



1 **The imaginary eruption. Volcanic activity through kids' eyes**

2 Micol Todesco¹, Emanuela Ercolani¹, Flaminia Brasini², Delia Modonesi², Vera Pessina³, Rosella Nave⁴,
3 Romano Camassi¹

4 ¹ Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Bologna, 40128, Italy

5 ² ConUnGioco Onlus, Roma, 00081, Italy

6 ³ Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Milano, 20133, Italy

7 ⁴ Istituto Nazionale di Geofisica e Vulcanologia, Osservatorio Vesuviano, Napoli, 80124, Italy

8 *Correspondence to:* Micol Todesco (micol.todesco@ingv.it)

9 **Abstract**

10 Strategies of risk mitigation become effective when citizens facing hazardous phenomena adopt rational behaviors that
11 contribute to lower the risk. This is more likely to occur when endangered communities share a widespread understanding of
12 natural phenomena and their impacts. To reach this goal, educational and outreach materials are often organized around the
13 descriptions of the natural process and its effects. Unfortunately, however, receiving correct information does not automatically
14 grant the adoption of safe behaviors. Our teaching efforts may fail because of pre-existing biases, beliefs and misconceptions.
15 The identification of these biases is important to plan effective educational campaigns, capable of providing the concepts that
16 are needed to actually inform citizens' choices about natural hazards.

17 In this work, we present the results of an unconventional workshop on volcanic risk that we proposed to primary and secondary
18 schools (ages 6-13), in Italy. The workshop is meant to explore the mental models that kids and youngsters have about volcanic
19 eruptions and it takes the form of a creative exercise. We asked the students to draw and write a story in four frames, describing
20 the onset and outcome of an imaginary eruption. All stories were then presented to the class, and always provided interesting
21 hints to spark discussion about volcanic processes and hazards. As a whole, the collected stories provide an interesting,
22 multifaceted description of volcanic eruptions and their potential impacts, as imagined by the kids. A careful analysis of this
23 material provided interesting insights useful to improve future outreach material and educational plans. The workshop is simple
24 to reproduce, even remotely, and could be easily extended to different types of hazards.

25 While very simple to organize, this approach grants the secure engagement of most participants and offers a very different
26 perspective on pupils' understanding of natural phenomena.

27 **1 Introduction**

28 The mitigation of natural risk commonly involves educational campaigns aimed at disseminating correct scientific information
29 among the exposed communities. A clear understanding of how natural phenomena may unfold and eventually impact our
30 lives is expected to favour the adoption of mitigation measures and cautious behaviour. However, the simple availability of
31 correct information may be insufficient. Mental models, personal experience and emotional belief play an important role in
32 shaping people's response to hazards. Research conducted to explore the commitment to mitigation measures against
33 hurricanes showed how bad habits (like leaving the windows open during a tornado) can be perpetuated by a poor
34 understanding of the physical phenomenon - in this case, the wrong assumption that building destruction is caused by the
35 pressure difference inside and outside the house (Meyer, 2009). Mental models and beliefs constitute the magnifying glass
36 through which laypeople will access and interpret any information regarding natural hazards (Gibson et al., 2016). Personal
37 experience and emotions also contribute to form risk perception and it is widely acknowledged that risk communication should
38 account for existing knowledge and public understanding of natural hazards, in order to target the specific needs of the
39 communities involved (Lacchia et al., 2020). The comparison between expert's and laypeople's mental models highlights



40 missing information, possible gaps and misconceptions on both sides and, most importantly, it grants a correct identification
41 of people's needs and expectations.

42 This work focuses on volcanic eruptions and their perception and targets kids and youngsters living in the Neapolitan urban
43 area. The town is surrounded by three active volcanoes: Vesuvius, Ischia, and Campi Flegrei. Last eruptive activity in the area
44 took place at Vesuvius, in 1944, when a lava plug obstructed the volcanic conduit (Sbrana et al., 2020 and refs. therein). Since
45 then, the volcano has been in a quiescent state, like Ischia, whose last eruption took place in 1302 (Iovine et al., 2017). Campi
46 Flegrei last erupted in 1538 (Di Vito et al., 1987), but this wide caldera has been giving signs of unrest since the 1950's, with
47 periods of remarkable seismicity and ground uplift in 1969-72 and 1982-84 (Del Gaudio et al., 2010). Then, after 20 years of
48 continuous subsidence, a new and slower uplift phase began in 2005 and continues to the time of writing. Ground deformation
49 is accompanied by minor and shallow seismicity and by changes in the composition of fumarolic gases. Observed changes led
50 the civil protection authorities to shift the emergency level from green (background) to yellow (scientific attention on the
51 phenomenon) in 2012 (Tamburello et al., 2019).

52 A dormancy lasting for centuries followed by decades of unrest without eruption is a common evolution for a caldera. Unlike
53 the case of stratovolcanoes, such as Vesuvius, even remarkable unrest phenomena may not constitute short-term precursors of
54 an impending eruption. However, with more than 3 millions people living in the municipality of Napoli and a volcanic risk
55 among the highest on the planet, this kind of volcanic pattern easily becomes a real communication nightmare. Living
56 memories from last Vesuvius' eruption further confuse the picture, bringing in vivid images from a very different volcanic
57 setting.

58 Given the relevance of the problem, volcanic risk perception in the area of Campi Flegrei was first tested in 2006 (Ricci et al.,
59 2013). Results showed that volcanic hazards were not listed among the principal concerns of a community mostly worried
60 about crime, pollution and corruption. Nevertheless, the people participating in the survey did consider the likelihood of
61 explosive eruption as moderately high. At the same time, many failed to identify the hazards posed by the caldera, which was
62 overshadowed by the concerns about Vesuvius. Researchers also highlighted the so-called 'optimistic bias', according to which
63 responding citizens tended to consider themselves less prone to severe impact than their own town (Paton et al., 2008). More
64 recently, a wider study was carried out to address different kinds of hazards (hydrogeological, seismic and volcanic, Avvisati
65 et al., 2019). Results revealed the importance of direct experience of eruption in assessing the likelihood of a future eruption
66 and showed that a good knowledge of the hazard does not necessarily correspond to a good knowledge of best mitigation
67 practices.

68 Within this context, we decided to focus on existing mental models of volcanic eruptions, thanks to the collaboration of the
69 local public schools (primary and junior high). The exploration of mental models usually takes the form of interviews
70 (Skarlatidou et al., 2012) or face to face surveys accompanied by follow up questions (Lacchia et al., 2020). However,
71 considering our particular target, we opted for a different approach. To engage participants, we proposed a creative writing
72 and drawing exercise, asking them to describe a short story featuring an eruption and its consequences. We collected
73 approximately 200 stories that depict a range of rather plausible scenarios for this volcanic area. We analyzed all stories in
74 detail, identifying the spatial and temporal frames in which kids place their eruption, as well as the accompanying words and
75 feelings.

76 While certainly not comparable to the results from more structured approaches, our exercise provided valuable insights on
77 widespread expectations and useful hints for future outreach materials.



78 2 The project

79 “The imaginary eruption” is an activity promoted within the EDURISK framework (www.edurisk.it), a long-term educational
80 project with the aim of promoting educational itineraries for risk reduction for schools of all grades, with particular attention
81 to ages 6 to 13 (Pessina and Camassi, 2012).

82 The activity involved ten school districts (8 in the Neapolitan area and 2 from non-volcanic regions) and was carried out during
83 two school years, in 2018 and 2019. A total of 25 classes participated in the activity, 13 from primary schools (6-10 years old)
84 and 12 from secondary schools (11-13 years old), for approximately 500 kids. In 2020, we proposed the same workshop to the
85 schools on the island of Stromboli. Due to the restrictions related to the COVID-19 pandemic, we held this activity remotely,
86 via videoconference. On the island, we gathered 11 stories on the island, 9 of which completed with drawings, and 2 featuring
87 only written text. Among the complete stories, 6 were from primary school and 3 were from secondary school. The analysis
88 presented below focuses on the earlier workshops run in presence, while results obtained in Stromboli are discussed aside. A
89 list of the schools involved is provided in Table 1.

90

91

Table 1: List of attending schools.

School district and name	Classes	School level
IC 3 De Curtis Ungaretti, Ercolano (NA)	3A, 3B	Primary
IC 2 F. Giampaglia, Ercolano (NA)	4	Primary
IC 6 Quasimodo Dicearchia, Pozzuoli (NA)	4D	Primary
DD Scafati 1, Scafati (NA)	2A, 2B, 2C, 3B, 4A, 5D	Primary
IC Bonati, Bondeno (FE)	3A	Primary
IC San Rocco di Marano, Napoli (NA)	3A, 3B 1A	Primary Secondary
IC 5 Testoni Fioravanti e Federzoni, (BO)	3A, 3B 3E	Primary Secondary
IC 3 Rodari-Annechchino, Pozzuoli (NA)	1C, 1F	Secondary
IC 3 CD S. Gaetano-Gadda, Quarto (NA)	1A, 1D, 1F, 2C, 2E, 2G	Secondary
IC S De Nicola Sasso, Torre del Greco (NA)	1B, 1D	Secondary
IC 2 De Amicis-Diaz, Monteruscello (NA)	1C, 1E	Secondary
IC Isole Eolie - Stromboli	Multi-age class Multi-age class	Primary Secondary

92

93 The activity featured an initial phase of direct interaction with the attending students. During this workshop, we guided the
94 stories’ realization, as better specified below. We introduced “The imaginary eruption” as a creative exercise rather than a
95 science essay. This was important to collect stories that probed the kids’ mental model rather than reflecting lessons’ contents.
96 We stressed the absence of a formal evaluation of the “correctness” of the description and suggested the possibility of fantastic
97 settings or characters. At the end of the workshop, participants shared and discussed their stories. Each tale provided many
98 opportunities to discuss eruptions, volcanic phenomena, various hazards, and their mitigation.

99 After the workshop with the students, we held three meetings with the teachers. During these encounters, we adopted
100 participatory techniques and explored the thoughts and feelings that emerged from the collected stories. In a few cases, the
101 teacher also participated in the same laboratory as the kids, producing their own stories about the eruption. The meeting with
102 the teachers explored different aspects of volcanic risk and resilience: during the first meeting, we addressed the environment
103 and its relations to volcanic hazards and risks. The teachers explored the visible and invisible features characterizing the
104 landscapes where they live and work. The analysis provides clues on volcanic risks and what amplifies or mitigates them. The
105 second meeting focused on responsibility, community, resources, and problems: the group assessed how to prepare and what



106 to do to mitigate the risk. Finally, the last meeting revolved around resilience, identifying the times and means to share
107 information and understanding.
108 We finally used the considerations raised during these discussions to plan future outreach activities related to volcanic hazards.

109 **3 The workshop**

110 Students worked in pairs or small groups, and their assignment was to invent a story in four frames, each featuring both
111 drawings and a written description. The materials required for the story's realization included: 4 sheets of paper (A4); pens,
112 pencils, and colors; eraser and sharpener; scissors. We asked participants to cut the sheets into a square (21x21 cm) destined
113 for the drawing and use the remaining rectangular stripe for the written text. Once the material is ready, we provide indications
114 to start, and we also specify the time (approximately 15 minutes) allowed for the realization of each frame. We instructed
115 participants to realize one frame at a time, following simple indications often offered in terms of guiding questions. An
116 important detail is that students were unaware of participating in a volcanic risk project and that the stories should have a
117 volcanic eruption as their main theme. Instructions were as simple as possible to allow ample creative freedom but were
118 needed to focus on volcanic eruptions and make the drawings comparable.

119 The first frame sets the story's scene. Students had to describe the main characters involved, the general setting, and the
120 environment in which they move. We only gave the constraint that a volcano should be present. Guiding questions for this
121 frame could include: *Our character(s) live(s) near a volcano: what kind of place is it? Who is the protagonist? What is she/he*
122 *doing? How does she/he feel?* Only when the first frame was finished (or when the allotted time passed), we provided
123 information on the successive step.

124 In the second frame, something unusual happens with the volcano. Participants had to describe what was going on and the
125 characters' reactions. The guiding questions inquired if someone noticed the changes or took action: *the volcano is doing*
126 *something unusual; perhaps it's waking up, What does the volcano do? Does the character see that? Does he/she talk about*
127 *that with someone? Do they do something about it? How do they feel about it?*

128 The third frame focuses on the eruption. We asked participants to describe the volcanic event and tell about its impact on the
129 surroundings and how it affected the characters. Guiding questions included: *The eruption begins, what does the protagonist*
130 *do? What do other people do? What is happening around them? How do they feel?*

131 The fourth frame is the story's epilogue: the eruption is over. Participants described the new setting, where the protagonists
132 are now, how much time had passed since the eruption. Possible guiding questions were: *The eruption is over: where are the*
133 *characters now? What do they do? How do they feel?*

134 An example of a full story is provided in the Supplement.

135 **4 Results**

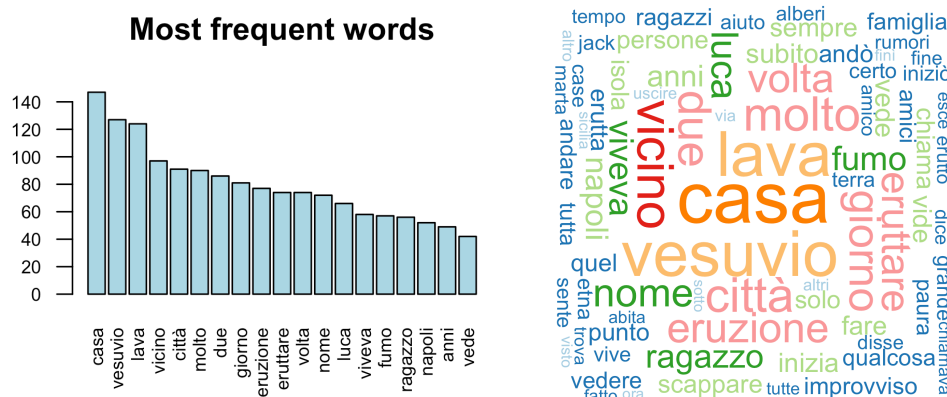
136 We collected 190 stories (2 of which without written text), with text and drawings (26 black and white, 148 in color). The
137 stories often describe realistic settings, but many contain imaginary situations or magic characters and events. Stories take
138 place in all sorts of locations, from the close neighbourhood to far, exotic places, as distant as other planets. Among the
139 protagonists we find kids, youngsters, adults, superheroes, animals. While stories tend to have a happy ending (in 163 cases),
140 most of them acknowledge severe destruction caused by the volcano. Some stories (25) have a dramatic conclusion, and a few
141 culminate with the protagonist's death.

142 **4.1 The stories' language**

143 We scanned all the stories and digitized the written descriptions (available for 188 stories) to perform a simple text analysis.



144 Text mining was performed with the R software (R Core Team, 2020), using a specific package (tm), and involved a
145 preliminary manipulation to remove the punctuation, extra white spaces, and the common words (or stopwords), like articles
146 or prepositions, which are not expected to bear specific information for the analysis. A collection of stopwords is available for
147 the Italian language in the R function we used (tm_map), but we added a few more that emerged from a first text review (as
148 reported in the caption of Figure 1). The resulting corpus contained 3428 terms that were used with different frequencies. More
149 than 1950 words were used only once. As expected, the most common term is vulcano [volcano], which is mentioned 581
150 times. Focusing on the other terms, the three most frequent words are casa [home], with 147 occurrences, Vesuvio, mentioned
151 127 times, and lava, which appears 124 times. Figure 1 shows an histogram of the 20 most used words (translation in the
152 caption). A more general idea is provided by the word cloud.
153



154 **Figure 1: Frequencies of the most used terms in the written descriptions of the imaginary eruption and associated word cloud.** The
155 meaning of the terms are as follows: casa [home], Vesuvio [Mt. Vesuvius], lava [lava], vicino [nearby], città [city], molto [much], due [two],
156 giorno [day], eruzione [eruption], eruttare [to erupt], volta [time, turns], Luca, viveva [lived], fumo [smoke], ragazzo [boy], Napoli, anni
157 [years], vede [she/he sees], subito [now], inizia [begins], fare [to do], vide [she/he saw]. Stopwords added to the original list and not included
158 in the count are: perché [why], così [therefore], poi [after], allora [then], cosa [what, thing], quindi [therefore], però [however], po' [a bit],
159 dopo [after], mentre [meanwhile], lì [there], quando [when].

160

161 The digitized text allows us to verify how many times specific words are used. We can see how many times death or salvations
162 are explicitly mentioned in the descriptions searching for the recurrences of the words related to death (including the
163 declination of the verb to die) and those related to survival or salvation. Frequencies of each term are listed in Table 2. The
164 simple frequency of these terms does not reflect the actual meaning of the story, as it does not account for possible negation
165 (“I did not die” or “they did not survive”). Table 2 shows that terms referring to salvation are slightly more mentioned than
166 those referring to death.

167 The same exercise can show how many times the words girl(s) (ragazza) and boy(s) (ragazzo) are mentioned. The search
168 included words for baby girls (bambina) and baby boys (bambino). The masculine term ragazzo (56) is almost twice more
169 frequent than the feminine ragazza (33). Baby boys and girls are less mentioned, but the difference between them is much
170 smaller (bambino (16), bambina (14)). The feminine plural terms are not common (ragazze (7), bambine (0)), while the plural
171 masculine, which in Italian may refer to both genders, is more frequent (ragazzi (34), bambini (15)). These kids and youngsters
172 are often protagonists of the stories and are commonly surrounded by their friends and family or by other people. Figure 2
173 illustrates the frequencies of the terms related to the people who are protagonists of the stories (specific Italian terms are listed
174 in the figure caption).



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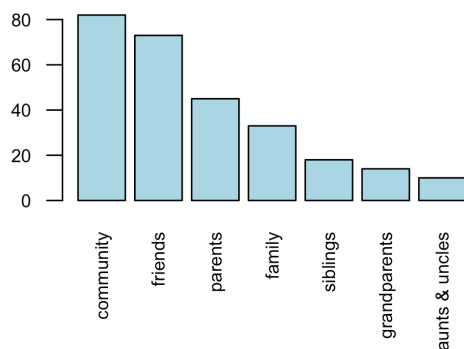
176 **Table 2: Recurrences of terms related to death and to the verb to die (*morte, morire*) and survival (including references to the words**
 177 **safe, alive, and the verbs to save, to survive) in the written descriptions of all collected stories.**

Word	Frequency	Word	Frequency
morte	7	salvo	11
mori	7	salvi	8
morti	7	salvò	8
morto	5	salvati	7
muore	4	salvato	6
muoiono	4	salvarono	5
morirono	4	salva	4
morta	3	salvano	4
		vivi	2
		sopravvissuti	1
		salvata	1
Total	41		57

178

179 The written descriptions shed light on the words used to describe the volcanic phenomena and products. The imaginary
 180 volcanoes mostly emit lava (124) and smoke (57) (Figure G), but products of magma fragmentation are also described as ash
 181 (19), stones (18), and lapilli (11). Magma, volcanic gases and dust are also mentioned a few times.

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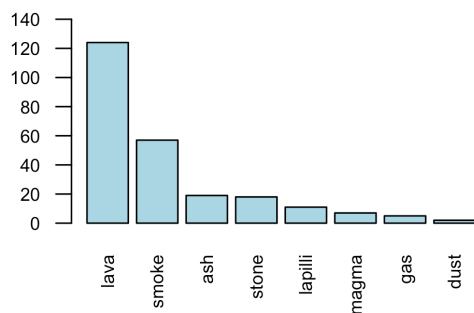
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184 **Figure 2: Frequency of words related to friends, families and communities.** The categories shown in the figure include the following
 185 Italian terms: ‘community’: cittadini [citizens], abitanti [residents], persone, gente [people]; ‘friends’: amico [friend] and compagno
 186 [companion]; ‘parents’: mamma [mum], madre [mother], papà [dad], padre [father]; ‘family’: famiglia [family]; ‘siblings’: fratello [brother],
 187 sorella [sister]; ‘grandparents’: nonna [grandma], nonno [grandpa] (note: the Italian language does not have a formal expression for
 188 grandmother or grandfather); ‘aunts & uncles’: zia [aunt], zio [uncle]. Both singular and plural, and masculine and feminine are always
 189 counted.

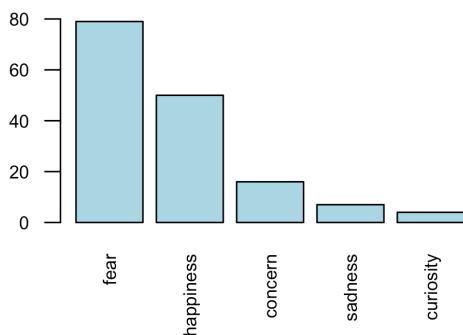
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191 Other words that may be of interest in this analysis are those referring to professional figures that may be related to the
192 assessment and the management of volcanic crises. Terms associated with these professional roles include scientists (16, one
193 of which female), volcanologists (17, one of which female), geologists (8, four of which female), firefighters (12), civil
194 protection, police, rescuers, and the mayor (2). The corresponding Italian terms are: ‘volcanologist’: *vulcanologo*; ‘scientist’:
195 *scienziato*; ‘geologist’: *geologo*; ‘firefighters’: *pompieri*, *vigili del fuoco*; ‘civil protection’: *protezione civile*; ‘police’: *polizia*;
196 ‘rescuers’: *soccorsi*; ‘mayor’: *sindaco*. Both singular and plural, and masculine and feminine are always counted.
197 Words can also tell us something about how the characters feel about the events. Figure 4 shows the most common words
198 related to sentiments: fear (79) includes terms such as *paura* [fear] (31), *panico* [panic] (10), *impaurito/a* [scared] and various
199 forms of the verb *spaventare* [to be scared]; happiness (22) includes words like *felice* [happy] (26), *contento* [glad] (20), or
200 *felicità* [happiness] (1).



201
202 **Figure 3: Frequencies of words used in the description of volcanic products.** The corresponding Italian terms are: ‘lava’: lava; ‘smoke’:
203 fumo; ‘ash’: cenere; ‘stone’: pietra; ‘lapilli’: lapilli; ‘magma’: magma; ‘gas’, gas; ‘dust’: polvere. Both singular and plural are always
204 counted.



205
206 **Figure 4: Frequencies of terms related to sentiments like fear, happiness, concern, sadness and curiosity.** The corresponding Italian
207 terms are as follows: ‘fear’: *paura* [fear], *panico* [panic], *impaurito* [frightened], *spaventato* [scared], *spaventare* [to scare]; ‘happiness’: *felice*
208 [happy], *contento* [glad], *gioia* [joy]; ‘concern’: *preoccupato* [worried], *preoccupazione* [concern]; ‘sadness’: *tristezza*; ‘curiosity’: *curioso*
209 [curious], *incuriosito* [intrigued]. Both singular and plural, and masculine and feminine are always counted. In the case of verbs, different
210 tenses and persons are considered.



211

212 **4.2 The frame contents**

213 **4.2.1 Frame 1 - The protagonists and the environment**

214 In 148 stories (78% of the total), the main characters are real people, often representing the authors themselves or other kids
215 slightly older than them. In 43% of the stories the protagonists are referred to as boys (55 times) or girls (27 times), but in
216 many stories one or more adults are present. Adults are mostly men (77% of adults) and are often identified through their
217 employment (e.g., farmer, scientist, explorer, rock star, hunter, lumberjack, astronaut, soccer player...). Scientists are
218 mentioned as leading characters in 12 stories, 4 times as volcanologists, and 2 times as geologists. In 2 stories, the protagonists
219 are related to civil protection. In a smaller number of cases, the adults are identified through their family relations with other
220 characters (grandpa, husband, wife, mother, father). Often the protagonists are accompanied by friends or pets and in a few
221 stories the animals are the leading characters. Fantasy characters appear in 54 stories and include princes and princesses,
222 magicians and fairies, cartoon characters and superheroes, aliens, gods, and pirates. In a few cases, the volcano itself becomes
223 a character, with anthropomorphic features.

224

225 The volcano is always represented as a conic mountain, generally rather small. Sometimes it is depicted with two peaks,
226 mimicking the profile of Mt. Vesuvius surrounded by Mt. Somma, the remnant of an ancient caldera structure (interestingly,
227 Mt Somma is often represented as a second volcano, with its own crater). Only one story features a submarine volcano. The
228 volcano can be a real one, with Vesuvius being the most common choice (named in 32 stories), followed by Etna (13) and
229 Solfatara (2). Stromboli, Vulcano, Ischia and Monte Nuovo are also mentioned once. In a few cases, the volcano has a fantasy
230 name, while often it is nameless. Explicit reference to the city of Naples is also present in 17 stories. Other localities mentioned
231 include Sicily (8), Pompei (4), Ercolano (3), Torre del Greco (2). Exotic settings are also frequent, with reference to Hawaii
232 (4 stories), Arequipa (Perù), Australia, Hollywood, Los Angeles, Paris, Alaska, Russia, Texas, Norway, the Caribbean. The
233 volcano can be on an island (18 stories) or surrounded by woods (8), in the countryside (9). Exotic environments include the
234 savanna, the Indian jungle, or the desert. Four stories are set on other planets.

235 Inhabited areas are rare and often represented by a single house (17 stories) usually built near the volcano. In a few cases, there
236 is specific mention of a small town or a village nearby (13 times) and only 7 stories mention a city.

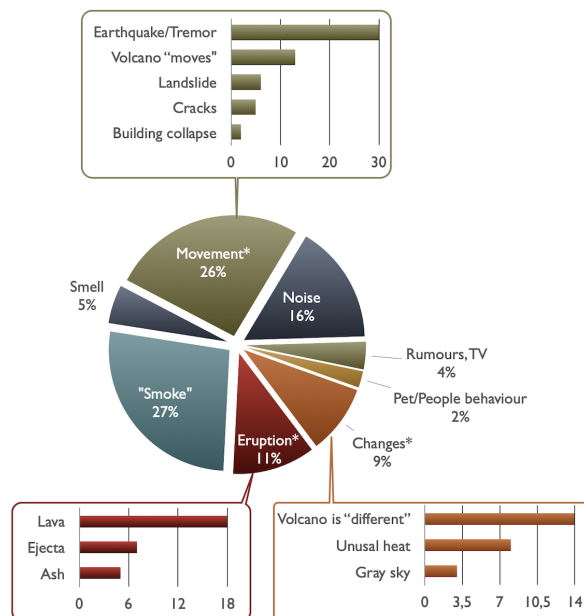
237 A few examples of the first frame are collected in the Supplement (Frame 1).

238

239 **4.2.2 Frame 2 - Something happens**

240 The most frequent sign of volcanic unrest is ground shaking (in 48 stories), sometimes described in terms of seismicity (the
241 word earthquake is used 12 times, with a couple of references to its magnitude). Other stories use generic terms like tremor
242 (20 times), or ground movements (15 times). Opening of cracks, landslides or building collapse are also mentioned (Figure
243 5). Another common signal of volcanic unrest is the presence of smoke on top of the crater, which is mentioned 44 times in
244 this frame. Based on both the written description and the drawings, the word smoke is used to intend volcanic gases (which
245 are explicitly mentioned only 2 times). Another reference to degassing activity is the smell (sometimes specifically sulphur
246 smell), that is mentioned in 8 stories. Volcanoes also make noises, which are mentioned in 33 stories. Other signs of unusual
247 behavior refer to actual eruptive processes, like the emission of lava (20), or various ejecta (stones and rocks, lapilli, and
248 volcanic ash, mentioned in 14 stories).

249



250
 251 **Figure 5: Signals of unrest mentioned in the collected stories (frame 2).**

252

253 Eruptions or explosions are mentioned 47 times at this stage of the story. In a few cases, the signals that something is going
 254 on are changes in the volcano's color or appearance, or the characters perceive an anomalous heat. Flames and burned
 255 vegetation are mentioned in a few cases, while animals detect the unrest in a couple of stories. In most cases, evidence of
 256 volcanic unrest is obvious enough for the protagonists to notice themselves. The only (indirect) reference to sensors installed
 257 to monitor the volcano is a seismogram drawn in one of the stories, while other 3 mention the magnitude of the earthquake,
 258 which presupposes the presence of seismometers in the area. In all other stories (the great majority) the signals from the
 259 volcano are easily detected by residents, with no need for monitoring instruments. Sometimes the characters learn (or have
 260 confirmation) that something is going on by watching the television (8 stories).

261 Most characters are frightened by the unrest (39 stories mention fear in this frame). Common reactions include talking to other
 262 people (50% of the stories) to warn them, but also to ask for explanation or seeking help. In about 30% of the stories, the
 263 protagonists have a companion, and sometimes they may talk to each other about what is going on. Talking to other people
 264 involves friends (26 stories), family (22), scientists (12), the community (either everybody, or the neighbors) (10). The
 265 authorities (police, firefighters, civil protection, but also the mayor, the professor, the director...) are called upon in 9 stories,
 266 while 5 times the protagonists refer to a wise, old character for advice.

267 In a few stories the protagonists try to warn others but are not believed or receive no answer. In one story, the volcano itself
 268 talks to the protagonist warning him to go away. In another story the warning comes from the mailman. In most cases, the
 269 protagonists realize that an eruption is possible, sometimes thanks to the opinion of others. Only in a few cases, the characters
 270 fail to recognize the danger or consider the signals a normal feature of the volcano that raises no worries.

271 In the majority of the stories, this frame does not specify whether the characters are going to take action. Only 22 stories (12%
 272 of the total) explicitly refer to leaving the place because of the impending danger, while in 15 cases, the character goes or
 273 remains home, or seeks shelter, waiting for further development. While most of the protagonists are worried, some are
 274 fascinated by the unusual phenomena, or look for answers and willingly move toward the volcano (17 stories). In a few stories
 275 (12), the characters seek a remediation for the problem: sometimes it's a magical intervention, while others refer to some kind



276 of authority to 'fix the problem' (usually, in an unspecified way). A small number of protagonists take actions to mitigate the
277 hazard, obstructing the volcanic vent with rocks (or even a cork), or pouring water inside the crater.
278 Examples of frame 2 are provided in the Supplement (Frame 2).

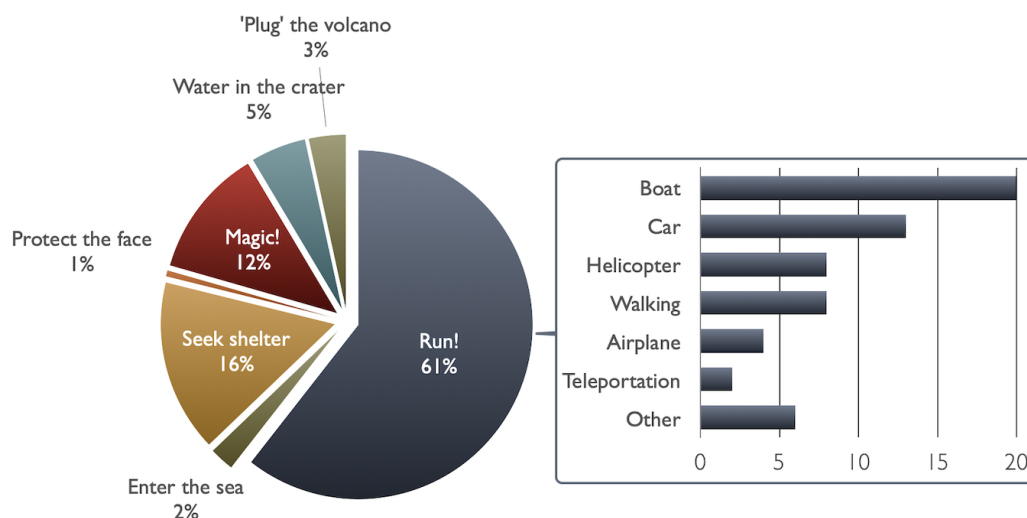
279 4.2.3 Frame 3 - The eruption

280 The eruption is usually sudden: the terms *improvviso* [sudden] and *improvvisamente* [suddenly] are used 26 times in this frame,
281 and *subito* [immediately] appears 8 times. The event may be described as an explosion or a blast (32 times). Based on drawings,
282 it is usually a small-scale event, whose impact is generally confined to the upper portion of the volcanic cone. It commonly
283 involves the emission of lava (mentioned in the text 60 times), but the Strombolian ejecta are present in several drawings.
284 Written text mentions ash, rocks and lapilli (23 in total, for this frame). Flames are also mentioned about 10 times, as a result
285 of fires set by the incandescent eruptive material. Only a few stories actually depict a major explosive eruption that occupies
286 most of the drawing area and generate clouds of ash that could represent pyroclastic flows. The terms pyroclastic flow, or *nuée*
287 *ardente*, are never used in the written descriptions.

288 As the volcano erupts, people scream and run away, but also watch, in a few cases with fascination, while many are frozen in
289 fear. Many characters just watch, gathering in the streets but without leaving. In several stories, the onset of the eruption is the
290 time when the characters begin to worry and start wondering what to do next. In a few cases, this is the frame where people
291 are warned about the danger, often by word of mouth, and only in very few cases through official actions (a siren, or police or
292 civil protection authorities alerting the population). The word evacuation is only mentioned twice.

293

294 The most common reaction to the eruption is to take the flight (83 times, in this frame, 60% of the stories considering both
295 text and drawings), mostly by running (Figure 6).



296

297 **Figure 6: Characters' actions and response to the eruption (frame 3).**

298

299 Many escape on a boat or a raft (20), others rely on their car. Airborne vehicles are also popular, helicopters in particular but
300 also airplanes, air balloons, or fantastic vehicles. Only a few leave the town by train or bus, or use animals. Many seek shelter,
301 often returning to their home (26 times), or entering into the sea. Also in this frame, a few bravely take some sort of action to
302 mitigate the hazard (34 times), either through magic intervention but also by pouring water into the crater, or by throwing
303 rocks into it, to obstruct the conduit. Rarely the action is taken by the community, or by public authorities.



304 Others call for help (21 times), sometimes hopelessly.
305 Text and drawings also reflect the damage (mentioned 34 times) to the environment (burned vegetation) and to infrastructures
306 (houses, mostly, but also cracks or lava interrupting roads). In 9% of the stories the destruction is pervasive and impacts the
307 entire city. In 11 stories someone dies in this frame, in a few cases the protagonists themselves do not survive. Examples of
308 the third frame are collected in the Supplement Frame 3.

309 **4.2.4 Frame 4 - The epilogue**

310 This frame shows how things ended, and the participants imagined a rather wide spectrum of possible outcomes: in some
311 stories the old life resumes, as if nothing happened, thanks to magic interventions or because it turns out it was just a dream.
312 In other cases, nothing will be the same ever again, because someone died or because it was necessary to move and live
313 elsewhere. Most of the stories end well (58%): the characters survive, perhaps a little battered (bruises or wounds are
314 mentioned; in one story the two characters end up with a headache). They often contribute to save their community, and
315 happily celebrate the end of the eruption. The relief is usually burdened by the damage caused by the volcano: even though
316 the characters are alive, in several stories (28%) they face destruction and losses. Destruction is mentioned 38 times in this
317 frame, and it affects both the environment (trees, animals) and urban infrastructures (buildings, roads), that are burned (15
318 stories) or covered in ashes (11 stories).

319 The disconsolate assessment of the devastation may be accompanied by the idea of reconstruction (13% of the stories), which
320 may take place either right away or after a long time. The protagonists may or may not be directly involved. Some choose to
321 rebuild elsewhere. Sometimes, the reconstruction is carried out while the characters are away, in a safe place. Other times
322 (11%), the reconstruction is described as a community effort acted by everybody, or by the city, or by the inhabitants. Only in
323 a few cases (3%) specific categories are mentioned to be in charge of reconstruction (masons, firefighters). Sometimes the
324 community that builds a new life after the disaster is limited to the characters and friends or relatives. Rescue teams of some
325 sort are mentioned only 6 times in this frame.

326 The need to move away is again mentioned (24% of stories) and only some of the protagonists (7%) envisage returning home,
327 perhaps after a long time. A small number of stories (10%) do not end well, and remind us that things can go really bad. Death
328 is explicitly mentioned 38 times in this frame, and in 15 stories the protagonists themselves die, sometimes in the heroic effort
329 to save their community, other times in loneliness or because nobody survives. In a couple of cases, the death is not directly
330 related to the eruption, but due to indirect or independent causes (heart attack, being hit by a firefighters truck, and even by an
331 atomic bomb, totally unrelated to the story).

332 A few stories do not provide details on the epilogue and simply state that the eruption ended, without further comments. The
333 story simply ends because the volcano “turns off” (or it rains, and this stops the eruption). There may be an acknowledgment
334 that everything is “burned”, but without information on what happens to the characters. In one story, the houses are only
335 covered by ashes, but still habitable. In another one, the bad ending features widespread destruction and scientists who do not
336 know what to do.

337 Examples of the fourth frame are collected in the Supplement (Frame 4).

338 **4.3 Stromboli**

339 The same workshop was later proposed to the student living on the island of Stromboli (Aeolian Island, north of the coast of
340 Sicily). This offered us the opportunity to collect stories from a context that is very different in terms of its geographic,
341 volcanic, and social settings. Stromboli is an open-conduit volcano, usually characterized by a mild Strombolian activity
342 (which takes its name from the island itself) and features continuous degassing and repeated explosions ejecting materials up
343 to tens or hundreds meters above the crater. Lava flow may occasionally form along the deserted slope of the volcano. This
344 persistent activity typically impacts only the summit of the volcano and is considered one of the main touristic attractions on



345 the island. This behaviour is sporadically interrupted by greater explosive events, known as paroxysms. The Imaginary
346 Eruption workshop was carried out in 2020, right after two paroxysmal eruptions took place in 2019, on July 3 and August 28
347 (Giordano and De Astis, 2021). Both events could raise an eruptive column of several kilometers and generate pyroclastic
348 flows that rushed down the deserted slope of the island to reach the sea. The two paroxysmal eruptions occurred without
349 noticeable precursors, were unusually close in time and the first one caused one causality, shaking the busy touristic season
350 that revolves around guided tours of the volcano's summit. Residents had to face the fear of both volcanic eruption and
351 economic disruption at the same time. In this context, we planned a workshop for the spring 2020 but, because of the COVID-
352 19 pandemic, we couldn't travel to the island. We did not want to miss the opportunity to get in touch with the students and to
353 offer them a safe space to discuss volcanic eruptions and their consequences. We therefore adapted the workshop to make it
354 suitable for remote fruition. Participants connected from their home and since it was not possible to organize the work in pairs,
355 each student elaborated her/his own story. We allowed longer times to work and to discuss the stories at the end. The workshop
356 was therefore organized in three days, with one session of 1 hour each day. The attending students were 13, from both primary
357 and secondary schools but we could collect only 9 stories featuring both drawing and written descriptions. This is a very small
358 number to allow for wide considerations. Nevertheless, we do consider these stories of interest for the peculiar circumstances
359 they reflect and we therefore provide here a terse description. Most stories are set on the island itself which, in two cases, is
360 the actual protagonist. The impending eruption can be announced by rock fallout (which in one case set the vegetation on fire),
361 small tremors, or even small eruptions. In one case, the eruption is announced by an "air pocket". The eruption is often a
362 typical strombolian eruption, with a lively launch of ash and scoriae, sometimes associated with a lava flow. In one case the
363 eruption begins under water, while in another one pyroclastic flows and their destructive power are mentioned. The stories
364 mostly feature a happy ending, with the volcano returning to its usual behaviour and inhabitants can resume their usual lives.
365 In a few cases, however, consequences are more serious and involve injured people or imply leaving the island and friends.

366 **5 Discussion**

367 The Imaginary Eruption provides a composite portrait of volcanic eruptions and their impact, as perceived by the kids and
368 youngsters, mostly from the urban area of Napoli. As a whole, it is a rather accurate portrait featuring many realistic features
369 that can be expected during a volcanic event. Collected stories provide a wide range of plausible eruptive scenarios. A
370 comparison with those envisaged by the scientific community reveals a few gaps and discrepancies that could inform future
371 outreach programs.

372 **5.1 The volcano and its activity**

373 In all collected stories, the volcano is an obvious geological feature of the landscape and the eruption invariably takes place at
374 the summit of the cone. A caldera setting is never mentioned, nor the possibility of new vents opening along the slope of the
375 volcano, or elsewhere. Pupils and students are commonly very passionate about volcanoes, and this passion is generally
376 accompanied by a good knowledge of different volcanic structures and phenomena. While many of the kids involved are
377 certainly aware about calderas and their behaviour, the choice of representing classic volcanic cones reflects the conventional
378 image that we all picture when we think about volcanoes. Some drawings explicitly refer to Vesuvius, and realistically feature
379 two peaks: one representing Vesuvius' cone, and the other being the remnants of the Somma strato-volcano. These drawings
380 testify to the interest and good knowledge of the local landscape. In most stories, however, the imaginary volcano is located
381 in remote regions, surrounded perhaps by a few isolated houses and, in general, at safe distance from populated areas. Only in
382 a few cases the volcano is portrayed in an urban environment.

383 Volcanic unrest is marked by a number of realistic precursors, such as shallow seismicity or the emission of smelly volcanic
384 gases, and is often associated with noise. Interestingly, in some cases, the first signs of volcanic unrest are actual eruptive



385 events, involving explosions and the launch of ejecta. In general, the unrest phase is too short to take action before the volcano
386 erupts. The quick transition from unrest to eruption suggests that most stories feature volcanoes with an open conduit. Open-
387 conduit volcanoes erupt more frequently and their activity is more likely to appear on television or social media. These images
388 easily contribute to building our mental model of erupting volcanoes. The eruptions from open conduit volcanoes are easily
389 strombolian, featuring launches of volcanic bombs, lava flows and spectacular lava fountains that closely resemble the events
390 drawn by the kids.

391 Most imaginary eruptions are small events, if seen through the eyes of a volcanologist. The main feature is usually a lava flow
392 that propagates along the slope of the volcanic cone. This effusion is commonly accompanied by the emission of gas and by
393 the launch of lapilli and bombs that in a few cases may reach beyond the volcano's slopes. This eruptive style recalls common
394 footage from frequently active Etna or Stromboli volcanoes, in Italy. Some stories mention ash, and this may reflect family
395 anecdotal accounts of last Vesuvius' eruption, in 1944. A small number of drawings show the development of an eruptive
396 column (that is never mentioned in the written text). The height of the column is usually small compared to the size of the
397 volcanic edifice. Only in a few cases, the drawing suggests that the eruption impacted a wider area (i.e., the entire city). Most
398 stories provide little or no evidence to assess the duration of the eruption. When they do, the event is short-lasting and usually
399 ends within a few hours or a day.

400 The imaginary eruption has consequences: most stories describe burnt vegetation and damages to houses and roads. In some
401 stories people are hurt or killed. Almost half of the stories (42%) mention casualties, but most stories reflect the optimistic bias
402 already seen in the analysis of risk perception conducted among adults. In these cases, the protagonists survive even though
403 others are severely affected. Ash covering the landscape and causing respiratory problems is also mentioned a few times.
404 Damage may be limited (especially when the eruption itself is small), but in a few stories destruction is pervasive. In many
405 cases, the eruption's consequences are long-lasting, and affect the lifestyle of the characters involved.
406 Interestingly, in a few stories the characters are killed or injured by events that have nothing to do with the eruption, suggesting
407 a clear understanding of the multiple hazards that threatens our communities.

408 The stories collected in Stromboli reveal a strong relation with the volcano and a good knowledge of its various eruptive styles
409 and products. The two stories that feature the volcano itself as a protagonist both suggest a strong tie connecting Stromboli
410 with its islet Strombolicchio and with the other Aeolian islands. This is consistent with the geological evolution of the
411 archipelago. In general, both the drawings and the written descriptions of the stories reveal a close attention toward eruptive
412 phenomena and their consequences.

413 As mentioned in section 2, some of the stories (39) were collected in schools located in non volcanic areas. We did not perform
414 a systematic comparison of stories drawn in different regions, but we can say that those collected in non volcanic areas often
415 lack details in the drawings and descriptions of volcanic activity, both before and during the eruption. The presence of
416 suspended ash, which can cause coughing and hinder respiration, is only mentioned in stories collected in the Neapolitan area,
417 and may reflect familial accounts of the 1944 Vesuvius eruption.

418

419 **5.2 The people**

420 The characters who live or find themselves near the volcano are commonly alone, or with a single companion. In most cases,
421 they face the unrest and the eruption without the support of a wide community. The protagonists are mostly well aware of the
422 impending danger, and discuss their options and fears with friends or neighbours. The stories provide a very realistic picture
423 of people's behaviours, highlighting well known issues, such as warning signs or alerts that are met with disbelief and lack of
424 action. The stories also capture both the fascination and the fear for the natural phenomenon, as major drivers for people's
425 actions. While most run or seek shelter, some are paralyzed by fear and a few reckless are rather attracted than scared by the
426 volcanic activity. The struggle to decide whether or not to leave is also present. The need to move somewhere else to be safe



427 is a recurrent concept, likely reflecting some knowledge of the emergency plans for the Neapolitan area. However, leaving is
428 always depicted as a personal decision that not everybody is willing to make.

429 Moving away from the volcano as a safety measure is described with different nuances in different geographic areas: kids
430 living far away from actual volcanoes may describe the departure with relief, as a permanent solution to the problem with no
431 apparent drawbacks; kids from the Neapolitan area, on the other hand, seem to be sorely aware of the many difficulties
432 associated with leaving, and often describe the characters as sad, lonely and homesick.

433 A good perception of the complexity of life on an active volcanic system also emerges in a couple of stories from Stromboli,
434 where people's concerns are mentioned as well as the necessity to leave to be safer elsewhere. One story addresses the very
435 different perceptions that different people may have of the same phenomenon, ranging from admiration to fear.

436 In general, the departure is not a planned evacuation, organized and carried out before the eruption, but rather an escape from
437 the ongoing phenomenon. In several cases, it takes place after the eruption ended, not as a defensive measure but because
438 houses are damaged, as it happens in case of earthquakes. In the (rare) description of rescue teams, they also intervene in the
439 aftermath of the eruption. In a seismic country like Italy, images of rescue teams at work after major seismic events is
440 unfortunately a rather common sight that easily entered the mental model of the kids.

441 An organized approach to hazard assessment and mitigation is missing. There are no monitoring networks to capture signals,
442 nor experts capable of interpreting them. If scientists are at the scene, they mostly acknowledge the ongoing activity, without
443 providing further information, or useful advice. Public authorities are rarely mentioned (less than 5% of the stories), and there
444 is no coordinated, public response to the change in the volcano's state of activity. Most of the characters face the impending
445 danger on their own and if action is taken to lower the risk, it mostly happens thanks to individual initiative.

446 In a small fraction of stories (approximately 10%), the aftermath of the eruption is characterized by reconstruction that sees a
447 full involvement of the entire community.

448 **6 Conclusions and steps forward**

449 The kids and youngsters attending the Imaginary Eruption workshop revealed sharp eyes and a keen attention to the dynamics
450 of both the natural phenomena and human interactions. Their works, considered together as a whole, capture most of the key
451 issues related to hazard assessment and mitigation. These were discussed at length in the meetings with the teachers after
452 working with the students.

453 The outcome of an eruption does not only depend on the magnitude and explosivity of the volcanic event: people play an
454 important role. Among other features, consequences depend on the distance between the volcano and inhabited areas, and on
455 the time available to evacuate. Widespread awareness and preparedness among the population can make a huge difference in
456 promoting safe actions and mitigating the damages. The conclusion of the story always depends on what goes on in the
457 preceding frames. The kids' drawings well represent the wide spectrum of possible combinations of eruptive styles and sizes
458 and people's behaviours.

459 The collected stories are works of fiction, and do not necessarily represent the actual beliefs or mental model of the drawers.
460 Nevertheless, in setting up the scene, the students made use of their personal knowledge, and the stories reveal what they think
461 could get their protagonists in trouble. The analysis of individual stories can be used to identify sound elements of their
462 understanding of volcanic eruptions and point at topics that may deserve further attention in future outreach work.

463

464 Among the positive elements, kids are aware that there will be precursors to an eruption in the Neapolitan area, and can name
465 several of them. On the other hand, the stories typically describe a very short unrest phase, with macroscopic signals that are
466 detected shortly before the actual onset of the eruption. The stories do not capture the uncertainty associated with long-lasting
467 unrest periods, featuring signals whose interpretation may be difficult or controversial. A long-lasting unrest has been going



468 on at Campi Flegrei since 2012, but uncertainty on the short-term evolution could characterize the awakening of any dormant
469 volcano. This crucial phase requires a continuous, strenuous effort to find an acceptable balance between costs and benefits of
470 possible mitigation actions. The unrest phase causes great stress in the resident population and extreme difficulties in managing
471 volcanic crises. Yet, the description of the unrest phase is easily neglected in the customary concise descriptions that classifies
472 volcanoes as dormant or active. School books depict the two options with clear details and images, but perhaps the concept
473 that a dormant volcano can indeed become active again should be emphasized some more. New outreach materials could focus
474 on what it takes, and how long it takes, to actually reactivate a dormant volcano. Dealing with uncertainty is hard on emergency
475 managers and citizens. Being aware that a period of uncertainty is ahead of us is a first step to get ready for it, and possibly
476 take actions to mitigate the fatigue associated with it. Some volcanic unrests terminate without culminating in an actual
477 eruption. This has occurred at Campi Flegrei several times (Del Gaudio et al., 2010) and has important implications for hazard
478 assessment: if an eruption is not the only possible outcome of precursory signals, false alarms based on monitoring signals
479 are bound to happen. This possibility is never mentioned in the collected stories, and should be perhaps better emphasized
480 when discussing volcanic hazards.

481 When the imaginary eruption strikes, it is usually small. The drawings may in part reflect images and sketches that students
482 find in their books, where the various features of explosive eruptions are concentrated in a small space for publishing
483 constraints. We may collaborate with graphic designers to devise sketches of volcanic eruptions that provide a better
484 understanding of the actual size of big explosive events. And we can put more emphasis on the fact that the same volcano can
485 display very different eruptive styles and generate big and small events.

486 The frame describing the eruption is also the one when the protagonists of most stories decide to take action. The kids expect
487 that an eruption will have a great impact and know that it will be necessary to run or seek shelter. Outreach material and
488 education itineraries should emphasize that there is time for evacuation, and this time is before the actual eruption begins.
489 Although distressing, a prolonged unrest phase is just what grants us enough time to organize an orderly evacuation.

490 As mentioned above, the characters of the Imaginary Eruption do not evacuate, but try to escape, while others hide inside huts
491 or other improbable shelters. The decision is never planned ahead, but is made in the heat of the moment. In making these
492 decisions, the characters of the stories mostly rely on their families. In reality, plans for an organized evacuation exist for
493 exposed areas (red and yellow zones), as detailed in the National Civil Protection Plans for Vesuvius and Campi Flegrei.
494 However, in a social context where family's ties are strong, outreach activities should take into account that important decisions
495 will be made inside the families. Education efforts should target all family members, helping the kids to identify unsafe
496 behaviour and the adults to recognize the optimistic bias.

497 A small but significant number of stories describe efforts to stop the eruption from happening. While we certainly cannot
498 control volcanic activity, there are common actions that are taken to hinder lava flow propagation, either using cold water or
499 building dams to temporarily contain or divert the lava. The problem-solving attitude should be encouraged by showing the
500 kids that their thinking was very much consistent with existing mitigation strategies. At the same time, we must emphasize
501 that in case of large explosive eruptions evacuation is the only viable option.

502 In a few cases, the characters refer to scientists for help, but the nature of the support provided is somewhat blurred. We can
503 work to better emphasize the insights we gain from volcano monitoring and from experience gathered at different volcanoes.
504 This knowledge provides the information based on which mitigation actions such as evacuation can be taken. Volcanic gases
505 are recognized as an integral part of the volcanic activity, but gas is commonly confused with smoke. Specific outreach material
506 should stress the differences between volcanic gas and smoke, and provide information on the key role of gases in hazard
507 assessment.

508 Finally, a few stories reveal the fear that scientists or authorities will not listen, while most indicate that in case of extreme
509 danger our characters only rely on family and friends. This stresses the need to reinforce the bond between scientists,
510 emergency managers and the population exposed to volcanic hazards. All the initiatives such as science fairs, citizen science



511 programs, evacuation exercises, or community meetings bring these stakeholders together and contribute to build and reinforce
512 mutual trust and understanding.
513 The Imaginary Eruption has been an interesting exercise that provided us with an unusual insight into how volcanic eruptions
514 are perceived by kids and youngsters. Far from being a formal assessment of the students' understanding of volcanology, these
515 stories provided interesting cues to discuss volcanic activities with the kids and explore a wide range of emotions and
516 sentiments stirred by the thought of an impending eruption. The teachers involved mostly found this a valuable tool to approach
517 a complex topic, and to build the lecture around the themes that the students propose in their stories. On our side, we gained
518 very important hints on how to improve our outreach materials and the activities we propose to the schools.
519 This approach can be easily implemented to explore the mental model related to different natural hazards. We proposed to the
520 schools of various Italian regions “Imaginary Earthquake” workshops to address seismic risk. During the Edurisk activities
521 (Camassi et al., 2021) we learned to constantly adapt our approaches and procedures during the projects in the schools, and
522 when the Covid-induced restrictions stimulated to adapt our teaching activities to the new constraints, we experienced closer
523 and immediate contact with students and teachers. The tools we used in attendance have been adapted to remote teaching: the
524 activity was structured in the same way, throughout a 4 sheets story, drawn and written, and we managed to keep the same
525 style of active participation, built on stimuli and discussions. The results we have obtained, in terms of students' laboratory
526 restitutions, are fully comparable with those above described obtained from the students of the Neapolitan area. We believe
527 that this approach could be further extended to other natural hazards.

528 **Author contribution**

529 All authors contributed to devising the workshop structure. RC provided the funding to sustain the activities and together with
530 EE and VP granted the synergy with the EDURISK project. Workshops were held by FB, DM, EE, RC, RN, VP. Analysis of
531 the collected stories was carried out by MT, FB, EE, DM and results were discussed by all co-authors. MT prepared the
532 manuscript with contributions from all co-authors.

533 **Competing interests**

534 The authors declare that they have no conflict of interest.

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540 **References**

- 541 Avvisati, G., Bellucci Sessa, E., Colucci, O., Marfè, B., Marotta, E., Nave, R., Peluso, R., Ricci, T., and Tomasone, M.:
542 Perception of risk for natural hazards in Campania Region (Southern Italy), *Int. J. Disaster Risk Reduction*, 40 (April), 101164,
543 <https://doi.org/10.1016/j.ijdr.2019.101164>, 2019.
544 Camassi, R., Ercolani, E., Brasini, F., Modonesi, D., Pessina, V., Castelli, V., and Meletti, C.: One hundred years after: The
545 results of an educational project, 37th European Seismological Commission (ESC), 19-24 September (virtual), S06-294, 2021.



- 546 Del Gaudio, C., Aquino, I., Ricciardi, G. P., Ricco, C., and Scandone, R.: Unrest episodes at Campi Flegrei: A reconstruction
547 of vertical ground movements during 1905–2009, *J. Volcanol. Geotherm. Res.*, 195(1), 48–56,
548 <https://doi.org/10.1016/j.jvolgeores.2010.05.014>, 2010.
- 549 Di Vito, M., Lirer, L., Mastrolorenzo, G., and Rolandi, G.: The 1538 Monte Nuovo eruption (Campi Flegrei, Italy). *Bulletin*
550 *of Volcanology*, 49(4), 608–615, <https://doi.org/10.1007/BF01079966>, 1987.
- 551 Gibson, H., Stewart, I., Pahl, S., and Stokes, A.: A “Mental Models” approach to the communication of subsurface hydrology
552 and hazards, *Hydrol. Earth Syst. Sci. Discussions*, May, 1–29, <https://doi.org/10.5194/hess-2015-542>, 2016.
- 553 Giordano, G., De Astis, G. The summer 2019 basaltic Vulcanian eruptions (paroxysms) of Stromboli. *Bull. Volcanol.* 83, 1,
554 <https://doi.org/10.1007/s00445-020-01423-2>, 2021.
- 555 Iovine, R. S., Mazzeo, F. C., Arienzo, I., D’Antonio, M., Wörner, G., Civetta, L., Zeudia, P., and Orsi, G.: Source and magmatic
556 evolution inferred from geochemical and Sr-O-isotope data on hybrid lavas of Arso, the last eruption at Ischia island (Italy;
557 1302 AD), *J. Volcanol. Geotherm. Res.*, 331, 1–15, <https://doi.org/10.1016/j.jvolgeores.2016.08.008>, 2017.
- 558 Lacchia, A., Schuitema, G., and McAuliffe, F.: The human side of geoscientists: comparing geoscientists’ and non-
559 geoscientists’ cognitive and affective responses to geology, *Geoscience Communication*, 3(2), 291–302.
560 <https://doi.org/10.5194/gc-3-291-2020>, 2020.
- 561 Meyer, R. J.: Why We Fail to Learn from Disasters. In E. Michel-Kerjan and P. Slovic (Eds.), *The Irrational Economist: Future*
562 *Directions in Behavioral Economics and Risk Management*, pp. 0–10. Public Affairs Press, 2009.
- 563 Meyer, R. J.: Failing to learn from experience about catastrophes: The case of hurricane preparedness, *J. Risk Uncertainty*,
564 45(1), 25–50. <https://doi.org/10.1007/s11166-012-9146-4>, 2012.
- 565 Pessina, V. and Camassi, R. (eds.): *Edurisk 2002 – 2011 - 10 anni di progetto di educazione al rischio, MISCELLANEA*
566 *INGV*, vol. 13, Roma: Istituto Nazionale di Geofisica e Vulcanologia (INGV), ISSN: 2039-6651, 2012.
- 567 R Core Team: R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna,
568 Austria. URL <https://www.R-project.org/>, 2020.
- 569 Ricci, T., Barberi, F., Davis, M. S., Isaia, R., and Nave, R.: Volcanic risk perception in the Campi Flegrei area, *J. Volcanol.*
570 *Geotherm. Res.*, 254, 118–130, <https://doi.org/10.1016/j.jvolgeores.2013.01.002>, 2013.
- 571 Sbrana, A., Cioni, R., Marianelli, P., Sulpizio, R., Andronico, D., and Pasquini, G.: Volcanic evolution of the Somma-Vesuvius
572 Complex (Italy), *J. Maps*, 16(2), 137–147, <https://doi.org/10.1080/17445647.2019.1706653>, 2020.
- 573 Skarlatidou, A., Cheng, T., and Haklay, M.: What Do Lay People Want to Know About the Disposal of Nuclear Waste? A
574 Mental Model Approach to the Design and Development of an Online Risk Communication. *Risk Analysis*, 32(9), 1496–1511,
575 <https://doi.org/10.1111/j.1539-6924.2011.01773.x>, 2012.
- 576 Tamburello, G., Caliro, S., Chiodini, G., De Martino, P., Avino, R., Minopoli, C., Carandente, A., Rouwet, D., Aiuppa, A.,
577 Costa, A., Bitetto, M., Giudice, G., Francofonte, V., Ricci, T., Sciarrà, A., Bagnato, E., and Capecchiacci, F. (2019). Escalating
578 CO₂ degassing at the Pisciarelli fumarolic system, and implications for the ongoing Campi Flegrei unrest, *J. Volcanol.*
579 *Geotherm. Res.*, 384, 151–157. <https://doi.org/10.1016/j.jvolgeores.2019.07.005>, 2019.
- 580
581