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Can a web application foster emotional competence in children and adolescents? The case of PandHEMOT®

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Abstract

The COVID-19 pandemic has had many traumatic consequences for the physical and psychological functioning of children and adolescents. Internet-based interventions can reach a large audience and be a potentially powerful resource for promoting well-being among young people. We tested the efficacy of the web application PandHEMOT®, developed ad hoc for increasing knowledge about pandemics, emotions, and emotion regulation. We involved a sample of 147 Italian third and seventh graders. The sample was assigned to an experimental (participating in the training) and a waitlist condition (who participated following a waitlist design). All the participants completed pretest and posttest measures. The intervention was structured into three units. The training took place between November and December 2021. Generalized linear mixed models and linear mixed models revealed that knowledge about pandemics, emotions, emotion regulation, and metacognitive awareness increased for the experimental condition. Moreover, adolescents performed better than children. The findings supported the efficacy of an Internet-based training for increasing children and

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adolescents' resilience, according to the standards of evidence-based research.

KEYWORDS
children and adolescents, COVID-19, emotional competence, psychoeducational intervention, web application

INTRODUCTION

A pandemic is a geographically widespread occurrence of an infectious disease that occurs within a relatively short period of time. As such, it has the potential to become a naturally occurring disaster. The World Health Organization declared the spread of COVID-19 to be a pandemic on 11 March 2020 (WHO, 2020). After more than 3 years, it has become clear that COVID-19 has impacted communities around the world in a range of ways. Several studies have documented its lasting impact on both physical and mental health among adults, adolescents, and children. The latter two groups are usually considered as a particularly vulnerable population in the context of disasters (Thomas et al., 2013). Young people are more prone than adults to lack the life experience and mental resources that might support emotional resilience in the face of a disaster. Previous research has demonstrated that young people can be helped by enhancing their knowledge about the characteristics of a disaster and their own emotional reactions to it (e.g. Hisli Sahin et al., 2011; Raccanello et al., 2020b, 2023c).

Several interventions have recently been delivered through web-based applications aimed at reducing the traumatic impact of the pandemic (e.g. Linardon et al., 2022; Sun et al., 2022). For example, Sun et al. (2022) created a mindfulness-based mobile intervention for adult students. Internet-based training such as this can reach a large target population, overcoming some of the difficulty in accessing sometimes already overloaded services, without time or space constraints (Fairburn & Patel, 2017; Torous et al., 2021). This is particularly useful when people are confined, as in the cases of quarantine due to the COVID-19 pandemic (Sun et al., 2022). Moreover, Internet-delivered interventions can play a key role in mitigating long-term effects of the pandemic and promoting people's resilience when adapting to a changed context (Ang et al., 2022; Figueroa & Aguilera, 2020). While, for example, Sun et al. (2022) used a randomized controlled trial to support the goodness of their procedure, the efficacy of many Internet-based programmes delivered during the pandemic has rarely been assessed (Chen et al., 2020; Liu et al., 2020). Indeed, it seems that the underlying basis of many of the mental health applications accessible by consumers is not evidence-based (Wasil et al., 2019). It has been argued that the validity of such Internet-delivered tools should be documented following the standards of evidence-based research (Flay et al., 2005).

In our research, we evaluated the efficacy of an evidence-based training programme that includes a web application, that is, PandHEMOT® (Pandemics—Helmet for EMOTions, https://www.pandhemot.eu), that we developed specifically for the programme. The programme was designed to help children and adolescents cope with the current and future psychological challenges posed by the COVID-19 disaster. The content is aimed at fostering their knowledge about pandemics, the associated emotions they might experience, and emotion regulation strategies they might use as a way of coping.

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Impact of the COVID-19 pandemic on children and adolescents

The COVID-19 pandemic has impacted many areas of everyday life, due not only to the sequalae of the disease but also from the social restrictions implemented to reduce spreading the coronavirus (Ellis et al., 2020; Galea et al., 2020; Margaritis et al., 2020). Some studies demonstrated the negative short-term effects of school closures on primary and secondary students' achievement levels, in particular among younger students and those with a lower socioeconomic status (Hammerstein et al., 2021). Other studies have also reported negative consequences for both physical and mental health. A study involving Canadian parents documented a decrease in young people's physical activity levels and an increase in their sedentary behaviour and sleeping time (Moore et al., 2020). A comparison of measures before and after the beginning of the COVID-19 pandemic showed a decline in physical activity levels in a sample of Croatian adolescents living in urban areas (Zenic et al., 2020). These changes are of concern mainly because of their potential long-term effects (Carson et al., 2016). Some meta-analyses focussed on the pandemic-related psychopathological consequences for young people (Panda et al., 2021; Raccanello et al., 2023b; Racine et al., 2021). Panda et al. (2021) explored the psychological and behavioural impact of lockdown and quarantine measures with a sample of about 23,000 children and adolescents across 15 studies. They found that more than 30% of the participants suffered from anxiety, depression, irritability, and inattention; almost 80% were negatively affected by the quarantine measures; and more than 20% had an intense fear of COVID-19, boredom, and sleep problems. Two meta-analyses documented the incidence of anxiety, depression, post-traumatic stress disorder (PTSD), and psychological distress in children and adolescents during the COVID-19 pandemic. Racine et al. (2021) examined 29 studies involving a total of nearly 81,000 children and adolescents, finding an overall level of 25.2% reporting depression and 20.5% anxiety, with higher symptoms for females in contrast to males. The analysis also showed that adolescents were more prone to anxiety than were children. Similarly, another meta-analysis of 26 studies (Raccanello et al., 2023b) revealed that 20% of children and adolescents manifested disorders and/or symptoms related to depression, anxiety, PTSD, and psychological distress. However, it is known that after a widespread disaster, most children and adolescents do not show severe disturbances, or they recover without long-term consequences, that is, they demonstrate resilience (Luthar et al., 2015). Among the factors that influence young people's reactions to a disaster are the extent (or "dose") of exposure, their stage of physical and intellectual development, individual differences, and the societal support supplied by the family, school, and general community (Masten, 2021). The experience of school can be particularly important as a context for incorporating socio-educational programmes designed to increase resilience and disaster preparedness (Bagneris et al., 2021; Fu & Underwood, 2015; Rolfsnes & Idsoe, 2011).

Emotional competence in children and adolescents

Emotional competence is a key resource for building children and adolescents' resilience. It can be defined as the ability to express, understand, and regulate one's own and others' emotions (Denham, 1998). Knowledge about these three abilities is gradually acquired during development, from 2 to 3 years of age to adolescence. To be emotionally competent, children need to

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master knowledge about the nature of emotions, their causes, and their regulation (Pons et al., 2004).

For children to understand the nature and the causes of emotions, it is important that they can recognize facial expressions associated with emotions, comprehend an emotional lexicon, and be able to distinguish emotions according to their positive and negative valence. It is also important for them to understand that different events can cause similar emotions. To date, only a few studies have focussed on the development of emotional knowledge in the context of the pandemic. Concerning the recognition of emotions, data from a sample of 7 to 13-year-olds suggested that wearing face masks can impact their ability to recognize facial expressions of emotions; however, such an effect could also occur when people wear sunglasses (Ruba & Pollak, 2020). Other researchers explored adolescents' production of the emotional lexicon and found that they commonly referred to their emotions in terms of stress and boredom. While there were terms about positive emotions, expressed emotions were frequently less positive and more negative compared with 1 year before the outbreak of the pandemic (Alivernini et al., 2021; Ellis et al., 2020; Waselewski et al., 2020). Moreover, adolescents demonstrated the ability to identify the causes of their emotions (Fioretti et al., 2020). For example, they attributed their negative emotions to being confined to home, to changes in the school context, to the impact of the new daily routines, and to the fear of being lonely. Nevertheless, they acknowledged that positive emotions were due to being part of something exceptional, to discovering themselves and their families, and to remotely sharing their life with others.

To comprehend the regulation of emotions, it is important to understand that an emotion can vary in strength and that there are different ways to influence it. Emotion regulation comprises intentional and unintentional processes that can affect the kind of emotion and its intensity and duration (Gross, 1998). While children tend to understand these processes at the end of the school years (Pons et al., 2004), they progressively refine the ability to regulate emotions from infancy to adolescence. As the age increases, children expand their repertoire of emotion regulation strategies. For example, they add intraindividual strategies such as self-reliance to interindividual strategies such as support seeking; they also begin to use cognitive strategies such as reappraisal rather than previously mastered behavioural strategies such as problem solving (Phillips & Power, 2007; Thompson & Goodvin, 2007). Another construct related to emotion regulation is coping, a multicomponent process that includes attempts to reduce the negative impact of stressful events (Lazarus & Folkman, 1984; for analogies and differences between emotion regulation and coping, see Compas et al., 2014). A recent taxonomy of coping strategies classifies these strategies using a developmental framework that distinguishes them according to their function, that is, adaptive or maladaptive (Zimmer-Gembeck & Skinner, 2011). Whether someone resorts to adaptive or maladaptive strategies can depend on whether they see a traumatic event as a challenge or a threat. Such events can trigger each of three basic needs, that is, the need for competence, relatedness, and autonomy (Deci & Ryan, 1985). Within the taxonomy, the authors identified 12 families of coping strategies, resulting from combining the two functions, the three needs, and considering two kinds of families for each of the six subgroups (for a more detailed description, see Zimmer-Gembeck & Skinner, 2011). Adaptive strategies comprise problem solving and information seeking (directed at competence); self-reliance and support seeking (directed at relatedness); and accommodation and negotiation (directed at autonomy). Maladaptive strategies include helplessness and escape (contrasted with competence); delegation and social isolation (contrasted with relatedness); and submission and opposition (contrasted with autonomy). These adaptive and maladaptive functions had been confirmed in the case of natural disasters and, recently, in the case of a

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pandemic (Raccanello et al., 2021a, 2023a, 2023b). For example, a sample of adolescents reported that they reacted to the pandemic using strategies pertaining to problem solving (e.g. respecting safety measures), self-reliance (e.g. trying to relax), support seeking (e.g. being connected with others), accommodation (e.g. keeping busy), and negotiation (e.g. following daily routines; Waselewski et al., 2020). Some studies also revealed the efficacy of strategies concerning problem solving, self-reliance, social support, and accommodation and the negative impact of strategies such as escape and social isolation, documenting their associations with various indicators of well-being and/or mental health (e.g. Duan et al., 2020; Ellis et al., 2020; Tang et al., 2021). Finally, it is worth noting that adolescents have the potential for being aware of the challenges associated with the COVID-19 pandemic. For example, a sample of American adolescents, when asked about the three most relevant pandemic-related challenges they faced, reported issues concerning their education, followed by aspects pertaining to mental health, physical health, and social relations, in particular concerning friends (Scott et al., 2021).

Disaster-related interventions for children and adolescents

Previous literature demonstrated the efficacy of interventions devoted to enhancing socio-emotional skills in children and adolescents (Durlak et al., 2022), also through digital interventions (Reynard et al., 2022). However, little research has been focussed on evidence-based programmes aimed at increasing emotional competence as a key resource to cope with disasters. Several meta-analyses and systematic reviews documented the beneficial effects of different psychological treatments for helping children and adolescents with psychopathologic disorders in the aftermath of a variety of disasters. These include trauma-focussed cognitive behavioural therapy, eye movement desensitization and reprocessing, and the narrative exposure therapy (e.g. Bastien et al., 2020; Brown et al., 2017; Gutermann et al., 2016). Nevertheless, only a limited number of studies focussed on interventions from a preventive, resilience building perspective.

According to the American Psychological Association (APA, n.d.), primary prevention includes those initiatives involving the whole population, designed to avoid the occurrence of mental health disturbances; secondary prevention is devoted to a specific group of individuals with pre-existing difficulties, to prevent more severe problems; and tertiary prevention comprises actions to help people with already existing disorders to facilitate their recovery. Adopting a simple primary prevention strategy that helps young people build their preparedness to cope with disasters is an important step in reducing the emotional, social, and economic costs associated with applying post-disaster secondary and tertiary prevention actions. They may be especially important in cases such as a pandemic in which the emergency phase of the disaster is prolonged.

Previous research has demonstrated the value of using psychoeducation as a way to empower people's knowledge in relation to risk management, with increased awareness recognized by the United Nations as a pillar for improving children and adolescents' readiness towards disasters, rather than supporting people's natural recovery (Howard & Goelitz, 2004; Seddighi et al., 2020; Torani et al., 2019). Coherently with this, we documented a rise in children's knowledge and metacognitive awareness about how to cope with earthquakes through an evidence-based psychoeducational programme combining traditional and digital activities (Raccanello et al., 2023c). Such intervention was based on a theoretical model focussing on the psychological processes characterizing the responses to disasters (Raccanello et al., 2023c).

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According to the model, interventions on emotional competence and disaster preparedness help to prepare people to encode both declarative and procedural knowledge concerning safety measures and emotion regulation strategies that can be retrieved during and just after a disaster. Specifically, training individuals about the nature of a disaster and related safety behaviours, typical emotional reactions, and effective emotion regulation strategies facilitates the management of the psychological processes activated during a disaster. People need to recognize the nature of the stimuli through their sensory and perceptive processes, to use their memory to retrieve adaptive behavioural responses and effective emotion regulation strategies, and to deal with decision-making processes underlying their reactions. Therefore, enhancing young people's knowledge on the aforementioned three core components (i.e. nature of disasters and safety behaviours, emotional reactions, and emotion regulation strategies) can be critical for their safety and well-being during a disaster. A related component fostered by such trainings is metacognition. We specify that metacognitive awareness includes different components; one of them is knowledge about cognition (Schraw & Dennison, 1994). The latter comprises a declarative component that can be measured asking someone whether s/he knows or not something (Ozturk, 2017). An improved metacognition can also facilitate the transfer of acquired knowledge to real-life contexts (Bransford et al., 1999).

It is worth noting that a common concern within the literature about disaster-related psychoeducational interventions regards the possible negative effect of introducing a training on traumatic events, forcing young people to be in contact with possibly traumatic topics (e.g. earthquakes, tornados, and assaults). Nowadays, there are heterogeneous findings indicating both increases and decreases of short-term fear or anxiety related to such interventions, together with evidence underlying the positive impact of moderated levels of anxiety and the key relevance of talking with young people especially for those disasters for which there is a wide media coverage (Johnson et al., 2014). Specifically for our case, we were aware that our participants were very familiar with the characteristics of the pandemic and its consequences. Available research also suggests that even during the first months of the COVID-19 outbreak, 3 to 11-year-olds were already aware of concepts such as contagion risk and the potential severity of the disease (Persici Toniolo et al., 2021).

During the initial phase of the COVID-19 pandemic, some psychoeducational initiatives have been implemented, for example, the development of a public communication campaign aimed at providing adults with easy ways to help children and adolescents manage their pandemic-related emotions (Raccanello et al., 2020b). However, to our knowledge, previous research has not investigated the efficacy of digitally delivered, evidence-based programmes designed to support young people in adopting appropriate strategies for coping with the stress of pandemics.

The current study

The main aim of this study was to test the efficacy of an evidence-based programme delivered by the app PandHEMOT®. The programme was designed to assist elementary and middle school students increase their knowledge and metacognition about pandemics, emotions, and emotion regulation. We involved third and seventh graders because they represent students in the central grade of each school level, that is, elementary and middle. It is particularly relevant to compare these two groups in light of the range of psychological changes characterizing the transition between the two school levels, at the biological, cognitive, emotional, social, or

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identity domains (Raccanello et al., 2021b). The students were assigned to an experimental and a waitlist condition, following a waitlist design. We had three aims. First, we aimed at fostering young people's knowledge across three content areas, that is, pandemics, emotions, and emotion regulation.

> **Hypothesis 1.** Knowledge about the nature of the pandemic and pandemic-related safety measures, emotion recognition abilities and emotional lexicon, and pandemic-related emotion regulation strategies were hypothesised to be higher for the participants in the experimental compared with the waitlist condition (1a) and lower for third graders compared with seventh graders (1b).

Second, we aimed at improving children and adolescents' metacognition.

> **Hypothesis 2.** Participants in the experimental condition were hypothesised to increase their pandemic-related metacognitive awareness about the characteristics of pandemics, safety measures, pandemic-related emotions, and emotion regulation strategies, compared with the waitlist condition.

Moreover, we explored class level differences in metacognitive awareness.

Third, we measured well-being before and after the intervention to check for possible short-term negative effects of a training focussing on a possibly traumatic event.

MATERIALS AND METHOD

Design and participants

The study was based on a quasi-experimental design, following the standards of evidence-based research (Flay et al., 2005). The data were collected longitudinally in class. We used a cluster-randomized design in which classes were randomized to different conditions, that is, experimental or waitlist condition (Grolnick et al., 2018; see Supporting Information S1 for more details). The students in the experimental condition participated in a three-unit programme using the app PandHEMOT®; in the same period, the students in the waitlist condition continued normal school activities. A week before the training, we administered a pretest to both conditions, and a week after the training, we administered a posttest. In each case, we used a self-report questionnaire to evaluate participants' knowledge about pandemics, emotions, and emotion regulation strategies. The students in the waitlist condition experienced the training at the end of the project.

The sample consisted of 147 students from elementary and middle schools of Northern Italy. We involved 65 third graders and 82 seventh graders, attending a total of 12 classes. Eighty students were allocated to the experimental condition (third graders: three classes, $n = 38$, $M_{age} = 8.40$, $SD = 0.26$, range: 7.91–8.86, 40% females; seventh graders: three classes, $n = 42$, $M_{age} = 12.42$, $SD = 0.29$, range: 11.91–12.86, 60% females) and 67 to the waitlist condition (third graders: three classes, $n = 27$, $M_{age} = 8.27$, $SD = 0.28$, range: 7.75–8.84, 56% females; seventh graders: three classes, $n = 40$, $M_{age} = 12.38$, $SD = 0.31$, range: 11.90–13.40, 43% females). The two conditions had a similar demographic composition (see Supporting Information S1, for descriptive statistics and tests), in terms of participants' age and gender, parents'

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age, parents' level of education and job position, and participants and family members' COVID-19 experience (i.e. having been tested positive to the SARS-CoV-2 or not).

Procedure

The training took place between November and December 2021. The study was approved by the Ethical Committee of the Department of Human Sciences of the University of Verona (protocol number 433148). After obtaining the informed consent forms signed by parents, the project began with the administration of a pretest questionnaire. Then, the students in the experimental condition participated in the training, composed of three units, administered in class approximately once a week (for three consecutive weeks) during school time and with a duration of an hour. We monitored their participation registering their responses to the app units. After the training, students of both conditions completed a posttest questionnaire. In case some students were absent during the pretest/posttest questionnaires or the units, we gave them a link through which they could do the activity, individually. For ethical issues, the students in the waitlist condition took part in the training in February 2022. The information about the recruitment and the attrition rates are detailed in Supporting Information S1, together with the CONSORT flow diagram (Figure S1).

We implemented a three-unit programme based on digital activities delivered via the app PandHEMOT® (adapted from Raccanello & Burro, 2019; Raccanello et al., 2020, 2023c; Vicentini et al., 2020). The students used tablets and headphones for doing the activities. All the units were facilitated by two experts in educational psychology (i.e. the second and the third authors) with the help of at least two collaborators, using protocols derived from the psychological literature (Durlak et al., 2022). The facilitators followed a previously defined script for giving all the instructions. PandHEMOT® is composed of nine levels, divided into three units, aimed at increasing users' knowledge on pandemics (unit 1; levels 1 and 2), emotions (unit 2; levels 3–6), and emotion regulation strategies (unit 3; levels 7–9). The training contents are described in Supporting Information S1. See Figure S2 for examples of screenshots from the app.

We administered pretest and posttest questionnaires to evaluate participants' knowledge about pandemics, emotions, and emotion regulation strategies through open questions on the one hand and their metacognitive awareness towards such knowledge and general well-being through two scales with closed responses on the other hand. For assessing possible changes in the participants' knowledge in relation to the training, we chose to use ad hoc open questions as a flexible way that can be adapted to assess the acquisition of specific contents, as the ones presented through the units. This procedure permits to increase the content validity of the measures about knowledge, as their capacity to grasp the contents of interest mirroring the underlying representation of the participants. In doing so, we adapted some questions used in previous research about disasters (Raccanello et al., 2023c), and we developed the coding scheme for each measure deductively on the basis of reliable sources (e.g. WHO, n.d.) and inductively taking into account the students' responses, further increasing the validity of such procedure as in the case of mixed qualitative and quantitative research (Levitt et al., 2018). We also assessed the reliability of the measures about knowledge, as the degree of consistency with which coding segments are assigned to the same categories, calculating Cohen's k (in case of categorical data) and the percentage of agreement (in case of numerical data) between the evaluation of a first rater who coded 100% of the protocols and of a second rater who independently coded 30% of them—they are reported as follows. Disagreements between judges were resolved through

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discussion. Overall, the interrater reliability was very high (Landis & Koch, 1977). Open questions and examples of open-ended answers are reported in Table S3.

Measures

Knowledge on pandemics: Pandemics definition

We evaluated students' knowledge about the characteristics of pandemics through an open question. The answers were divided into units, defined as subject–verb constructions (Raccanello et al., 2022). Then, we counted the number of units with plausible information concerning the definition of some basic characteristics of a pandemic (adapted from Raccanello et al., 2023c); agreement is at 98.60%.

Knowledge on pandemics: Pandemic-related safety measures

We assessed students' knowledge about safety measures to prevent the contagion through an open question. For each answer, we counted the number of adequate safety measures (adapted from Raccanello et al., 2023c); agreement is at 98.75%. The adequacy was established on the basis of reliable sources (e.g. WHO, n.d.).

Knowledge on emotions: Emotion recognition

The ability to recognize facial expressions of emotions was assessed through a labelling task (adapted from Izard et al., 2003; Raccanello et al., 2023c). We asked the students to write a label to describe each of six drawings corresponding to the facial expressions of six emotions, that is, enjoyment, surprise, calm, sadness, fear, and anger (the gender of the drawn faces was the same of the respondent to favour identification). We coded the answers by counting the number of plausible labels, ranging from 0 to 6; $k = 0.98$.

Knowledge on emotions: Emotional lexicon

We evaluated students' knowledge about psychological lexicon requesting to write a list of synonyms of six emotions, that is, enjoyment, surprise, calm, sadness, fear, and anger (adapted from Raccanello & Hall, 2021; Raccanello et al., 2023c). We coded the answers by counting the number of plausible synonyms; agreement is at 99.17%.

Knowledge on emotion regulation strategies

To assess students' knowledge about emotion regulation, we asked them to report a list of strategies that can be adequate to regulate pandemic-related negative emotions. Then, we counted the number of plausible adaptive strategies (adapted from Raccanello & Hall, 2021; Raccanello et al., 2023c); agreement is at 99.54%. The adequacy of the strategies was established on the

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basis of the psychological literature (Raccanello et al., 2023a; Zimmer-Gembeck & Skinner, 2011).

Pandemic-related metacognitive awareness

We measured pandemic-related metacognitive awareness through four items developed ad hoc (adapted from Raccanello et al., 2023c; Schraw & Dennison, 1994; Sperling et al., 2002), aimed at assessing declarative (*How many things do you know about pandemics/about how people feel during a pandemic?*) and procedural knowledge (*How many things do you know about what to do in case of a pandemic/about how getting rid of negative emotions?*). The items had a 5-point response scale (1 = *nothing* and 5 = a *very great number of things*); $\omega = 0.77$.

General well-being

We administered an adapted version of the School-related Well-Being Scale (previous works documented both its internal and external validity; Stockinger et al., 2023; Italian validation by Raccanello et al., 2021b) to assess students' general well-being, deleting the reference to the school context. The scale comprised six items (e.g. *I feel good*) to be evaluated on a 5-point scale (1 = *not at all* and 5 = *extremely*); $\omega = 0.90$.

Data analysis

We utilized the R software, version 4.1.1. We conducted five generalized linear mixed models (GLMM) and two linear mixed models (LMM). We took into account the condition (experimental or waitlist) and the class level (third graders or seventh graders) as categorical fixed between-subject effects; the phase (pretest and posttest) as categorical fixed within-subject effect; and the participants, gender (female or male), and classes (12 classes) as the random effects. The dependent variables were, for each of the seven models, the number of plausible units concerning pandemic definition (count variable; GLMM); the number of adequate pandemic-related safety measures (count variable; GLMM); the proportion of adequate labels in the emotion recognition task on the total of possible adequate labels, that is, six (proportion variable; GLMM); the number of plausible synonyms of emotions (count variable; GLMM); the number of plausible pandemic-related emotion regulation strategies (count variable; GLMM); the level of pandemic-related metacognitive awareness (rating variable; LMM); and the score of general well-being (rating variable; LMM). For the GLMM, involving, respectively, proportion and count variables, we used binomial family and logit link function and Poisson family and log link function. For the LMM, regarding rating variables, we utilized the Gaussian family and the identity link function. For both types of models, we constructed mixed-model analysis of variance (ANOVA) tables (omnibus tests) through likelihood ratio tests with chi-square tests. We calculated the conditional R^2 for each model, which can be small ($.02 \leq R^2 < .13$), medium ($.13 \leq R^2 < .26$), or large ($R^2 \geq .26$; Cohen, 2013); it corresponds to the variance explained by a model, comprising both fixed and random effects (Johnson, 2014; Nakagawa et al., 2017). We reported in Table 1 all the effects and interactions and the key post hoc tests; in Table S4 means, standard deviations, and 95% confidence intervals (CI) for pretest

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TABLE 1 Chi square (with degrees of freedom) and level of significance for effects and interactions and key Bonferroni tests and effect sizes for all dependent variables.

Variables	Significant effects or interactions	χ^2 (*df*)	*p*	Bonferroni comparisons	*z*	*p*	*d*
Pandemics definition	Condition	4.45 (1)	.035	EX vs. WA	2.55	.011	0.33
	Class level	21.04 (1)	<.001	3rd vs. 7th	7.89	<.001	1.00
	Phase	12.65 (1)	<.001	PRE vs. POST	3.60	<.001	0.29
	Condition × class level	0.07 (1)	n.s.	—	—	—	—
	Condition × phase	16.91 (1)	<.001	EX: PRE vs. POST	6.37	<.001	0.62
				WA: PRE vs. POST	0.40	n.s.	0.05
				PRE: EX vs. WA	0.04	n.s.	0.01
				POST: EX vs. WA	4.59	<.001	0.67
	Class level × phase	4.56 (1)	.033	3rd: PRE vs. POST	3.29	.006	0.46
				7th: PRE vs. POST	1.48	n.s.	0.11
				PRE: 3rd vs. 7th	7.51	<.001	1.17
				POST: 3rd vs. 7th	5.81	<.001	0.83
	Condition × class level × phase	6.20 (1)	.013	EX, PRE: 3rd vs. 7th	4.86	<.001	1.01
				WA, PRE: 3rd vs. 7th	5.71	<.001	1.34
				EX, POST: 3rd vs. 7th	5.99	<.001	1.07
				WA, POST: 3rd vs. 7th	2.65	n.s.	0.60
Pandemic-related safety measures	Condition	14.66 (1)	<.001	EX vs. WA	5.72	<.001	0.42
	Class level	19.78 (1)	<.001	3rd vs. 7th	7.49	<.001	0.55
	Phase	41.78 (1)	<.001	PRE vs. POST	6.48	<.001	0.41
	Condition × class level	0.06 (1)	n.s.	—	—	—	—
	Condition × phase	26.20 (1)	<.001	EX: PRE vs. POST	9.66	<.001	0.73
				WA: PRE vs. POST	0.83	n.s.	0.08
				PRE: EX vs. WA	0.90	n.s.	0.09
				POST: EX vs. WA	8.32	<.001	0.74
	Class level × phase	2.54 (1)	n.s.	—	—	—	—
	Condition × class level × phase	0.73 (1)	n.s.	—	—	—	—

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TABLE 1 (Continued)

Variables	Significant effects or interactions	χ^2 (*df*)	*p*	Bonferroni comparisons	*z*	*p*	*d*
Emotion recognition	Condition	8.45 (1)	.004	EX vs. WA	3.24	.001	0.82
	Class level	4.30 (1)	.038	3rd vs. 7th	2.07	.039	0.53
	Phase	17.49 (1)	<.001	PRE vs. POST	3.94	<.001	0.85
	Condition × class level	0.90 (1)	n.s.	—	—	—	—
	Condition × phase	8.58 (1)	.003	EX: PRE vs. POST	4.13	<.001	1.45
				WA: PRE vs. POST	0.98	n.s.	0.24
				PRE: EX vs. WA	0.81	n.s.	0.22
				POST: EX vs. WA	3.69	.001	1.43
	Class level × phase	1.54 (1)	n.s.	—	—	—	—
	Condition × class level × phase	1.32 (1)	n.s.	—	—	—	—
Emotional lexicon	Condition	7.57 (1)	.006	EX vs. WA	3.23	.001	0.25
	Class level	25.33 (1)	<.001	3rd vs. 7th	9.32	<.001	0.74
	Phase	50.89 (1)	<.001	PRE vs. POST	7.15	<.001	0.38
	Condition × class level	0.54 (1)	n.s.	—	—	—	—
	Condition × phase	11.45 (1)	<.001	EX: PRE vs. POST	8.51	<.001	0.56
				WA: PRE vs. POST	2.39	n.s.	0.20
				PRE: EX vs. WA	0.75	n.s.	0.07
				POST: EX vs. WA	4.80	<.001	0.43
	Class level × phase	5.54 (1)	.019	3rd: PRE vs. POST	2.81	.030	0.25
				7th: PRE vs. POST	9.06	<.001	0.50
				PRE: 3rd vs. 7th	6.19	<.001	0.62
				POST: 3rd vs. 7th	9.50	<.001	0.87
	Condition × class level × phase	1.32 (1)	n.s.	—	—	—	—
Pandemic-related emotion regulation strategies	Condition	0.84 (1)	n.s.	—	—	—	—
	Class level	6.51 (1)	.011	3rd vs. 7th	2.95	.003	0.49
	Phase	40.31 (1)	<.001	PRE vs. POST	6.43	<.001	0.37

(Continues)

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TABLE 1 (Continued)

Variables	Significant effects or interactions	χ^2 (*df*)	*p*	Bonferroni comparisons	*z*	*p*	*d*
	Condition × class level	0.88 (1)	n.s.	—	—	—	
	Condition × phase	52.83 (1)	<.001	EX: PRE vs. POST	10.28	<.001	0.79
				WA: PRE vs. POST	0.62	n.s.	0.05
				PRE: EX vs. WA	1.45	n.s.	0.26
				POST: EX vs. WA	3.33	.005	0.58
	Class level × phase	0.15 (1)	n.s.	—	—	—	—
	Condition × class level × phase	0.02 (1)	n.s.	—	—	—	—
Pandemic-related metacognitive awareness	Condition	1.79 (1)	n.s.	—	—	—	—
	Class level	7.05 (1)	.008	3rd vs. 7th	2.62	.033	0.28
	Phase	28.18 (1)	<.001	PRE vs. POST	5.50	<.001	0.33
	Condition × class level	1.30 (1)	n.s.	—	—	—	—
	Condition × phase	9.71 (1)	.002	EX: PRE vs. POST	6.45	<.001	0.51
				WA: PRE vs. POST	1.60	n.s.	0.14
				PRE: EX vs. WA	0.38	n.s.	0.05
				POST: EX vs. WA	2.66	n.s.	0.33
	Class level × phase	2.29 (1)	n.s.	—	—	—	—
	Condition × class level × phase	0.01 (1)	n.s.	—	—	—	—
General well-being	Condition	0.24 (1)	n.s.	—	—	—	—
	Class level	18.08 (1)	<.001	3rd vs. 7th	4.85	.002	0.55
	Phase	0.77 (1)	n.s.	—	—	—	—
	Condition × class level	0.01 (1)	n.s.	—	—	—	—
	Condition × phase	0.02 (1)	n.s.	—	—	—	—
	Class level × phase	0.09 (1)	n.s.	—	—	—	—
	Condition × class level × phase	0.05 (1)	n.s.	—	—	—	—

Note: For *z* and *d*, we reported the absolute value.

Abbreviations: 3rd, third graders; 7th, seventh graders; χ^2, Chi square; *d*, Cohen's *d*; *df*, degrees of freedom; EX, experimental condition; n.s., not significant; *p*, level of significance; POST, posttest; PRE, pretest; WA, waitlist condition; *z*, z-ratio.

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and posttest by condition (for the whole sample and by class level); and in Figure 1 means and 95% CI concerning the interaction between condition and phase. We anticipate that the GLMM and the LMM revealed no differences between the two conditions for each dependent variable in the pretest, given that all the interactions between condition and phase were not significant (i.e. for metacognitive awareness and well-being) or, whether they were significant (i.e. for all the other variables), they were associated with a nonsignificant post hoc test examining the comparison between the two conditions in the pretest (see Table 1 for interactions and post hoc tests; see Table S4 for descriptive statistics). We performed a post hoc sensitivity power analysis for the observed effects sizes, considering the conditional R^2 and calculating the effect size as Cohen's f^2, separately for the seven models. All the models had the same numerosity ($N = 147$); with alpha = 0.05, we always had a power equal to 99% (with the exception of the model with pandemic-related metacognitive awareness as the dependent variable, for which the power was 84%), higher than the threshold value of 80%. Therefore, the sample size was adequate.

RESULTS

Knowledge on pandemics, emotions, and emotion regulation (aim 1)

Pandemics definition and pandemic-related safety measures

Concerning the number of plausible units in pandemics definition, the GLMM (conditional $R^2 = .63$) revealed a significant effect of condition, class level, and phase (Table 1). The scores were lower for the waitlist (M = 2.72, *SD* = 2.40, 95% CI [2.31, 3.13]) compared with the experimental condition (M = 3.79, *SD* = 3.46, 95% CI [3.25, 4.34]); for third graders (M = 1.75, *SD* = 2.02, 95% CI [1.40, 2.10]) compared with seventh graders (M = 4.54, *SD* = 3.20, 95% CI [4.04, 5.03]); and for pretest (M = 2.82, *SD* = 2.59, 95% CI [2.40, 3.25]) compared with posttest (M = 3.78, *SD* = 3.42, 95% CI [3.22, 4.34]). As regards the significant condition × phase interaction, the post hoc tests indicated that scores raised from the pretest to the posttest only for the experimental condition; in the pretest, scores did not differ between the two conditions, while in the posttest, they were higher for the experimental condition (Tables 1 and S4 and Figure 1). Also, the interactions class level × phase and condition × class level × phase were significant (Tables 1 and S4): Examining the post hoc tests, we found that third-graders' scores were lower than seventh-graders' scores in all cases except than for the waitlist condition in the posttest. Pertaining to pandemic-related safety measures, in the GLMM (conditional $R^2 = .53$), condition, class level, and phase were significant (Table S4). The scores were lower in the waitlist (M = 3.53, *SD* = 2.03, 95% CI [3.18, 3.88]) compared with the experimental condition (M = 5.56, *SD* = 3.48, 95% CI [5.01, 6.10]); for third graders (M = 3.42, *SD* = 2.92, 95% CI [2.91, 3.92]) compared with seventh graders (M = 5.60, *SD* = 2.85, 95% CI [5.16, 6.04]); and for the pretest (M = 3.59, *SD* = 2.14, 95% CI [3.24, 3.94]) compared with the posttest (M = 5.67, *SD* = 3.50, 95% CI [5.10, 6.24]). Moreover, there was a significant condition × phase interaction (Table 1): The post hoc tests revealed that the number of correct pandemic-related safety measures did not differ between the two conditions in the pretest, while in the posttest, it was higher for the experimental condition; moreover, it increased from the pretest to the posttest only for the experimental condition (Table S4 and Figure 1). On the whole, these results supported Hypothesis 1a,

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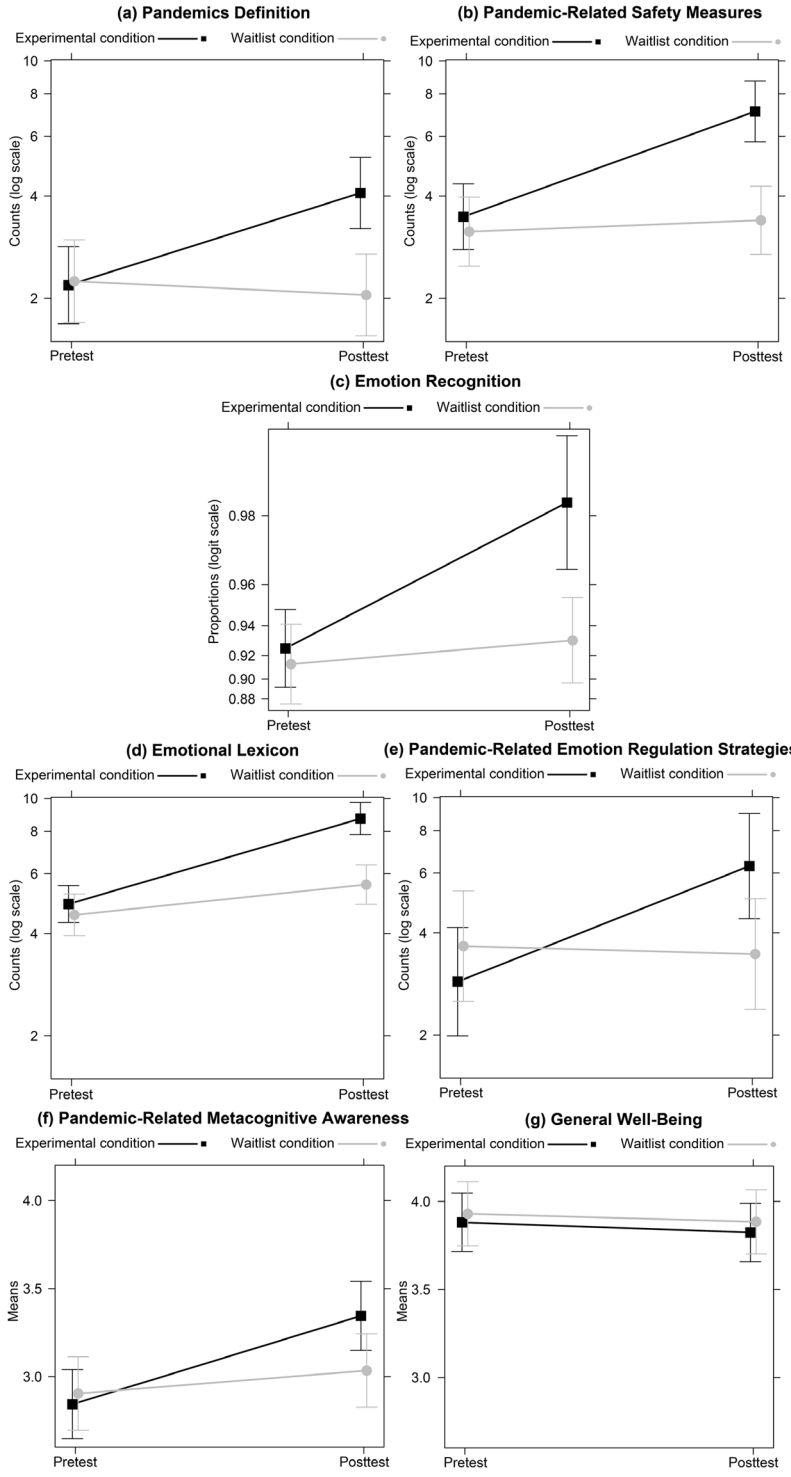

FIGURE 1 Means and 95% confidence intervals concerning the interaction between condition and phase, for (a) pandemics definition, (b) pandemic-related safety measures, (c) emotion recognition, (d) emotional lexicon, (e) pandemic-related emotion regulation strategies, (f) pandemic-related metacognitive awareness, and (g) general well-being.

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demonstrating that participating to the training increased knowledge about pandemics, both considering their definition and related safety measures. In addition, although some exceptions, adolescents had a deeper knowledge compared with children, corroborating Hypothesis 1b.

Emotion recognition and emotional lexicon

The GLMM showed for both emotion recognition (conditional $R^2 = .67$) and emotional lexicon (conditional $R^2 = .65$) significant effects of condition, class level, and phase (Table 1). The scores were lower in the waitlist (emotion recognition: M = 0.90, *SD* = 0.12, 95% CI [0.88, 0.92]; emotional lexicon: M = 5.69, *SD* = 3.14, 95% CI [5.16, 6.23]) compared with the experimental condition (emotion recognition: M = 0.94, *SD* = 0.10, 95% CI [0.93, 0.96]; emotional lexicon: M = 7.52, *SD* = 5.04, 95% CI [6.73, 8.31]); for third graders (emotion recognition: M = 0.91, *SD* = 0.13, 95% CI [0.89, 0.93]; emotional lexicon: M = 4.14, *SD* = 2.79, 95% CI [3.66, 4.62]) compared with seventh graders (emotion recognition: M = 0.94, *SD* = 0.10, 95% CI [0.92, 0.95]; emotional lexicon: M = 8.71, *SD* = 4.34, 95% CI [8.04, 9.38]); and for the pretest (emotion recognition: M = 0.90, *SD* = 0.12, 95% CI [0.88, 0.92]; emotional lexicon: M = 5.14, *SD* = 2.86, 95% CI [4.67, 5.60]) compared with the posttest (emotion recognition: M = 0.95, *SD* = 0.10, 95% CI [0.93, 0.96]; emotional lexicon: M = 8.24, *SD* = 5.02, 95% CI [7.42, 9.06]). Moreover, the interaction condition × phase was significant (Tables 1 and S4 and Figure 1): The results of the post hoc tests showed an increase in scores from the pretest to the posttest only for the experimental condition; moreover, there were no differences between the two conditions in the pretest, while in the posttest, the scores were higher for the experimental condition. In addition, for emotional lexicon, we found a significant class level × phase interaction (Table 1). The post hoc tests showed that seventh graders had a higher score than third graders in both phases; however, the effect size was larger in the posttest compared with the pretest. To sum up, the students who took part in the training increased their knowledge for both facial expression of emotions and emotional lexicon, confirming Hypothesis 1a. In addition, adolescents performed better than children, supporting Hypothesis 1b.

Pandemic-related emotion regulation strategies

The GLMM (conditional $R^2 = .73$) concerning pandemic-related emotion regulation strategies revealed significant class level and phase effects (Table 1). The number of reported strategies was lower for third graders (M = 3.83, *SD* = 4.07, 95% CI [3.13, 4.54]) compared with seventh graders (M = 5.79, *SD* = 4.52, 95% CI [5.10, 6.49]) and in the pretest (M = 3.88, *SD* = 3.59, 95% CI [3.29, 4.46]) compared with the posttest (M = 5.97, *SD* = 4.93, 95% CI [5.17, 6.78]). There was also a significant condition × phase interaction (Tables 1 and S4 and Figure 1). The post hoc tests indicated that there was an increased number of strategies in the posttest compared with the pretest only in the experimental condition; again, there were no differences between the two conditions in the pretest but only in the posttest. Therefore, the training enabled the participants to increase their knowledge about strategies to cope with pandemic-related negative emotions, corroborating Hypothesis 1a. Moreover, the analysis supported also Hypothesis 1b showing class level differences.

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Metacognition (aim 2)

For pandemic-related metacognitive awareness, in the GLMM (conditional $R^2 = .57$), class level and phase effects were significant (Table 1). Awareness was lower for third graders (M = 2.90, $SD = 0.88$, 95% CI [2.74, 3.05]) compared with seventh graders (M = 3.15, $SD = 0.62$, 95% CI [3.06, 3.25]) and in the pretest (M = 2.87, $SD = 0.71$, 95% CI [2.76, 2.99]) compared with the posttest (M = 3.21, $SD = 0.77$, 95% CI [3.08, 3.33]). Moreover, the post hoc tests concerning the significant condition × phase interaction (Tables 1 and S4 and Figure 1) indicated that, only for the experimental condition, awareness increased from the pretest to the posttest. These results supported Hypothesis 2, highlighting an increased awareness for students in the experimental condition. In addition, we found class level differences, showing that adolescents had higher levels of awareness than did children.

Well-being (aim 3)

The GLMM (conditional $R^2 = .58$) concerning general well-being indicated a significant effect of class level (Table 1). Third graders (M = 4.18, $SD = 0.71$, 95% CI [4.06, 4.30]) reported higher level of well-being compared with seventh graders (M = 3.64, $SD = 0.78$, 95% CI [3.52, 3.76]). Therefore, the training did not worsen participants' well-being, but we did find a developmental trend showing a lower level of well-being in adolescents compared with children.

DISCUSSION AND CONCLUSIONS

We examined the efficacy of the PandHEMOT® training to increase children and adolescents' knowledge about pandemics and related emotional competence. Overall, all the tested models explained a large proportion of variance, supporting their validity. The first unit of the app focussed on basic scientific knowledge (level 1) and safety measures (level 2) concerning pandemics and epidemics in general and specifically about the current COVID-19 pandemic. All the users of PandHEMOT® demonstrated an improvement in such knowledge, providing more detailed definitions of a pandemic and a longer list of adequate safety behaviours (supporting Hypothesis 1a). Basic knowledge already possessed by children in the first phases of a pandemic (Persici Toniolo et al., 2021) can therefore be extended through specific learning practices delivered through digital activities such as those implemented in our app. Our findings also indicated that, in most of the cases, the adolescents showed a richer representation of both basic concepts and safety measures (corroborating Hypothesis 1b). We speculate that students' basic scientific knowledge mirrors their expertise in school domains, mainly in science, being deeper and more organized for older students.

The second and the third units of the app delved into core elements of emotional competence, that is, knowledge of emotions and emotion regulation. Our analyses revealed a significant increase in their ability to label a facial expression, to express emotions through a variety of synonyms, and to list adequate ways to regulate pandemic-related emotions for the participants to the digital training (confirming Hypothesis 1a). Previous research indicated improvements in basic knowledge about disasters such as earthquakes and emotion-related issues in training combining traditional (e.g. with paper-and-pencil tasks, collaborative learning, and support by adult experts) and online activities (e.g. using a web application; Raccanello et al., 2023c). Our results extend

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such evidence-based results to training based only on digital activities. Nevertheless, it is worth noting that the children and adolescents using PandHEMOT® were supported by adult experts who guided them through the programme. Therefore, to maximize the benefits of PandHEMOT®, we recommend that while children and adolescents are using the version available for download (which includes a final memory game for consolidating previous learning and fostering engagement), they are supported by adult guidance. Given that the understanding of emotions develops with age, it was not surprising that older participants in our study performed better than younger participants (corroborating Hypothesis 1b; Pons et al., 2004).

The students who used PandHEMOT® not only increased their knowledge of pandemics but also increased their awareness of their own wealth of knowledge about pandemics and emotions (confirming Hypothesis 2). Again, such awareness was higher for adolescents, reflecting the level of their education. From an applied perspective, we speculate that such awareness can be an important step in being able to implement the acquired knowledge in real-world contexts.

Finally, we also checked the possible impact of the training experience on participants' well-being, acknowledging the heterogeneous findings on this issue reported in the literature (Johnson et al., 2014). Despite the initial uncertainties about the contents of the training shared by some parents, our data indicated that the general well-being of all the participants did not worsen at short term at the end of the intervention. This could be explained in part by the fact that when we conducted the training (i.e. November and December 2021), the COVID-19 pandemic was still active, and people had become more familiar with it and the high levels of anxiety and fear associated with its first phases had weakened. Moreover, the playful characteristics of the content style could have helped diminish difficulties in facing content concerning such a severe and pervasive disaster. Finally, class level differences confirmed a previous finding of a decreasing well-being at increasing ages (Raccanello et al., 2021b).

This study suffers from some limitations. First, in our study, we tested a first prototype of the app. Future research should validate our findings across new samples and adapt it to different disasters. Second, we could not gather data to assess the long-term persistence of participants' learning; however, this was related to the choice of implementing a waitlist design, which requires exposing the students in the waitlist condition to the training within a relatively short period. Third, we did not assess participants' post-training intentions and behaviours concerning both safety measures and emotion regulation strategies. Fourth, some measures in the pretest and posttest phases included self-report instruments which, albeit their privileged role for capturing inner states, should ideally be validated with behavioural data. Moreover, many of the measures used in this study were developed ad hoc. To increase validity and reliability of instruments assessing the same constructs, future studies could include also validated scales, for example, about emotion regulation difficulties. Fifth, the app was used within a very challenging context, in which participants were supported in cases of digital literacy difficulties and were continuously prompted to be engaged. Future research should explore learning processes when the app is used without these kinds of support.

The COVID-19 pandemic has posed huge challenges for children and adolescents, who had to adapt abruptly to a new context threatening their mental health. They were forced to increase their digital competence to cope with everyday developmental tasks previously delivered in person. Our evidence-based research indicated that Internet-based training can improve their level of behavioural preparedness and emotional competence. Testing the efficacy of digital interventions promoting mental health following the standard of evidence-based research is of pivotal importance, especially considering the variety of tools available online (Torous

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et al., 2021). The relevance of such interventions is increasing also in the light of the widespread digital literacy (mainly among children and adolescents), the easy access to Internet and digital devices, and the need for mental health solutions that are scalable, affordable, and widely accessible. In addition, psychoeducational initiatives have the potential to overcome the stigma usually associated with other types of psychological support (Howard & Goelitz, 2004). For all these reasons, the app PandHEMOT® may be a feasible and promising means to promote psychological resilience towards a post-pandemic phase. Together with more traditional activities, it could be inserted within programmes aiming at empowering communities' resilience, also in the case in which young people are involved actively to foster it (e.g. McCarty et al., 2022). Taking into account the variety of psychological processes on which it is based (Raccanello et al., 2023c), it could also be adapted for a range of other disasters, as a valid way to conduct prevention and preparedness actions to be included within evidence-based guidelines promoted by local, national, and international organizations deputed to foster youth's mental health.

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CONFLICT OF INTEREST STATEMENT

We have no known conflict of interest to disclose. Rob Hall is employed by the company Environmetrics Pty Ltd, which however had no role in designing and conducting the research.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author, D.R., upon reasonable request.

ETHICS STATEMENT

The study was approved by the Ethical Committee of the Department of Human Sciences of the University of Verona (protocol number 433148). The students participated after obtaining parents' signed informed consent form.

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