.91/0.97/0.87	[2.89, 3.13]/[2.91, 3.31]/[2.80, 3.10]

TABLE 4 (Continued)

Variable	Pretest *M*	Pretest *SD*	Pretest 95% CI	Posttest *M*	Posttest *SD*	Posttest 95% CI
Beliefs on malleability of negative emotions						
Experimental group	2.83/2.82/2.83	1.00/1.04/0.95	[2.72, 2.93]/[2.66, 2.97]/[2.68, 2.99]	3.12/3.08/3.17	1.00/1.05/0.93	[3.01, 3.23]/[2.93, 3.24]/[3.02, 3.33]
Control group	3.00/3.03/2.97	0.97/1.01/0.95	[2.87, 3.12]/[2.82, 3.24]/[2.81, 3.14]	3.04/3.09/3.00	1.05/1.18/0.95	[2.90, 3.18]/[2.85, 3.33]/[2.84, 3.17]
General wellbeing						
Experimental group	3.87/3.86/3.88	0.85/0.92/0.76	[3.78, 3.97]/[3.73, 4.00]/[3.76, 4.01]	4.01/4.05/3.95	0.81/0.83/0.78	[3.92, 4.10]/[3.93, 4.17]/[3.82, 4.08]
Control group	3.83/3.67/3.95	0.89/1.06/0.73	[3.72, 3.95]/[3.45, 3.89]/[3.82, 4.07]	4.03/3.97/4.06	0.80/0.91/0.72	[3.92, 4.13]/[3.79, 4.16]/[3.94, 4.19]

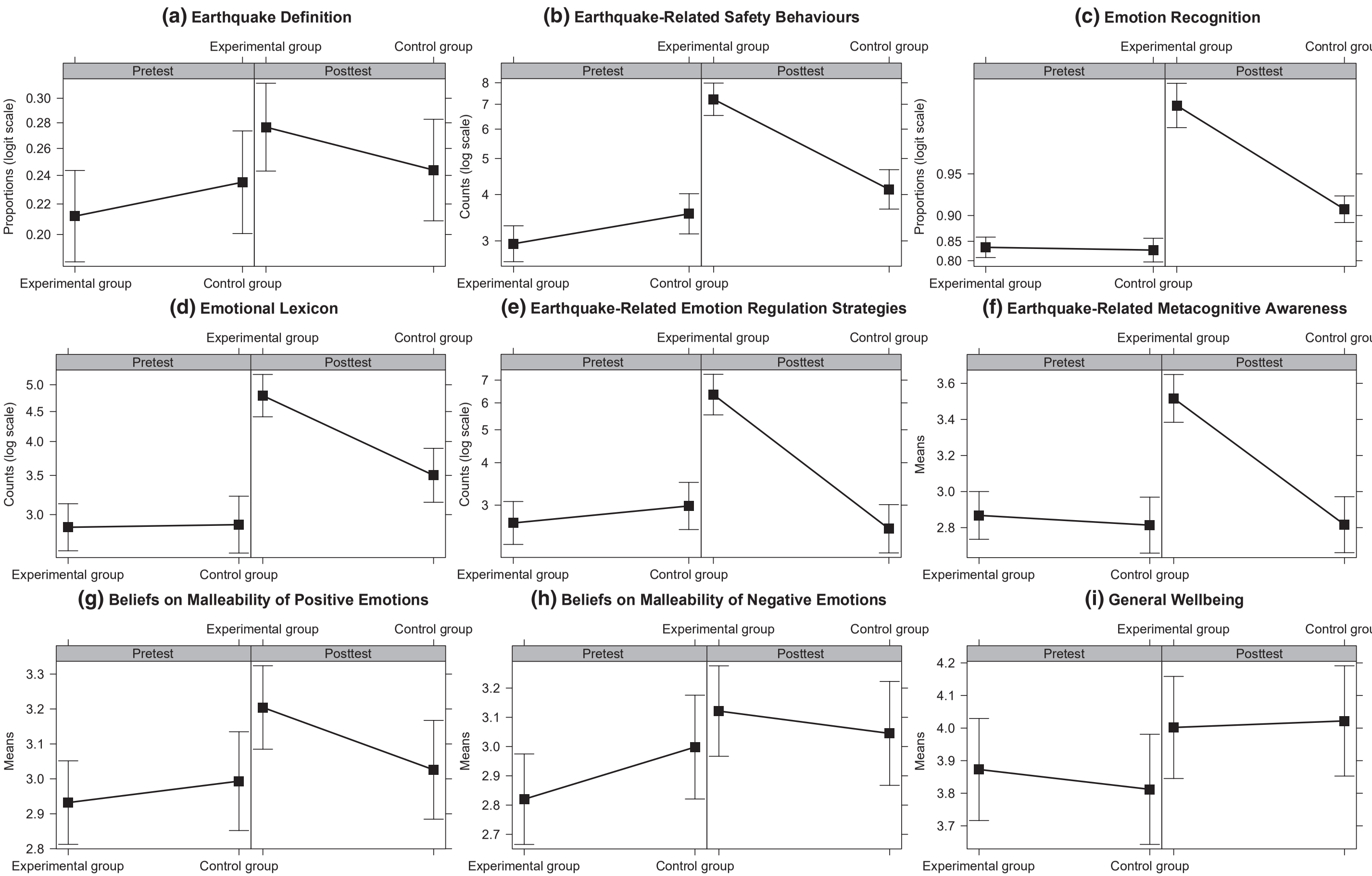

FIGURE 2 Means and 95% confidence intervals concerning the interaction between group and phase, for (a) earthquake definition, (b) earthquake-related safety behaviours, (c) emotion recognition, (d) emotional lexicon, (e) earthquake-related emotion regulation strategies, (f) earthquake-related metacognitive awareness, (g) beliefs on malleability of positive emotions, (h) beliefs on malleability of negative emotions, and (i) general wellbeing.

RESULTS

Knowledge about earthquakes, emotions, and emotion regulation (aim 1)

Knowledge about earthquake definition and earthquake-related safety behaviours

In the case of knowledge about earthquake definitions, the GLMM (conditional $R^2=0.12$) revealed a significant effect of phase (Table 3): The scores increased from the pretest ($M=0.23$, $SD=0.18$, 95% CI [0.21, 0.24]) to the posttest ($M=0.27$, $SD=0.16$, 95% CI [0.25, 0.28]). This effect was moderated by a significant group × phase interaction: The *post-hoc* tests indicated that the scores only increased from the pretest to the posttest for the experimental group (Tables 3 and 4; Figure 2). In addition, there was a significant effect of class level (Table 3), with a lower variety of contents for second-graders ($M=0.22$, $SD=0.16$, 95% CI [0.21, 0.23]) compared to fourth-graders ($M=0.27$, $SD=0.17$, 95% CI [0.26, 0.29]). However, the *post-hoc* tests concerning the significant phase × class level interaction revealed that the scores differed only in the pretest, and that only for second-graders they were lower in the pretest compared to the posttest (Tables 3 and 4).

As regards knowledge about earthquake-related safety behaviours, in the GLMM (conditional $R^2=0.53$) group, class level, and phase were significant (Table 3). The number of reported safety behaviours was lower in the control group ($M=4.16$, $SD=2.15$, 95% CI [3.96, 4.36]) compared to the experimental group ($M=5.27$, $SD=3.57$, 95% CI [5.00, 5.55]); for second-graders ($M=3.98$, $SD=2.82$, 95% CI [3.75, 4.22]) compared to fourth-graders ($M=5.63$, $SD=3.18$, 95% CI [5.36, 5.89]); and for the pretest ($M=3.37$, $SD=2.10$, 95% CI [3.19, 3.54]) compared to the posttest ($M=6.25$, $SD=3.29$, 95% CI [5.98, 6.53]). These effects were moderated by a significant group × phase interaction (Table 3). The *post-hoc* tests revealed that in the posttest the number of safety behaviours was higher for the experimental group compared to the control group, while there were no differences in the pretest; moreover, for both groups it increased from the pretest to the posttest, but the effect size was weaker for the control group (Tables 3 and 4; Figure 2). There was also a significant group × class level × phase interaction (Table 3). Examining the *post-hoc* tests, we found that there were age differences in the pretest for the experimental but not for the control group, and in the posttest for both groups (Tables 3 and 4).

In summary, participating in the training program was associated with an increase of knowledge about earthquakes, both in terms of their definition and appropriate safety behaviours, corroborating Hypothesis 1a. Moreover, older children had a richer representation about earthquakes compared to younger children, with some exceptions, partially supporting Hypothesis 1b.

Knowledge about emotion recognition and emotional lexicon

For both emotion recognition (conditional $R^2=0.39$) and emotional lexicon (conditional $R^2=0.54$), the GLMM revealed significant effects of group, class level, and phase (Table 3). The scores were lower in the control group (emotion recognition: $M=0.84$, $SD=0.20$, 95% CI [0.83, 0.86]; emotional lexicon: $M=3.73$, $SD=2.32$, 95% CI [3.52, 3.94]) compared to the experimental group (emotion recognition: $M=0.88$, $SD=0.18$, 95% CI [0.87, 0.90]; emotional lexicon: $M=4.19$, $SD=3.15$, 95% CI [3.95, 4.44]); for second-graders (emotion recognition: $M=0.83$, $SD=0.22$, 95% CI [0.81, 0.85]; emotional lexicon: $M=2.97$, $SD=2.43$, 95% CI [2.77, 3.18]) compared to fourth-graders (emotion recognition: $M=0.91$, $SD=0.15$, 95% CI [0.89, 0.92]; emotional lexicon: $M=5.02$, $SD=2.85$, 95% CI [4.78, 5.26]); and for the pretest (emotion recognition: $M=0.80$, $SD=0.22$, 95% CI [0.78, 0.82]; emotional lexicon: $M=3.28$, $SD=2.34$, 95% CI [3.09, 3.48]) compared to the posttest (emotion recognition: $M=0.94$, $SD=0.12$, 95% CI [0.93, 0.95]; emotional lexicon: $M=4.72$, $SD=3.10$, 95% CI [4.46, 4.98]). There was also a significant group × phase interaction (Table 3). The *post-hoc* tests showed that the two groups did not differ in the pretest, while in the posttest the scores were higher for the experimental compared to the control group; in addition, for both groups, the scores increased from the pretest to the posttest, with weaker effect sizes for the control group (Tables 3 and 4; Figure 2).

There was a significant group × class level × phase interaction for emotional recognition (Table 3). The *post-hoc* tests indicated that fourth-graders had higher scores than second-graders for both groups in the pretest, but only for the experimental group in the posttest (Tables 3 and 4). Finally, there was a significant class level × phase interaction for emotional lexicon (Table 3). The *post-hoc* tests revealed that second-graders performed worse than fourth-graders in both phases, and that for each class level the scores were lower in the pretest compared to the posttest; however, it is interesting to note that for the comparison between second-graders' performance in the posttest and fourth-graders' performance in the pretest, the effect size was weaker compared to all the other comparisons, $z = |3.15|$, $p = .010$, and $d = |0.22|$ (Tables 3 and 4).

Overall, the training program positively affected both emotion recognition and emotional lexicon, confirming Hypothesis 1c. In addition, both constructs were mastered better for fourth-graders compared to second-graders, partially corroborating Hypothesis 1d.

Knowledge about earthquake-related emotion regulation strategies

The GLMM (conditional $R^2 = 0.65$) results testing earthquake-related emotion regulation strategies, indicated that group, class level, and phase were significant (Table 3). There were fewer strategies mentioned by the control group ($M = 3.44$, $SD = 2.83$, 95% CI [3.18, 3.70]) compared to the experimental group ($M = 5.08$, $SD = 4.67$, 95% CI [4.71, 5.44]), for second-graders ($M = 3.86$, $SD = 4.18$, 95% CI [3.51, 4.21]) compared to fourth-graders ($M = 4.93$, $SD = 3.93$, 95% CI [4.60, 5.26]), and for the pretest ($M = 3.25$, $SD = 2.36$, 95% CI [3.05, 3.44]) compared to the posttest ($M = 5.56$, $SD = 5.03$, 95% CI [5.13, 5.98]). The *post-hoc* tests of the significant group × phase interaction indicated that the two groups did not differ in the pretest, while in the posttest the strategies were more numerous for the experimental group compared to the control group; in addition, the number only increased from the pretest to the posttest for the experimental group (Tables 3 and 4; Figure 2). Finally, the GLMM revealed a significant group × class level × phase interaction (Table 3). The *post-hoc* tests showed that second-graders' performance was lower than fourth-graders' performance only in the pretest for the experimental group and only in the posttest for the control group (Tables 3 and 4).

Therefore, our analyses suggested that participating in the training program increased children's ability to report strategies to cope with earthquake-related negative emotions, confirming Hypothesis 1e. Moreover, some class level differences gave partial support to Hypothesis 1f.

Metacognition (aim 2)

Earthquake-related metacognitive awareness

The GLMM showed significant effects (conditional $R^2 = 0.55$) of group and phase, moderated by a significant group × phase interaction, for earthquake-related metacognitive awareness (Table 3). Awareness was lower for the control group ($M = 2.82$, $SD = 0.83$, 95% CI [2.75, 2.90]) compared to the experimental group ($M = 3.19$, $SD = 0.96$, 95% CI [3.11, 3.26]) and for the pretest ($M = 2.85$, $SD = 0.94$, 95% CI [2.77, 2.93]) compared to the posttest ($M = 3.22$, $SD = 0.87$, 95% CI [3.15, 3.30]). However, the two groups did not differ in the pretest, but only in the posttest, with higher awareness for the experimental group compared to the control group; moreover, the scores only increased from the pretest to the posttest for the experimental group (Tables 3 and 4; Figure 2).

In summary, earthquake-related metacognitive awareness increased only for the experimental group, confirming Hypothesis 2a. Finally, we found no significant effects or interactions involving class level.

Beliefs on malleability of emotions

A GLMM revealed a significant effect of phase, moderated by a significant group × phase interaction (Table 3) for the beliefs on malleability of both positive (conditional $R^2 = 0.24$) and negative emotions (conditional $R^2 = 0.34$). The scores were lower in the pretest (positive emotions: $M = 2.96$, $SD = 0.94$, 95% CI [2.88, 3.04]; negative emotions: $M = 2.90$, $SD = 0.99$, 95% CI [2.81, 2.98]) compared to the posttest (positive emotions: $M = 3.13$, $SD = 0.92$, 95% CI [3.05, 3.21]; negative emotions: $M = 3.09$, $SD = 1.02$, 95% CI [3.00, 3.17]). Nevertheless, the analysis of the interaction indicated that this only happened for the experimental group (Tables 3 and 4; Figure 2), confirming Hypothesis 2b. As for awareness, there were no differences related to class level.

Wellbeing (aim 3)

General wellbeing

The GLMM (conditional $R^2 = 0.45$) indicated a significant effect of phase, moderated by a significant class level × phase interaction for wellbeing (Table 3). Wellbeing increased from the pretest ($M = 3.86$, $SD = 0.87$, 95% CI [3.78, 3.93]) to the posttest ($M = 4.01$, $SD = 0.81$, 95% CI [3.95, 4.08]). The *post-hoc* tests for the interaction revealed that wellbeing improved for second-graders and not for fourth-graders (Tables 3 and 4). Moreover, students' responses with respect to their wellbeing had mean values higher than 3, indicating a medium-high level of wellbeing for our participants.

Overall, our findings indicated that the training program about earthquakes had not negatively impacted children's wellbeing. Moreover, they revealed a positive trend for the younger children as time passed.

DISCUSSION

We tested the efficacy of a 10-unit training program focused on earthquake knowledge and related emotional competence using a quasi-experimental design with longitudinal data collected at pretest and posttest in a sample of more than 500 primary school students (Raccanello, Vicentini, et al., 2021). The students in an experimental group participated in both digital activities, i.e., using the web-based application HEMOT® (Raccanello, Vicentini, et al., 2020, Raccanello, Vicentini, Florit, et al., 2020; Vicentini et al., 2020), and more traditional activities, including individual and cooperative learning methodologies (Johnson & Johnson, 2009; Slavin, 1991). The traditional methods included lessons presented by an instructor, pencil-and-paper activities, poster activities, and mimic-gestural activities. Following the standards of evidence-based research (Flay et al., 2005; Gottfredson et al., 2015), our study found that participating in the training program was associated with an increase in knowledge and metacognition about earthquakes, emotions, and emotion regulation. From a theoretical perspective, this extends the literature justifying actions to improve both prevention and preparedness, as means to help children to better cope with the cognitive, emotional, and motivational processes (e.g., as postulated within the PFD model, Raccanello, Vicentini, Rocca, et al., 2020, Raccanello, Vicentini, et al., 2021) that can make the difference for their survival during a disaster such as an earthquake.

Our findings (Aim 1) indicated that knowledge about earthquakes and safety behaviours increased for the experimental group after the 10 weeks of the training program, supporting Hypothesis 1a. Learning about earthquakes and how to survive them was the focus of the first two units of the program, and we can presume that the contents presented in these units fostered the children's overall engagement with the topic both in and out of school. Our data suggest also that the children in the control group slightly increased their knowledge on safety behaviours, and this too is in line with the presumption that participating in a class project on earthquakes could have increased their interest in the topic. We noted, too, that before the intervention, all second-graders demonstrated less complex knowledge about the nature of earthquakes, as could be expected in absence of instruction on the topic. Similarly, the data generally indicated less knowledge about safety procedures for younger children than for older children. Therefore, our data partially supported Hypothesis 1b.

In addition, we found increases in both emotion recognition and emotional lexicon for the experimental group, corroborating Hypothesis 1c. Within Unit 3, the students consolidated their abilities to identify and express emotions, by (1) evaluating the match between drawn facial expressions and a label in the digital app, (2) photographing their owns faces with a tablet-based camera as they demonstrated facial representations of emotions, and (3) solving a puzzle using six drawings representing emotions. Within Unit 4, they became more familiar with the ability to recognize and produce synonyms for emotions in the app, and through group brainstorming about the terms that could adequately describe the emotions of drawn faces. Through these sets of activities, the children in the experimental group increased their performance on emotional recognition tasks, as has already been indicated by a long tradition of SEL programs teaching socio-emotional skills (Durlak et al., 2011, 2022). As for Hypothesis 1d, previous research has amply documented that the ability to recognize and describe emotions is acquired during the early stages of primary school (Pons et al., 2004); moreover, as age increases, children continue to gradually refine these skills. Our data confirmed this trend in two ways. First, we found a slight improvement for the control group from the pretest to the posttest, i.e., a period of about 3 months, confirming partially Hypothesis 1d. However, we noted that this effect was much less marked for the control group compared to the experimental group. Second, there were class level differences for both emotion recognition and emotional lexicon, with fourth-graders generally performing better than second-graders. It is interesting to note that the second-graders' performance in the posttest was not so far from the fourth-graders' performance in the pretest, suggesting a possible linear process in the acquisition of such knowledge.

Acknowledging the challenges related to the so-called knowledge–behaviour gap (Nakano & Yamori, 2021), we could speculate that the acquisition of knowledge on earthquakes and safety behaviours on the one hand, and of emotion recognition and emotional lexicon on the other hand, can be considered a prerequisite for having access to and implementing earthquake-related emotion regulation strategies both during and just after an earthquake. After reflecting on which emotions are particularly salient during and after an earthquake (Unit 5), the children were trained in the general characteristics of emotion regulation processes, such as the possibility to modify intensity of emotions (Unit 6) and to categorize strategies as behavioural/cognitive or establishing an appropriate reliance on other people rather than the self (Unit 7). At this point in the program, we assumed that the participants would have become familiar with basic knowledge required to recognize and produce possible strategies to cope effectively with emotions during and after an earthquake (Units 8 and 9). Our analyses indicated that the children in the experimental group had increased their ability to have access to a wide range of plausible regulation strategies in the posttest compared to the pretest. It is worth noting that, for the control group, there were no differences between the two phases. Therefore, we confirmed Hypothesis 1e. Concerning class level differences, we found that, in general, fourth-graders' knowledge was richer than second-graders', with a greater ability to have access to and report lists of plausible strategies.

During the whole training program, and especially in the last unit (Unit 10), we repeatedly helped children to reflect on the fact that both individual and contextual characteristics should be considered to understand whether a strategy can be adaptive in a specific occasion. Even though we did not explicitly measure this potential effect, anecdotical evidence gathered both from the children and their teachers suggested that the training program probably supported, at least to some extent, the development of this kind of knowledge.

We also examined whether increases in knowledge corresponded to changes in children's metacognition (Aim 2). Our analyses clearly showed that metacognitive awareness (Hypothesis 2a) and beliefs on the malleability of positive and negative emotions (Hypothesis 2b) improved for the experimental group compared to the control group. In this case there were no differences between class levels. It is worth noting that the increase we observed for both constructs, i.e., knowledge and metacognition, is an indicator of children's reliability in assessing their psychological inner states. The current literature on malleability is usually focused on adults (De Castella et al., 2013), so our results extend these findings to children. Moreover, following previous research reported in the literature, we could speculate that such beliefs can be considered a prerequisite for the use of emotion regulation strategies.

Finally, our analyses indicated that, across the sample, children's general wellbeing was not negatively influenced by the training content (Aim 3). In fact, we observed an improvement in wellbeing for second-graders during the period in which they participated in the project and no significant changes for fourth-graders. Our finding confirmed the results of previous research and supported the view that participating in interventions to prepare for disasters is ethically appropriate. Future research could investigate which specific features of the interventions might be responsible for this.

Limitations, implications, and future research

The study has some limitations related to the research design, to the content of the interventions, and to some characteristics of the sample. First, concerning the research design, we could not test the efficacy of the training program in the long-term for the whole sample, because of the outbreak of the 2020 COVID-19 pandemic. Moreover, for the same reason, we could not conduct the training program with the control group as planned using a wait list design. Second, as regards the content of the intervention, we focused mainly on semantic knowledge and less on episodic and/or procedural knowledge. Future studies could include evacuation drills within a similar training program, checking the combined effects of a broader range of knowledge types. Moreover, we did not assess children's self-efficacy, attitudes, or intentions for performing specific behaviours during an earthquake, that, beginning from the pioneer works of authors such as Fishbein and Ajzen (1975), are considered as central elements within persuasion models. In addition, we used self-report instruments to assess children's inner states. Self-report instruments can be influenced by biases related for example to social desirability. Future research could integrate self-report measures with other measures, e.g., assessing observational or physiological indicators. Third, we used the training program with school children who had already mastered the basic literacy skills enabling them to read and write. Both within the app and during the traditional activities, we paid particular attention to support those children who could have had difficulties in mastering these abilities. Nevertheless, future research could adapt the training program reducing the weight on literacy skills, and thus be applicable for use with younger children. Fourth, we developed a training program which could be implemented by a variety of adults and/or professionals interested in students' wellbeing; however, we did not evaluate whether a similar adapted training program could be used by them, to improve their own capacity to respond to the students' needs and to increase their own wellbeing and resilience (Qualter et al., 2017). Future research could explore this issue.

Overall, our analyses indicated that participating in the PrEmT training program improved children's knowledge and metacognition about earthquakes, earthquake-related emotions, and associated regulation strategies. However, we also received anectodical feedback from a variety of sources, such as teachers and parents, about the generalisability of the acquired knowledge beyond the specific topic of earthquakes. On the one hand, this change was observed in everyday contexts, in which the children must manage intense emotions as in the case of anger outbursts in class. On the other hand, the outbreak of the 2020 COVID-19 pandemic challenged the psychological wellbeing of both children and adults (Panda et al., 2021). In this second context, feedback suggested the efficacy of the previous participation in the PrEmT project as providing a way to cope with the variety of emotions due to the pandemic.

CONCLUSION

Our study demonstrated the efficacy of the PrEmT training program as a mean to increase primary school children's knowledge and metacognition about earthquakes, emotions, and emotion regulation.

We followed the standards of evidence-based research and took advantage of the benefits offered by technology. As postulated by theoretical models such as the PFD model (Raccanello, Vicentini, Rocca, et al., 2020, Raccanello, Vicentini, et al., 2021), preparedness and prevention actions aimed at enhancing knowledge can be central to diminishing the traumatic impact of disasters – both preserving physical and psychological wellbeing and reducing psychopathological consequences. Being aware of the possible catastrophic impacts of natural disasters and activating children's psychological resources in advance is one of the important steps in fostering their resilience.

AUTHOR CONTRIBUTIONS

Daniela Raccanello: Conceptualization; funding acquisition; investigation; methodology; project administration; resources; supervision; validation; writing – original draft. **Giada Vicentini:** Conceptualization; data curation; investigation; methodology; writing – original draft. **Emmanuela Rocca:** Investigation; methodology; writing – review and editing. **Rob Hall:** Conceptualization; methodology; visualization; writing – review and editing. **Roberto Burro:** Conceptualization; data curation; formal analysis; investigation; methodology; software; visualization; writing – original draft.

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CONFLICT OF INTEREST STATEMENT

We have no known conflict of interest to disclose.

DATA AVAILABILITY STATEMENT

Materials and analysis code for this study are available by emailing the corresponding author. This study's design and its analysis were not pre-registered.

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APPENDIX

Further characteristics of the sample

The groups had similar family characteristics that included fathers/mothers' age (experimental group: M_{age} = 45.38/42.06, SD = 6.08/5.41, range: 29.49–64.78/27.56–61.07; control group: M_{age} = 44.84/41.78, SD = 5.68/5.25, range: 28.00–65.60/23.03–53.36), their level of instruction (experimental group: 0/1% no title, 0/0% primary school, 15/8% lower secondary school, 51/46% upper secondary school, 34/45% university or post-lauream degree; control group: 0/1% no title, 0/1% primary school, 21/7% lower secondary school, 49/43% upper secondary school, 30/48% university or post-lauream degree), and their job position (experimental group: 2/25% student or homemaker or unemployed or retired, 65/59% employee, 32/14% self-employed worker, 1/2% casual worker; control group: 2/14% student or homemaker or unemployed or retired, 68/69% employee, 30/17% self-employed worker, 0/0% casual worker). They came from a wide range of socio-economic background.

Attrition information

We display the information on the recruitment process and the attrition rates in the CONSORT flow diagram (Figure 1). We delivered the informed consent form to 621 children. We excluded 34 children because their parents did not give consent or changed school before the beginning of the pretest. We randomized the classes of the remaining 587 children into the experimental group or into the control group (Grolnick et al., 2018). We excluded another two children because they changed school after the beginning of the project. We then excluded another 37 children (experimental group: n = 22; control group: n = 15) from the analyses because of intellectual or learning disabilities, language difficulties, or because they were absent during the pretest or the posttest. The final sample comprised 548 children, 321 for the experimental group and 227 for the control group.

Implementation fidelity

We assessed the fidelity of the way each conductor of the intervention followed the manual (adaptation from Berger et al., 2016; O'Donnell, 2008). For the first wave, each session was videotaped (for a total of 30 units), for the fidelity review and to be used as the basis for training the conductors and the collaborators for the second wave. Two observers coded each videotaped session using a checklist on a 6-point scale (0 = *not at all stipulated in the manual* and 5 = *exactly as stipulated*) for four aspects: (a) adherence of the conductor to the topic, (b) implementation of the activities, (c) active participation of collaborators and students, and (d) adhering to the psychological bases of the manual. For the second wave, one collaborator coded one session of each conductor for each unit (for a total of 20 units) using the same checklist. All the ratings scored 4 or 5 in all the sessions, indicating a high implementation fidelity.

Transparency and openness

We declare that we have reported how we determined our sample size, all data exclusions (Figure 1), all manipulations, and all measures in the study, and we follow JARS (American Psychological Association, 2020). Materials and analysis code for this study are available by emailing the corresponding author. This study's design and its analyses were not pre-registered.