


Article

Gaming and Resilience: Teaching by Playing Together—Online Educational Competition at School during the Pandemic

Giovanna Lucia Piangiamore ^{1,*}  and Alessandra Maramai ²¹ Istituto Nazionale di Geofisica e Vulcanologia, Sezione Roma2, Sede di Lerici, 19032 Lerici, Italy² Istituto Nazionale di Geofisica e Vulcanologia, Sezione Roma1, Sede di Roma, 00143 Rome, Italy

* Correspondence: giovanna.piangiamore@ingv.it; Tel.: +39-0187-978266

Abstract: Educational and training initiatives for natural hazard reduction, climate change, and environmental sustainability are increasingly common. We describe educational games in which the protagonist, a fictional character girl, saves herself and others from natural disasters. This girl faces risk situations, from earthquake to flood to environmental challenges, and for each of these she is the protagonist of educational quizzes and of an escape room. These games were designed and played online during the COVID-19 pandemic, to introduce an engaging activity, reducing the difficulties of both students and teachers in *distance learning*. Simultaneous challenges between several classes were played during special scientific events, with a total of more than 8000 students flanked by about 500 teachers, always with very positive feedback. We pooled our knowledge to embrace innovation in gamification at school. Our games aim at increasing the response capacity of future more resilient citizens to protect themselves and others, adapting to natural risks, and to spread good practices in support of the civil protection. Each online race between classes from primary and middle school (ISCDE 2) is based on *cooperative learning* and followed by an important *debriefing* moment of *reflective learning*, guided by researchers to deeply analyze scientific topics.

Keywords: knowledge; gamification in education; educational competition; transformative learning; prevention; best practice dissemination; how to act; self-protection; natural risks; environmental sustainability



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1. Introduction

Gaming is a powerful communication tool. It enhances cognitive development, experiencing and reasoning and is an effective *active learning*, allowing the assessment of players' abilities, learning progress, and limits. Through gaming, natural phenomena can be explained, science can be communicated and, in addition, good practices can be instilled to automatically promote safe behaviors to be implemented during natural events [1–4]. Students are familiar with games, and games can be an amusing way to raise awareness on natural disaster reduction and risk education. Our gaming experience in natural hazard mitigation and environmental sustainability education, has shown that games are a versatile, effective, and attractive tool for addressing environmental issues in school-based civic education. In our gaming practice, we have always used *serious games*, which unlike the classic “just for fun” game, intrinsically have the idea of stimulating learning [5–7].

Serious games can be essentially divided into three types: (a) *teaching games*, which aim to teach something through play; (b) *meaningful games*, conveying a significant message to promote change; (c) *purposeful games*, whose game path has some outcome in the real world. All these three types of educational games are enclosed in our experiment of implementing a new scientific game series that has turned out to be a powerful learning tool in dealing with our research topics.

The purpose of our study is to educate future citizens to be responsible and to adopt safe behavior to cope with natural disasters, as well as to train them on good practices to

protect the environment. Our experiment is aimed at conveying general behavioral insights into the attitudes to cultural change. To do so, we use the nudge through game activity, as a positive support and suggestion that influences the right behavior choices. Such activities are also designed to be a support to civil protection, ensuring that the students thus trained could be dispensers of good practices both within their families and among their peers.

Our serious games are *transformative learning* educational tools useful to ensure effective dissemination and communication and increased public awareness of risks related to natural events. In the recent past, one of the authors successfully experimented learning geosciences through competitive activities [8,9].

Our game thinking has also an environmental educational purpose, to raise awareness among players on the issues of preventing global warming and climate change. We adopt the gamification logic of competition with virtual goods, real-time feedback, storytelling, points, rankings, levels, etc. [10–12]. This is to develop “emotional intelligence” and *soft skills*, with the aim to set off personality traits, communication and social skills. Personal habits characterizing relationships with other people are also highlighted, building a *lifelong-lifewide* resilience [13,14].

The need to design engaging and educational activities in occasion of special scientific events during the emergency caused by COVID19, has led to experiment in the online use of innovative digital teaching methods for science outreach educational activities for schools in *distance learning*. On some occasions, such as the *World Environment Day 2021 and 2022*, the *Planet Earth Week 2021*, *European Researchers’ Night 2021 and 2022*, *Rome Science Festival 2021*, and the *10th anniversary of the 2011 Ligurian floods*, some distance lab activities have been carried out.

During these events, students from different classes challenged each other by playing with the Salvina’s adventures, a character born from our imagination using *Bitmoji*. She is a young girl who faces several hazardous situations, from earthquake to flood, to environmental issues and for each of these scenarios she is the protagonist of educational quizzes and of an Escape Room. The games were created by using *Quizziz*, a free online learning platform that offers multiple classroom tools that are amusing, interactive, and engaging.

Each game was designed with a level of complexity that fits the target it was intended for. Difficulty levels of the online games have been adapted to the age and the degree of intellectual development of students. Specifically, all games were set up to be played in an online competition between the last two primary school classes and the first class of Middle school (ISCDE2).

In particular, four adventures of Salvina have been created: Salvina and the earthquake: what will she do? (Salvina e il terremoto: cosa farà?), Salvina and the flood: what will she do? (Salvina e l’alluvione: cosa farà?), Salvina and the environment: what will she do? (Salvina e l’ambiente: cosa farà?), Salvina and the 4Rs: what will she do? (Salvina e la 4R: cosa farà?).

These adventures were played exclusively online for the whole 2021, during special scientific venues attended by more than 350 classes connected by interactive whiteboard, or by tablets and mobile phones internet-connected from more than 120 schools from all over Italy and France. Each challenge that had to be overcome to advance in the game was the result of *cooperative learning* [15–18] by the whole class in the competition. *Salvina and the 4Rs* was played in person on the occasion of the *European Researchers’ Night 2022*. During this event, individual players, both children and adults, equipped with smartphones, competed in groups of up to 20 people for logistical reasons.

Playing Salvina’s individual adventures highlighted the remarkable potential of these games, so we were encouraged to go forward in educational gaming design. Therefore, we have designed a digital escape room that requires a deepening understanding of natural phenomena in order to solve the various enigmas and survive in the case of an earthquake, tsunami, landslide, and flood.

Our multi-hazard hypernarrative Escape Room, named *Let’s free Salvina!, an online Escape Room to elude natural risks*, was created using *Genially*, a free online learning platform

that offers multiple tools to make the classroom fun, interactive, and engaging. It has been enthusiastically played simultaneously by almost a thousand students all over Italy.

At the end of each scientific special venue we collected relevant data through individual satisfaction questionnaires, differentiated for teachers and students.

2. Materials and Methods

The term *e-learning* was established in 1998 [19,20] to refer to distance learning and training, made possible by the growth of the Internet and personal computers. Nowadays, this sector has literally exploded also due to the global COVID19 pandemic that required the large-scale use of digital technologies. Online teaching demands a greater lecturer ability to catch the attention of students who, participating remotely, have a shorter attention time and increased concentration difficulties. To overcome these difficulties, we have applied the logic of gamification to the *e-learning* successfully, as highlighted by the answers to the questionnaires distributed to both students and teachers after each online scientific event. In fact, at the end of each special venue, we asked participants to fill anonymous questionnaire, differentiated for teachers and students, after each race, being aware that answers would be used for scientific purposes. Students answered the questionnaire after playing the game, while teachers after observing their class playing. The collection and analysis of the questionnaires was essential in our study to gather findings about learners' experience. Furthermore, the acquired data helped us in our study and in improving the design of future games that are increasingly effective for learning. In our experiment, the researchers were communicators of science in the dissemination activities that preceded the games during the special events. They were also game designers, with the aim of providing a permanent and successful educational tool for the school. The games designed by the researchers and conducted by them, empowered the educational aspect also thanks to the *debriefing* phase following every scientific race. This phase is important for clarifying misconceptions and favoring students' *critical thinking* and *soft skills*.

Introducing gamification into the educational experience can provide several benefits. First of all, game dynamics increase engagement, keeping the attention high and stimulating good practices; students are actively involved in a race and enthusiastically make efforts to win. Therefore, education turns into a fun and immersive activity. In addition, the increased involvement facilitates information storage and memorization.

Dissemination and science communication thus meet education and one of our main purposes is the use of games to achieve *transformative learning* [21,22] as a 'help' to important civil protection topics, clarifying the essential differences in safe behaviors, depending on the type of natural events in which people can be involved.

Transformative learning paths use mixed didactic methods that are always based on *social emotional learning (SEL)* [23–25].

2.1. Building Lifelong-Lifewide Resilience vs. Transformative Learning

The *Education and Training Programme ET 2020* defines the strategic framework for European cooperation in the education and training fields to accomplish four strategic goals: 1. achieving *lifelong learning*; 2. improving the quality and effectiveness of education and training; 3. promoting equity, social cohesion and active citizenship; 4. encouraging creativity and innovation [26–28].

Our society increasingly urges for a school training that continues throughout life, and this need can be achieved through a collaboration between school, research, and family. In this frame, our activities involve researchers in educational action and aim to train children to become disseminators of good practices both within the family and with their peers.

Nowadays, we often use the expression *lifelong learning* [29–33], meaning that learning process should concern the entire life span, overcoming a defined temporal dimension (the time of initial education), which is too often the only part of life dedicated to learning. Since the learning-temporal dimension is inherent in every human action, we use the concept of *lifewide learning* [34], embracing all areas of life, and overcoming places dedicated to

learning (traditionally school and university) to enhance every life experience. The complete expression becomes *lifelong-lifewide learning*, in which times and places of learning widen to include every time and every area of life. This type of learning does not make people professionals, but able to recognize opportunities that favor them in various aspects of their life, and how they can make the most of from this knowledge [35]. Building resilience means raising community awareness, developing education and engagement programs versus *transformative learning*, which is the process of deep, constructive, and meaningful learning beyond the simple knowledge acquisition [36,37]. The need for further engagement in community resilience programs fits well with *lifelong-lifewide learning*. Indeed, this often results in a fundamental change in our worldview, and supports critical ways in which learners become reflective and conscious of learning experiences, changing their attitude of mindless or unquestioning acceptance of available information [38]. To become critically aware of tacit assumptions/expectations and to assess relevance for making an interpretation, people have to reach a “perspective transformation”. The latter works on the psychological dimension, changing self-understanding on conventional aspects, revisioning their belief system and behavioral sphere, in other words, making changes in lifestyle [39–41].

2.2. The Importance of an Educational Competition

According to the Institute of Competition Science (ICS) approach, best practices in educational contests allow students to develop intrinsic motivations for the challenges they face. In this case, a competition is not the antonym of collaboration because, even though winning is the goal, students have to work hard together to boost their specific skills. Consequently, throughout educational competitions, students can also improve teamwork (*collaborative learning*) along with a better understanding of how to deal with conflicting opinions and ideas to work together in spite of different personalities (*SEL*). External incentives (prizes, public recognition, becoming a scholastic hero for peers, etc.) may create a challenge behind the competition, goading students to act for the external reward and increasing their inborn desire to excel in the contest [42]. The intrinsic sense of competition, which comes from the wish to beat other students, drives them to do better, beyond their own limits. A well-designed educational competition can also help students to develop a beneficial peer comparison, advantaging them in other social status comparisons and strengthening their self-concept and self-efficacy. Recent social psychology studies [43,44] encourage competitions designed to ensure that even the “not-winners” end up benefiting from their participation, highlighting their efforts. Such competitions can facilitate growth mindsets, thanks to the engagement to improve themselves. Setting successive tasks to explore students’ increasing skills may help them to appreciate their improving knowledge over time [45–47]. Skills of persistence, resilience, and grit are all components of mental toughness, and educational competitions allow students to practice these skills, discovering how to bend and not break under pressure and how to handle stressful situations through participation. Losing is not the end, but just a step of an amazing learning experience. Protecting students from failing can disadvantage their future. Thus, following Yeager and Dweck [48], educational competitions can be considered training to build their own personality.

Keeping in mind the relevance of these issues, in our experiment of educational gaming, the presence of researchers is relevant to provide reflective learning. The *debriefing* at the end of the race is the essential step of the activity in which the correction of mistakes becomes a moment of collective growth. In fact, it is carried out without judgment, but as a moment of discussion, emphasizing the importance of errors as a resource for fixing key concepts [49–52].

2.3. Playing Science: Salvina’s Adventures

As mentioned, during the Covid19 pandemic, it was necessary to find new modalities to keep the important School/Research relationship active, despite the inability to be

physically in the classroom to carry out scientific events. In order to connect electronically with students to cope with isolation, we devised the character of Salvina, a little girl they could identify with. So, we developed a set of five educational games having Salvina as the protagonist: she has to face different dangerous situations due to the occurrence of natural phenomena and she has to choose good practices to adopt on a daily basis to respect the environment. Indeed, Salvina, whose name is a synonym for rescuer, is capable of saving herself, others, and our planet. These games allowed to involve simultaneously about 8200 students located all over Italy in a compelling challenge, reaching an impressive number of people with a participative approach and at the same time to better face distancing and reduced social contact.

They also allowed to reach about 500 teachers to promote gamification at school as a powerful didactic tool. The teachers involved were, mainly, those from STEM disciplines. However, the topics dealt with environmental civic education issues closely related to the acquisition of *soft skills* and, therefore, teachers of literary disciplines were also involved. In addition, since the special venues were held simultaneously at a fixed date and time, sometimes teachers from different disciplines were engaged. All Salvina’s games simulate real situations of natural hazards in settings where anyone can find themselves during extreme events; playing the games is like experiencing a danger in person and making the right choice gives you the chance to concretely use what you have just learnt (see Table 1).

Table 1. Schools involved in all the educational online Salvina’s gaming experience.

Region	Primary Schools	PS Classes	PS Students	Middle Schools (ISCDE2)	MS Classes	MS Students	Total n. Students
Abruzzo	2	4	100	2	4	81	181
Lazio	6	10	258	6	8	194	452
Lombardia	4	9	222	2	7	176	398
Piemonte	4	9	222	3	6	140	362
Sicilia	22	57	1267	23	67	1560	2827
Toscana	2	6	151	3	11	265	416
Calabria	1	6	151	1	4	90	241
E. Romagna	3	6	139	3	7	200	339
Campania	2	12	317	1	5	75	392
Friuli	1	4	83	1	4	98	181
Liguria	5	20	381	12	48	1075	1456
Marche	2	4	68				68
Sardegna	1	4	92	1	3	74	166
Veneto	4	9	200	2	6	147	347
Puglia	2	7	181	1	4	100	281
France (Grenoble)	1	2					50
						TOTAL	8157

The game phase is always preceded by an explanatory scientific lesson on earthquakes, tsunamis, hydrogeological risk, and environmental topics, guided by researchers. The competition is the core of the activity and is performed in a scheduled time.

Each game played ends with an overall ranking, highlighting the three top players and designating the winner. After the game award, the most important educational moment is held, the debriefing. The researcher discusses the results of all the game phases with the players, dwelling on the incorrect answers, concluding the activity with a relevant moment of collective *reflective learning*.

At the end of each event where the Salvina’s adventures were played, we conducted a survey by administering a satisfaction questionnaire, different for teachers and students. The answers were very useful in assessing the perception and appreciation of our educational games and they guided us in the design of new games which were even more complex. In addition, every student and all classes were handed with a certificate of

participation to the event. In Figure 1, the icons created for each Salvina's adventure games are shown.



Figure 1. Representative images of Salvina's adventure games logo collections.

2.3.1. *Salvina and the Earthquake: What Will She Do?*

The first adventure created was *Salvina and the Earthquake: what will she do?*, officially played for the first time online with the International Section of the 'Jean Jaurès' Primary School in Grenoble, in the framework of the Isère Departmental Challenge of Modern Languages, organized by the Académie de Grenoble. On this event, about 50 pupils played the game and the school ranked first.

In this adventure, classes challenge each other by drawing on their resources and knowledge to adopt safe behaviors in case of an earthquake and/or tsunami. The goal of this game, as well as the other Salvina's adventures, is to promote automatic choice of good practices stimulating mind, instinct, and logic in the perspective of team building.

Salvina and the Earthquake was also played at the close of the first year of the 'Future Responsible Citizens' (FCR) Project to mark the opening of the *United Nations Decade for Restoration for World Environment Day 2021*. The project is divided into "Educational Paths" of civil and environmental responsibility, within the agreement between the Istituto Nazionale di Geofisica e Vulcanologia (INGV) and Associazione per lo Sviluppo Sostenibile e il Centro di Educazione Ambientale di Messina (AssoCEA Me APS). FCR project develops multidisciplinary modules by the INGV, the Consiglio Nazionale delle Ricerche (CNR) and the Istituto di Ricerca, Sviluppo e Sperimentazione sull'Ambiente ed il Territorio (CTS IRSSAT).

On that occasion, about 300 students from 14 classes of Primary and Middle Schools in Sicily, raced the quiz online within the *CON.I.RI.* (Living with Natural Risks) module, by INGV. FCR project was declared a Project of Excellence in the 'Networks and Training Systems' Section at the *19th Edition of the Filippo Basile 2021 Prize for Public Administration*.

Finally, the game *Salvina and the earthquake* was played by 560 students from 22 classes of fourteen Primary and Middle Schools from all over Italy, in an educational lab at the *Rome Science Festival* from 22 to 28 November 2021. Figure 2 shows the flyer promoting the Salvina's activity during the event.



Figure 2. Representative image of the *Salvina and the earthquake: what will she do?* an online race on the importance of good practice in case of earthquake and tsunamis, played online at the *Science Festival of Rome 2021*.

This Salvina’s adventure was played by a total of more than 900 students of 38 classes from Italy (Campania, Lazio, Lombardia, Piemonte, Sicilia, and Toscana) and France (Grenoble). Among them, about 500 pupils were from 21 classrooms of primary school and about 400 students were from 17 classrooms of middle school (ISCDE 2) (see Table 2).

Table 2. Schools involved in the *Salvina and the earthquake* educational online gaming experience.

Region	Primary Schools	PS Classes	PS Students	Middle Schools (ISCDE2)	MS Classes	MS Students	Total n. Students
Campania	1				6		154
Lazio	3	3	75	2	2	52	127
Lombardia	1	2	55	1	1	24	79
Piemonte	1	1	23				23
Sicilia	4	7	143	3	7	154	297
Toscana				2	7		177
France (Grenoble)	1	2	50				50
						TOTAL	907

2.3.2. *Salvina and the Flood: What Will She Do?*

On the occasion of the tenth anniversary of the flood that hit Liguria and Tuscany on 25 October 2011, we decided to develop a second Salvina’s adventure, to be played by fourth and fifth-year primary school children and first-year middle school (ISCDE 2) students.

The game *Salvina and the flood: what will she do?* was designed to stimulate *reflective learning* about hydrogeological risk. This new adventure caught the interest of the Consiglio Nazionale dei Geologi. Therefore, an online special venue was organized for schools throughout Italy, for the comprehension of landslides and floods and for the dissemination of good practices to be adopted in the case of a flood event. Figure 3 shows the poster of the special venue where *Salvina and the flood* was played for the first time.








EVENTO ON-LINE
30 NOVEMBRE 2021
10:00 - 11:30

I 10 ANNI DALL'ALLUVIONE DEL 2011: ricordiamo insieme e impariamo giocando tutto quello che si deve sapere per ridurre il rischio

Sono già passati 10 anni dall'alluvione del 25 Ottobre 2011, che ha colpito Liguria e Lunigiana. Il Consiglio Nazionale dei Geologi e l'Istituto Nazionale di Geofisica e Vulcanologia propongono un incontro on-line alle scuole primarie e secondarie di primo grado di tutta Italia, per non dimenticare e guardare al futuro con speranza.

Valentina Casolini (CNG) illustrerà i fenomeni idrogeologici e il caso dell'Alluvione del 25 Ottobre 2011.

Seguirà un'attività di apprendimento attraverso il gioco, a cura di Giovanna Lucia Piangiamore, Alessandra Maramai ed Anna De Santis (INGV).

PROGRAMMA DELL'EVENTO



➔ "La memoria: importante strumento per diffondere consapevolezza e conoscenza dei rischi naturali".
 Valentina Casolini (CNG)

Ricordiamo l'Evento del 25 Ottobre 2011 per capire le cause e gli effetti al suolo dei fenomeni idrogeologici estremi che provocano alluvioni e riflettere insieme su pericolosità e rischi derivati.

➔ "Laboratorio quiz on-line" SALVINA E L'ALLUVIONE: COSA FARA?
 Giovanna Lucia Piangiamore, Alessandra Maramai ed Anna De Santis (INGV).

Una sfida tra classi in cui le squadre seguiranno Salvatrice, detta Salvina, che le accompagnerà per favorire la scelta automatica delle buone pratiche. Dovranno attingere alle loro risorse e conoscenze sui fenomeni naturali per non farsi cogliere impreparati e agire con prontezza per superare illese tutti i pericoli adottando i comportamenti corretti in caso di alluvione.

PER CHI: classi quarte e quinte della scuola primaria e classe prima della scuola secondaria di primo grado.

COSA SERVE: una LIM per classe con connessione internet.

PRENOTAZIONI: per classi a giovanna.piangiamore@ingv.it

Vi aspettiamo!

Figure 3. Poster promoting the *Salvina and the flood*, played online at the event "10 Years after the 2011 flood: let's remember together and learning by playing how to reduce hydrological risk".

This Salvina's adventure was played by a total of 4660 students from about 200 classes of fourteen Primary and Middle Schools from all over Italy. Among them, about 2400 pupils were from 100 classrooms of Primary School and about 2300 students were from 99 classrooms of Middle School (ISCDE 2) connected from Abruzzo, Calabria, Campania, Emilia Romagna, Friuli, Lazio, Liguria, Lombardia, Marche, Piemonte, Puglia, Sardegna, Sicilia, Toscana, and Veneto regions (see Table 3).

Table 3. Schools involved in the *Salvina and the flood* educational online gaming experience.

Region	Primary Schools	PS Classes	PS Students	Middle Schools (ISCDE2)	MS Classes	MS Students	Total n. Students
Abruzzo	2	4	100	2	4	81	181
Lazio	1	1	25	2	4	89	114
Lombardia	2	6	140	1	6	152	292
Piemonte	3	8	199	3	6	140	339
Sicilia	6	16	399	5	11	258	657
Toscana	2	6	151	1	4	88	239
Calabria	1	6	151	1	4	90	241
E. Romagna	3	6	139	3	7	200	339
Campania	1	6	163	1	5	75	238
Friuli	1	4	83	1	4	98	181
Liguria	4	18	352	5	28	662	1014
Marche	1	3	51				51
Sardegna	1	4	92	1	3	74	166
Veneto	3	8	180	2	6	147	327
Puglia	2	7	181	1	4	100	281
						TOTAL	4660

2.3.3. The Escape Room *Let's Free Salvina!*

In the wave of enthusiasm shown by teachers and students after playing *Salvina's* adventures concerning natural hazards, we thought of grouping the existing games and, by adding new online tests with enigmas to solve, create a digital escape room to get away from natural hazards. It is a competitive hypertextual escape room, in which groups race through enigmas scattered within the same thematic room, building a story in which the players' choices and solutions directly affect the plot. In this engaging journey, the team's survival skills are tested in the event of an earthquake, tsunami, landslide, and flood. To win, players will have to choose as quickly as possible the right actions to undertake in order to help *Salvina* to survive all dangers safely, thanks to their knowledge about natural hazards.

To create the structure of the escape room rich in interactive contents, *Genially*, a no-code platform for interactive visual communication, was used. To develop the various interactive educational games and enigmas, we used several free learning apps, including *Flippity*, *Word Wall*, as well as the aforementioned *Quizziz*. Figure 4 shows the image used to promote the *Salvina's* escape in occasion of the special event.



Figure 4. Flyer of the *Let's free Salvina!*, an Escape Room to run away from natural risks, played online at the 9th Planet Earth Week 2021.

This adventure was played during the *9th Planet Earth Week* in October 2021 by a total of more than 900 students, connected from Lazio, Liguria, Lombardia, Marche, and Sicilia regions. Among them, about 300 pupils were from 14 classrooms of five primary schools and about 600 students were from 29 classrooms of fifteen middle schools (ISCDE 2). See Table 4.

Table 4. Schools involved in the *Let's free Salvina!* Escape Room educational online gaming experience.

Region	Primary Schools	PS Classes	PS Students	Middle Schools (ISCDE2)	MS Classes	MS Students	Total n. Students
Lazio	1	1	25				25
Lombardia	1	6	139				139
Sicilia	2	6	129	2	7	166	295
Liguria	1	2	29	7	20	413	442
Marche				1	1	17	17
						TOTAL	918

2.3.4. *Salvina and the Environment: What Will She Do?*

To take part in the *European Researchers' Night 2021 (ERN 2021)*, we designed a new *Salvina's* adventure, this time related to environmental issues. The educational game design was conceived as an online challenge aimed at fourth and fifth grade primary school classes and first and second middle school (ISCDE 2) classes. The aim of the game is the dissemination of sustainable behavior to be adopted to protect the environment, to promote the automatic choice of good environmental practices. Through the digital game *Salvina and the environment*, we had the chance to deal with several items concerning the environment. In particular, we focused on topics, such as the ecological footprint and the water footprint, issues that are rarely examined in depth at school.

This adventure was played for the first time at the *ERN 2021* inside the *NET project program* by 280 students connected from Lazio, Liguria, Lombardia, Sicilia and Veneto regions. Among them, about 170 pupils were from 7 classrooms of primary school and about 90 students were from 4 classrooms of middle school (ISCDE 2). Figure 5 shows the image used by the NET Project for promoting the *Salvina's* activity at the *ERN 2021* special event.



Figure 5. Poster of the *Salvina and the environment*, discovering the eco-friendly behaviors, played online at the *European Researchers' Night 2021*.

Salvina and the Environment was also played by about 1600 students. In particular, about 600 pupils from 28 classes of primary schools and just shy of 1000 students from

41 classes of middle schools from Sicily, at the close event of the *Future Responsible Citizens 2.0 (FCR 2.0)* Project during the *World Environment Day 2022* within the *CON.I.RI.* module, by INGV.

FCR 2.0 project was also declared a Project of Excellence in the ‘Networks and Training Systems’ Section at the *20th Edition of the Filippo Basile 2022 Prize for Public Administration*.

This project was also declared a Project of Excellence in the *10th edition of the Vivere a spreco zero Prize 2022*, a competition dealing with the good practice of circular economy and sustainable development.

This Salvina’s adventure was played by a total of more than 1800 students from all over Italy. Among them, about 770 pupils were from 35 classrooms of primary school and about 1050 students were from 45 classrooms of middle school (ISCDE 2), as shown in Table 5.

Table 5. Schools involved in the *Salvina and the environment* educational online gaming experience.

Region	Primary Schools	PS Classes	PS Students	Middle Schools (ISCDE2)	MS Classes	MS Students	Total n. Students
Lazio	2	6	158	1	1	28	186
Lombardia	1	1	27				27
Sicilia	10	28	596	11	42	982	1578
Liguria	1	2	24				24
Veneto	1	1	20				20
						TOTAL	1835

2.3.5. *Salvina and the 4Rs: What Will She Do?*

Living a more sustainable lifestyle is the main message of the new Salvina quiz on the 4Rs we designed on the occasion of *European Researchers’ Night (ERN) 2022*.

Reduce, Reuse, Recycle and Repurpose are the four easy-to-follow stepping stones we can apply to everyday life to be eco-friendlier. Figure 6 shows the image used for promoting the Salvina’s activity at the special event.



Figure 6. Poster of the *Salvina and the 4Rs* discovering eco-friendly behaviors, played in person at the *European Researchers’ Night 2022*.

To win, the players should answer keeping clear in mind that whether you are reducing your waste, your water consumption, or your shopping habits, a little effort does a lot for the environment.

For this occasion, we changed the game mode from online to in-person. We switched from an online challenge between an unlimited number of simultaneously connected classes to a side-by-side individual game with a heterogeneous audience of visitors, both adults and children. The context in which the *ERN* takes place is that of ‘Science in a marketplace’, where many research institutions and universities offer a wide range of scientific activities to appeal to all target audiences. Therefore, on that occasion, competitions played by children supported by a parent were also organized. This was an interesting opportunity to enhance affinities and collaborations between parents and sons and more than 150 participants took part in the game.

During the game, a series of quizzes is proposed for each of the four ‘Rs’ to analyze the topics in detail. The first step to educating participants in the new Salvina’s race to this ecological quartet is *Reduce*, which means “only using less”.

The second “R” in the list is *Reuse*. There are endless ways to reuse items that would typically be wasted. Reusing products also means to trigger creativity, reflecting on both how many times and in how many ways an object can be reused.

Recycling means turning waste into new materials or objects; anyhow, producing any waste is unavoidable and we must be aware of the waste we are producing and how to recycle as much of it as possible. Several questions in *Salvina and the 4Rs* game are related to finding the right recycling bin to put the item into, also choosing if they have to be sent to the local recycling center.

Finally, the most creative of the four R’s is *Repurpose*: giving new life to an object by taking what you no longer use and using it for different purposes. It just takes a little bit of imagination (and a little help from the internet) to perfect any DIY repurposing project.

Salvina teaches us that if we start implementing the “four R’s of Green Living” into our everyday life, the difference in the environment will become exponential. In this context, the *debriefing* is very rewarding, sharing ideas about all the ways we can easily reduce, reuse, recycle, and repurpose.

3. Results

Research and School can plan together tools and strategies of risk communication and learning, encouraging future citizens to prompt safe behavior as an ability of personal processing. In this approach, researchers were not mere “dispensers of knowledge”, but tutors in an assisted scientific race to come up with significant observations and considerations through shared research and reworking of *reflective learning* activity.

The digital game series of Salvina’s adventures has been the educational tool used to make even very complex actions simple in the most different simulations of real dangerous situations. Games have been designed to foster the automation of behaviors in the case of earthquakes, tsunamis, floods, and landslides, and they also have been “food for thought” about environmental sustainability choices in daily life.

Following the *game-based learning* methodology, complex scientific concepts were dealt with in a simple and fun way, in order to achieve fundamental knowledge concerning natural risks and environmental issues.

More than 3800 pupils of the fourth and fifth classes of primary school and more than 4300 students of the first and second classes of middle school (ISCDE 2) took part in our scientific online events during 2021. Therefore, we have reached more than 8100 young people and about 500 teachers for a total of more than 8600 people from the school world in 2021. In addition, there were about 150 parents and children participating in the most recent event in person in 2022.

In each event, during the race, both students and teachers showed passion and engagement in the competition. In particular, at the end of the activities, the teachers expressed great interest in implementing at school this new way of *learn-to-learn* in which the goal is understanding in an amusing way. Students acquire important concepts almost unaware that they are studying.

Since customer satisfaction is one of the simplest tools for gathering feedback from players and measuring their fulfillment in an analytical manner, satisfaction surveys were performed at the end of each scientific venue. The aim was testing the enjoyment and the efficacy of our *game-based learning* activities and gathering comments and suggestions on our initiatives. Individual questionnaires, different for students and teachers, with short and simple questions have been administered. The answers received confirmed the high appreciation and interest of both children and teachers, already displayed in the numerous live chat comments during the events.

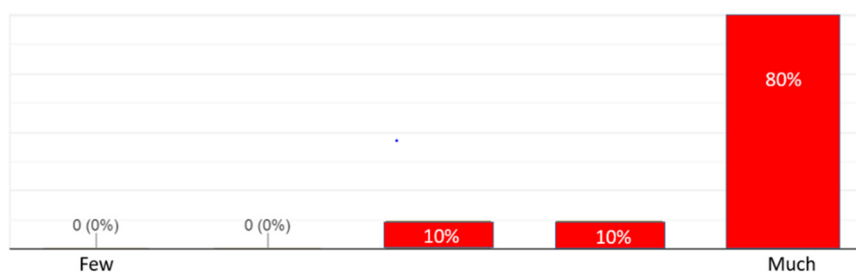
The following figures (Figures 7–13) display the answers of teachers and students to the satisfaction questionnaires administered. Results obtained for each individual educational game activity were processed and the graphs show the cumulative percentage value of all the answers to each question.

The results shown in Figure 13 highlight that teachers are very interested in getting involved in gamification experiences, in order to design with students new educational games that foster learning and at the same time arouse enthusiasm. On the other hand, the diagram also shows that teachers’ availability is often limited to activities that do not require too much involvement. This could be due to the objective difficulties of combining their several school duties, thus often having to renounce such activities appreciated by both students and teachers.

These encouraging results and the suggestions gathered have enabled us to sharpen our game design strategies for the creation of new and more appealing serious games.

By using a curiosity-driven approach, we had further confirmation that when the researchers’ knowledge is applied to gamification at the service of School, this kind of learning methodology became very useful in teaching. These activities, born during the pandemic to help homebound teachers and students, have been crucial in ensuring *distance learning*. Anyhow, they turned out to be relevant currently given that digital didactics is implemented in person as well.

How important do you consider initiatives connecting School and Research?
(Teachers)



How important do you consider initiatives connecting School and Research?
(Students)

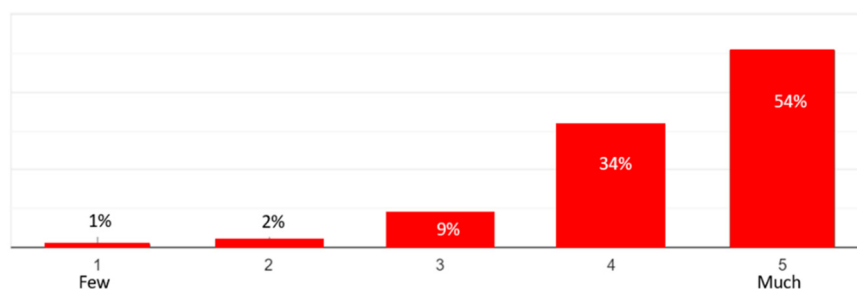
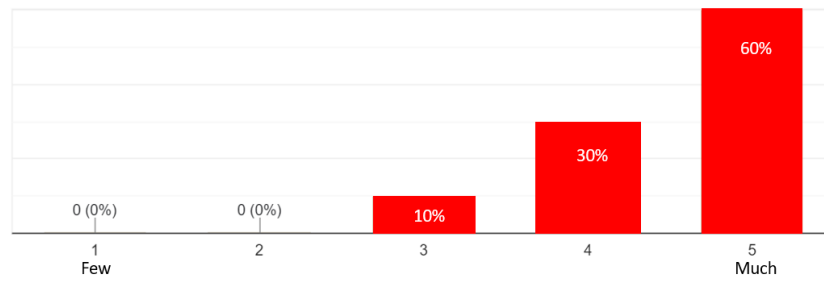


Figure 7. Cumulative values showing percentage of the feedback received for the first question from teachers and students, concerning all the played Salvina’s adventures.

How effective do you believe the Salvina's Adventures initiatives have been for students?
(Teachers)



How much do you believe you have learnt from playing Salvina's adventures with us?
(Students)

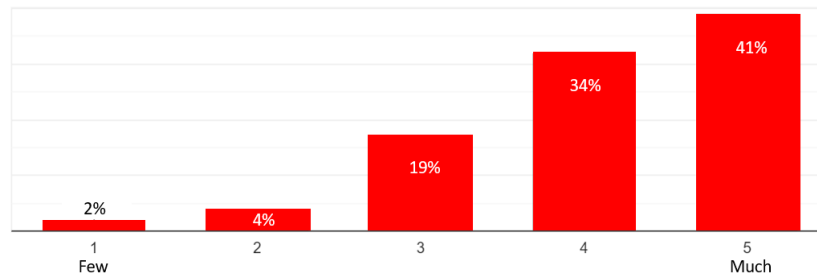


Figure 8. Cumulative values showing percentage of the feedback received for the second question from teachers and students, concerning all the played Salvina’s adventures.

How useful do you believe is it to test 'learning on gaming' activities at school?
(Teachers)

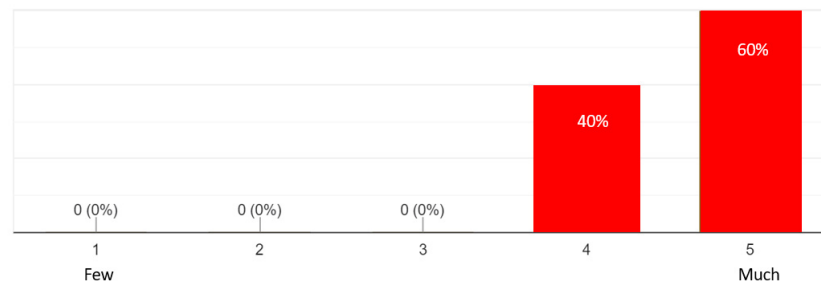


Figure 9. Cumulative values showing percentage of the feedback received for the third question from teachers, concerning all the played Salvina’s adventures.

How useful do you believe activities such as Salvina's adventures can be for teachers to develop new ideas for teaching?
(Teachers)

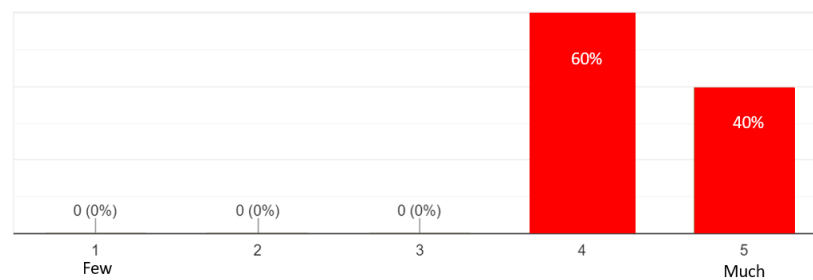


Figure 10. Cumulative values showing percentage of the feedback received for the fourth question from teachers, concerning all the played Salvina’s adventures.

Did you find the game activity with Salvina's adventures interesting and/or useful? (Students)

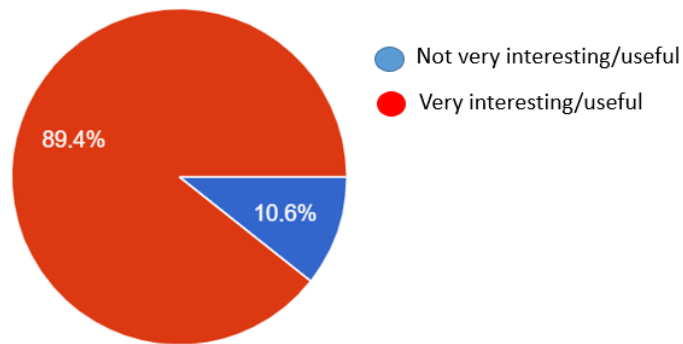


Figure 11. Pie chart showing cumulative percentage of the feedback received for the third question from students, concerning all the played Salvina’s adventures.

How effective do you believe it was to play Salvina's adventures to spread good practices to be followed in case of natural hazard? (Teachers)

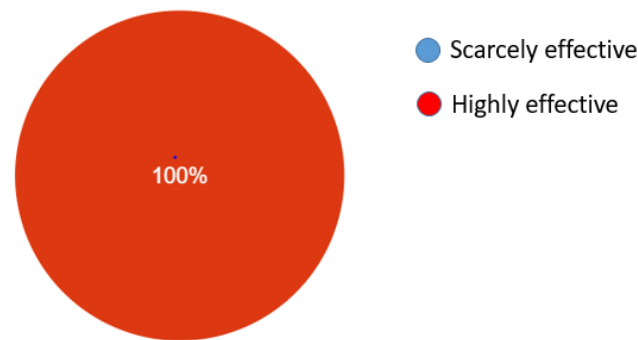


Figure 12. Pie chart showing cumulative percentage of the feedback received for the fifth question from teachers, concerning all the played Salvina’s adventures.

Would you cooperate with us in creating an environmental Escape Room? (Teachers)

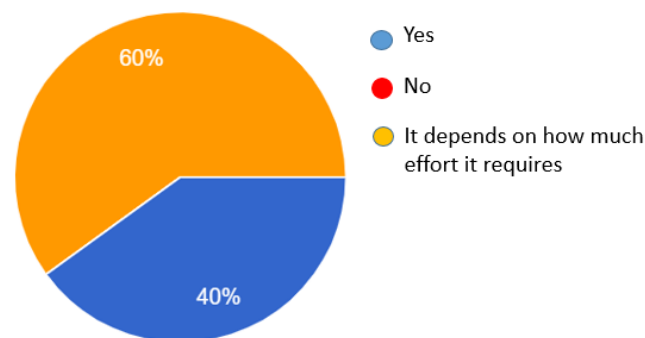


Figure 13. Pie chart displaying percentage of the feedback received from teachers about the Salvina’s Escape Room.

4. Discussion

School education is crucial in the enhancement of knowledge and in risk awareness. At school, scientific dissemination approached with appropriate learning methodologies and techniques, moves from understanding to the construction and strengthening of learning. The aim is to influence behavior and mindsets, to address enhancing proactivity and resilience for the common benefit.

Our activities aim to increase the risk awareness related to earthquakes, tsunamis, floods, and environmental crises, through digital games, bringing students closer to the world of research and encouraging the personal development of the contents discussed with the experts. The *debriefing* with researchers is the most important moment of our activity from an educational point of view. Thus, the discovery of the error leads to knowledge [53,54]. With Perkinson [55], the mistake becomes the focus in the knowledge-building process, and it is introduced in the didactics at school.

This type of *reflective learning* aids the development of *critical thinking* [56]. Furthermore, being aware that they can make mistakes, students freely express themselves by using all their resources not being afraid of others' opinion. This allows students to share their way of facing natural hazards situations in order to save themselves and others and to finally win the race.

The decision to carry out our study during the pandemic was driven by the need to find engaging activities that would promote *distance learning*. Recent studies have shown that even in other countries, such as the UK and the USA, well-designed *online learning* can offer even better tools than traditional classroom learning [57].

Having tested our educational games during this particular period allowed us to reach a very high number of students and teachers simultaneously competing between each other from several regions. Thanks to the feedback from satisfaction surveys, we had a great deal of data on the appreciation and educational efficacy of the designed games. Additional benefits of our experimentation of gamification at school was the improvement of the interaction between School and Research. In the frame of the *National Science Communication Conference 2021* held at SISSA (Trieste) in November 2021, we proposed gamification to be performed as a round table topic. The organizers selected our suggestion titled "*The importance of playing in science communication and learning*" among more than 120 proposals. The round table, chaired by Prof. Sacerdoti of the Federico II University of Naples, was followed by a general discussion on the relevance of the gamification in learning. It was possible to debate on gamification with a heterogeneous audience of science communication experts, touching on some specific aspects introduced by the following three talks: "*Learning by playing together: role-playing and serious games in education*" (by G. L. Piangiamore), "*Game and Digital adventure paths: when Science is a game*" (by S. Maraffi) [58–60] and "*Game and resilience: online challenges and remote games in response to the health emergency from COVID-19*" (by A. Maramai). In particular, the last talk was fully devoted to our experience with the Salvina's adventures.

All the activities carried out in the Salvina's experimentation have been projected by the INGV in order to give a tool to spread good practices of civil protection at school, encouraging prompt, safe behavior as an ability of personal processing. Following the gaming methodology, complex scientific concepts have been explained by researchers thanks to suggestions triggered by playing Salvina's adventures. After every race, many questions arose by players, allowing the dissemination of fundamental knowledge about natural hazards confirming the power of competition as a mean to improve effort-based learning and attention [61–63].

One of the limits of our experiment concerns the race management. In fact, one of the major peculiarities of these activities is the researcher's expertise in handling natural hazards and environmental issues. The games can be easily conducted in classroom led by teachers alone, but the presence of the researcher with his knowledge strengthens learning, especially in the debriefing phase.

Another limitation concerns the game design phase regarding the choice of using free easy-to-use and teacher-appreciated apps. In fact, since the platforms are constantly evolving, gradually making more functions for a fee, the games need to be frequently updated.

The games *Salvina and the Earthquake*, *Salvina and the Flood*, *Salvina and the Environment* and the Escape Room on natural hazards *Let's Free Salvina!* were designed to be played remotely during the difficult period of the pandemic. Since the feedback we received was encouraging and showed that these types of serious games are a good tool for *learn-to-learn*,

we designed *Salvina and the 4Rs* to be played in person. Many teachers have shown interest in playing the Escape Room again in an even wider competition involving schools from all Italian regions. A few teachers manifested the desire to collaborate with us on a new hypertextual environmental Escape Room. In this frame, a participatory project is in progress with the class 2A of the I.C. Simone de Magistris Middle School of Caldarola (MC) in the Marche region.

Selected Salvina's games, namely *Salvina and the Flood*, *Salvina and the Environment* and *Salvina and the 4Rs*, were also used to train the team from the Provincial Center for Adult Education (CPIA) of la Spezia. The team, led by an INGV researcher as delegated of the territory and by a CPIA teacher, was selected to take part in the *EPALE EDU HACK 2022 competition: "Making peace with the environment. Territorial proposals for digital innovation for green transition"* by Electronic Platform for Adult Learning in Europe (EPALE). We are also planning a collaboration project with Civil Protection and Ecological Guards Volunteers of the Province of La Spezia (Liguria) to ensure that Salvina's games on responsible behaviors can also be used by the volunteers themselves in Primary and Middle School (ISCDE 2) classes as a fun educational tool in person. It is a project of training on environmental safety within the context of *LifeLong Learning* through a permanent training process, with a basic education (knowledge, awareness, how to act, self-protection and prevention) on natural risks, also encouraging in the youngest an interest in the voluntary world [64–67].

Future developments of this activity include the translation of the games into English, in order to reach an international audience during special scientific events or in the case of cooperation between schools. Furthermore, the translation of the games enables a *CLIL (Content and Language Integrated Learning)* methodological approach, aimed at teaching a non-linguistic discipline, such as science, in a foreign language [68].

Natural risk education for primary and middle school (ISCDE 2) students could provide an effective way of promoting preparedness and prevention skills to their families and peers, improving their public cognition and response to natural disaster capability.

One of the activities planned for future special scientific events is to make our games a tool for *peer education*. A group of middle school students will be trained to become game conductors and tutors for the primary school classes participating in our initiatives.

Anyhow, the educational background of students needs adequate initiative to support schools in similar disaster education knowledge and skills for a safer and more resilient society [69,70].

Participative game design is an example of good cooperation between school, scientific research and civil protection, enforcing the common aim of building a sustainable system of prevention for trained future citizens more resilient and capable of respecting the natural environment and nature.

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