A board game meets an App... this is GeoRisk!

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Short note

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ABSTRACT

***GeoRisk* is a *game-learning* experiment to raise awareness on disaster reduction, enforcing the ability to foster hazards before the occurrence of extreme events in an amusing way for the last two years of Primary School and the first year of the Middle School classes. The research program of risk education *interactive learning* involves a network of schools also in special scientific venues in a *Computer Supported Collaborative Learning Education* experience, also testing the efficacy of the *Risk Detective* (Seismic and Hydrogeological Risk) table game by the *Saving Yourself* APP (Volcanic, Seismic and Hydrogeological Emergencies). The resulting educational tool ensures effective dissemination on natural hazard understanding to instill a culture of safety promoting best practice. The highly innovative idea is to use an App as an authentic assessment tool. The table game stimulates and facilitates learning in a simulated situation, the App promotes authentic assessment, providing immediate feedback, which is essential for an excellent outcome (Trinchero, 2015; Bursztyn et al., 2016; Rugelj, 2016). Therefore, the engaging gaming experiences also accompanies innovation in authentic assessment and favors the correct use of technology, which can constitute a valid tool of conscious communication for the new generations.**

KEYWORDS: App, Computer Supported Collaborative Learning Education, Digital Learning, Gaming, Natural Risk Reduction, Safety.

INTRODUCTION

Today, students need learning tools that use different communication codes, as they are less accustomed to abstraction (Occhipinti, 2014). An increasingly interconnected and technological world requires students to have specific skills: knowledge of the disciplines' fundamental cores in an interdisciplinary key; technical and technological skills; mastery of foreign languages; flexibility; attitude to teamwork; creativity; entrepreneurship (Maraffi & Sacerdoti, 2018a, 2018c). Scientific subjects, such as Science, Technology, Engineering and Mathematics (STEM) need to be strengthened and studied through a laboratory approach. On the other hand, teachers need user-friendly teaching tools, which allow and promote teamwork laboratory teaching and the *CLIL (Content and Language Integrated Learning)* approach (Maraffi & Sacerdoti, 2016a). The aim is to provide teachers about with easy to use teaching materials, favoring students' effective training on natural risk reduction issue.

GeoRisk is a product implemented for disaster prevention to raise public awareness, supporting the existing method of teaching with educational purposes about natural hazards and active citizenship. It aims to guarantee an effective acquisition of the key competences through gaming as powerful tool for effective *active learning*. It is an union between the *Risk Detective* table game, developed by INGV and free available on line with its independent paths on Seismic and Hydrogeological Risk (https://riskdetective.wordpress.com/; Piangiamore, 2019) and the *Saving Yourself* APP with its separate tracks on Seismic and Hydrogeological Emergencies (https://apps.apple.com/us/app/saving-yourself/id1251674281/; Maraffi & Sacerdoti, 2018 a, b). Our gamification logic to improve knowledge in Earth Environmental Emergency and best practice is focused on the power of amusing tools such as competition between different teams with points, virtual goods, real-time feedback, and so on, during the development of an immersive storytelling. The age target is still 9-11 years, adaptable to older children with appropriate modifications. The reason that led to the combining is the need to impart the concept of safe behavior in case of earthquakes, floods and landslides. The efficacy of learning

by playing through *Risk Detective* real life setting have been tested in an interactive way by the *Saving Yourself* APP. During the experiment we observed that players: learn the importance of safe behavior to prevent natural disasters; understood the consequence of the home furnishing choices in seismic risk mitigation; reflected on the preventive actions in case of hydrogeologic risk, also testing its effectiveness in communicating the key concept of safe best practice. The idea behind the *GeoRisk* project to combine of the board game and the app is a response to the undeniable importance of developing an alternative learning tool for a smart and modern teaching. First the groups of students play the cooperative activities of the *Risk Detective* game, then every student use his smartphone to verify his learning using the *Saving Yourself* APP.

MATERIALS & METHODS

The serious game makes people reflecting on game dynamics as an effective cross-curricular teaching methodology to make usable to Society complex scientific topics of great relevance. Topics are approached with a primarily educational purpose, not only from a strictly scientific point of view, but as a laboratory for active citizenship. The educational strategies of *Cooperative learning*, "group" *problem solving*, *Goal-Based-Scenarios (GBSs)*, *Inquiry Based Learning (IBL)*, *Game learning* and *Reflective learning* are all aimed at the most important *Transformational learning* purpose to prepare conscious and responsible future citizens. This kind of activity includes both *Social Emotional Learning* and *Service Learning,* aiming to foster children's choice of safe and correct behaviors, by clarifying the difference among the seismic and hydrological risk for the benefit of society and to develop active citizenship skills. The role-play gaming mode allows players to confront their team and reflect on the issues of risk, dialoguing trial after trial to make the right choices during the race), (Piangiamore & Musacchio, 2019; Piangiamore et al., 2015). The use of educational technology and interactive methodologies are closer to the youngest's language and let to improve the teaching/learning process, in respect to Traditional and PPT lessons, independently by the school degree (Maraffi & Sacerdoti, 2016b). The game is a valid tool for education since the acquisition of knowledge and enhancing skills now requires more actual approaches. Therefore, *learning on gaming* (Maraffi S. & Sacerdoti, 2018c) by using tablets, smartphones, social networks, etc. is more comprehensible and funnier for young people, compared to traditional media, providing content with rich combinations of texts, pictures and possibly video and audio (Mori, 2012).

Risk Detective

The multi-hazard *serious game Risk Detective* is a classroom board game implemented by INGV within M@Ter 2.0 - Earth-Sea Planet project dealing with hydrogeological (floods and landslides) and seismic hazards (https://ingvambiente.com/2020/03/16/risk-detective/).

In the design phase, the *Risk Detective* prototype has been played to test effectiveness in teaching *life skills*, crucial for the educational success of the future citizens. Participatory workshops were conducted by INGV researcher with 150 children of 4th and 5th classes of all primary schools belonging to the ISA 10 Lerici (La Spezia) which is the lead partner of M@ter2.0 project. The involved classes joined in a "journey of knowledge through play" concerning how to face both hydrogeological and seismic risks. Two-hour meetings at primary schools, involving children playing the draft of *Risk Detective* serious game, were dedicated to check if quizzes and challenges were targeted to the testers' age and suitable for the purpose of education on multi-risk reduction. Thus, the designers improved the storytelling behind the game designed during the conception phase in collaboration with teachers through the analysis of the behavioral dynamics of the participants. Once this phase was concluded, and all feedback were collected, the game was improved and the fully downloadable online version for free was made. Seismic and hydrogeological hazards are covered in separate tracks: Track 1 deals with Earthquake and Track 2 deals with Landslide and Flood. Students are involved in a real-life story in the village of Picchio Roso where the lack of preventive measures turned natural hazards into a damaging event. The team-based educational game was planned to be played in class, starting with storytelling managed by a moderator (teacher or researcher) who choose the track to be played without revealing it to students. Players will find out if they are dealing with earthquake, flood or landslide "investigating" during the race. It is recommended to play both tracks in a short period to better fix the differences between the different natural phenomena and related risks to encourage the automation of the appropriate behavior according to the occurrence. By playing at least two matches to address separately seismic and hydrogeological hazards, confusion is avoided, and the different characteristics of the analyzed risks are underlined. The young students, divided into four competing teams, will face six different trials and setbacks. The challenge is to evaluate the best choices to avoid danger, trying to foresee the consequences of their own decisions. Every trial is associated with a score, according to which the winning team will be declared at the end of the competition. Everyone will receive a *Risk Detective* certificate. The *serious game* was presented at *TUTELASPEZIA: Exposition and meeting on prevention restoration and land care from floods, landslides and earthquakes for administrators and informed citizens* inside the "Risk is a choice, are you aware of it?" The resulting *Risk Detective* game was tested for children to arise interest in hazards and risks in their environment, promote a proactive attitude toward safe behaviors, and increase coping skills in the emergency phase of a disaster. Further, in the occasion of the *ScienzAperta 2017* at the INGV of Portovenere during the *"How Risk Detective are you?"* special venue, *Risk Detective* was tested as a tool to foster learning of the little scientists. The final version of the *serious game* was promoted at *Planet Earth Week 2018* in La Spezia and played by 320 pupils of all the primary schools of the I.C. "Don Milani" in La Spezia and in a special event in Varese. About 150 children played the Earthquake track of *"R as Risk Detective"* at *Words for the Earth* for the *1st Regional Earthquake Literacy Day* at INGV of Rome on January 2020. In this occasion about half of the users were students of second and third class of Middle Schools; the satisfaction surveys collected from both teachers and students

were an important proof to understand that, with little variations, the game can be easily adapted to older students, by increasing the difficulty of some trials and eliminating others (Fig. 1).

Unfortunately, because of the pandemic, all the special events including *Risk Detective* planned for Spring 2020 have been skipped: 1) the MIUR XXIX Week of Scientific Culture 1a) at "N. Olivieri" Primary School of La Spezia and 1b) at the special opening at MUGED (Duronia Geophysical Museum), 2) the TedX kids in Genoa, and 3) the Fosforo Science in Senigallia. *Risk Detective* was then adapting to the online mode and the fully downloadable version was spread remotely.

Saving Yourself

Saving Yourself (https://www.youtube.com/watch?v=SIYvU7WzSE4&t=54s) comes from a methodological experience of *learning on gaming* to improve Earth's Sciences, particularly Geophysics, and above all Environmental and Safety education. It is an App on iOS related to the experience of the *EvoQuest* (www.evoquest.eu) adventure game to learn the correct behaviors in Earth Environmental Emergency. The aim is to provide, in the most immediate and practicable way, what are the correct behaviors during geological emergencies, with particular reference to volcanological, seismic, and hydrogeological ones. The adventures have been built to be used at school for student of different ages to optimize education safety measures. A digital storytelling is available both in Italian and English version to engage players. The digital gaming activity wants to introduce children to the topics of natural hazards to raise awareness on the importance of the appropriate behavior choices in case of different natural events, such as earthquakes, landslides or floods. We choose interactive methodologies, also in case of *CLIL methodologies* to overcome the transmissive traditional teaching and frontal lessons. Therefore, an immersive learning environment is realized, focusing on "communication" with active interaction among all members of the educational community, so that "everyone can give according to his own abilities and receive according to his needs" (Marini, 2016). The inductive approach uses *ICT* as a tool to expand the potential of student investigation in inquiry method, using a language closer to pupils to improve the teaching/learning process (Maraffi, 2016; Maraffi & Scamardella, 2016; Boniello et al., 2017). Game design emphasizes challenge, while considering players' skills, which also contribute to the engagement and immersion (Maraffi & Sacerdoti, 2016b). All *Saving Yourself* Apps are enriched with original illustrations, suitable for the youngest (we can use storytelling to bring kids through our comics), and nice for all ages (Fig. 2).

A significant learning experience by a player requires a challenge that is well suited to skill level and immediate meaningful feedback. Individuals stretch their skills to the limit looking for a challenging goal (Mayo, 2009). We developed two age-differentiated paths on volcanoes and Earth Sciences, one route on the seismic emergency and another one on the hydrogeological emergency. Questions with automatic feedback are correlated by the correct answer and the relative explanation to verify the learning level acquired through game. Immediate feedback indicates the wrong answer in red, while the correct answer appears in green (Fig. 3). This is a good strategy for managing mistakes made by students during the game.

Fig. 1 - Special scientific venues dedicated to Risk Detective test (in classroom) and share (in public events) at Lerici, Portovenere, La Spezia, and Rome.

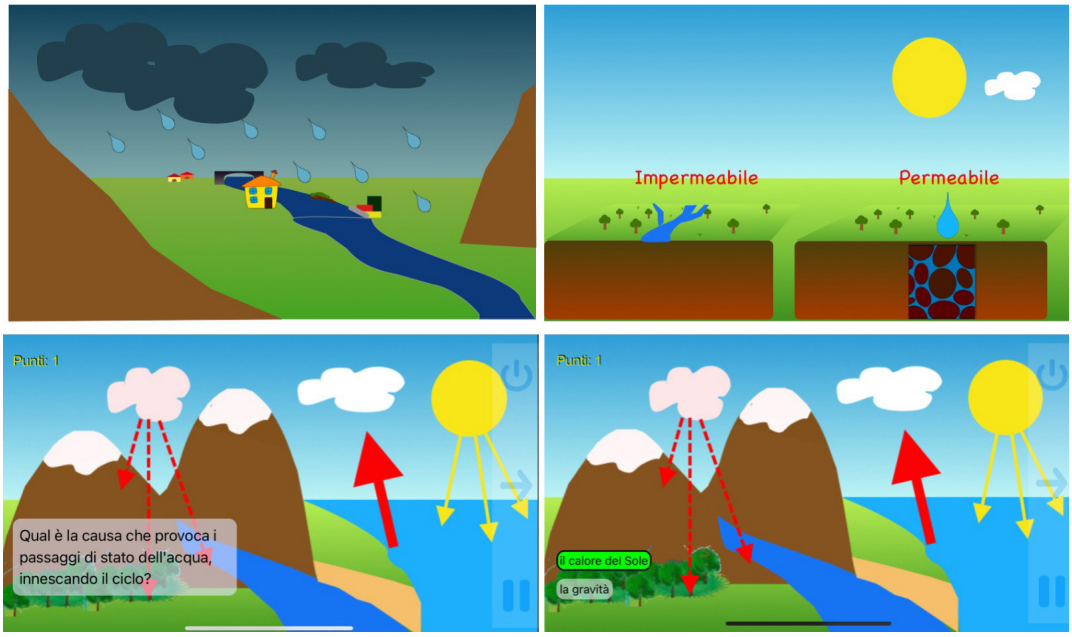

Fig. 2 - The Saving Yourself App conveys complex concepts thanks to captivating images. Immediate feedback facilitates learning.

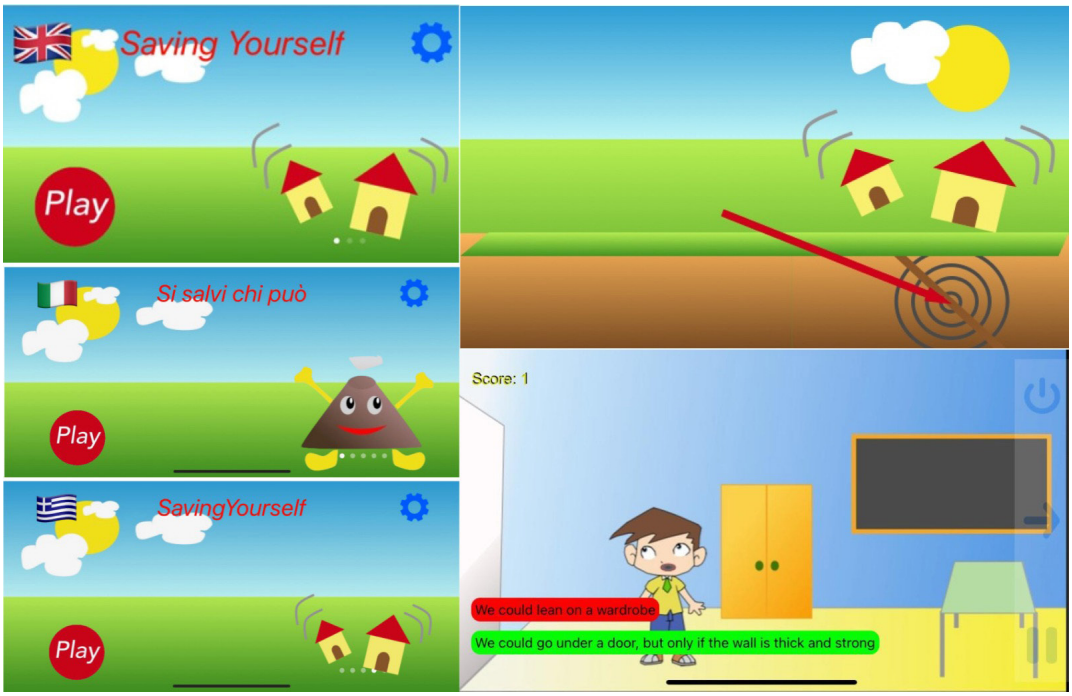

Fig. 3 - In the Saving Yourself App you can choose the language (top left) and the path (right). There are different game paths, dedicated to geo-environmental emergencies: earthquakes, volcanoes, and hydrogeological instability.

Indeed, while in school activities an error is a potential source of frustration, during a game it is an integral and normal part of the experience.

GeoRisk (Risk Detective + Saving Yourself)

In order to deepen our Educational Research, continuing the experimentation, we tested the effectiveness of scientific learning through gaming. The result is *GeoRisk* experiment (https://www.researchgate.net/publication/364082164_A_board_game_meets_an_App_this_is_GeoRisk_Geosciences_at_School_-_Geosciences_for_a_sustainable_future_SGI-SIMP_Congress_Turin_Italy_19-21_September_2022), where the evaluation of learning through *Risk Detective* game is realized by the *Saving Yourself* APP (Fig. 4) in a currently underway free collaboration between INGV researchers and the video game creators. This collaboration aims to increase widespread awareness of the importance of science and technology for everyday life and the sustainable development of society. The mixed methodology for innovative teaching now includes storytelling, gaming, use of information and communication technologies. Putting together *Risk Detective* and *Saving Yourself* APP the main aim is to favor the growth of *emotional intelligence* and *soft skills. GeoRisk* encloses in itself all three types of educational game: *Teaching games, Meaningful games*, *Purposeful games.* In the *Teaching games,* the tools are not shown, but discovered by passing tests, solving

Fig. 4 - The GeoRisk is an experiment where the evaluation of learning through Risk Detective game is realized by the Saving Yourself APP.

puzzles, etc... which need an ever deeper understanding of the subject matter. *Meaningful games* convey a significant message to promote change. *Purposeful games* are targeted to develop a game path that has some outcome in the real world (Piangiamore & Maramai, 2022 and references therein). The Risk Detective board game need the presence of a teacher, the *Saving Yourself* APP is interactive, but in any case, the teacher (or researcher) has the key-role of learning facilitator to conduct the final and most important debriefing phase of the educational activities in which *reflective learning* should become *transformational learning* to trigger the correct behaviors to prevent natural disaster. *GeoRisk* is a way to reason together about the importance of safe choices in civil protection issue by means of the *Risk Detective* table game and evaluating its effectiveness through the correlated digital multi-risk game *Saving Yourself.* The game test should be carried out in France at the "Ecole Jean Jaures" Primary School in Grenoble for an international edition of *OpenScience* in a comparison study between Italy and France school systems on innovative science learning techniques. Unfortunately, the special event skipped due to Covid19 emergency.

The *GeoRisk* activity has been adapted to *Distance Learning* during the pandemic. The webinar *"GeoRisk: App and board game meet in a new integrated tool to educate for sustainable development and risk prevention"* launching our activity at the *City of Science, 3 days for school city - EDU2021*. Furthermore, the immersive workshop *"Experiments in Geosciences Didactics for Natural Hazard Education through Play and Active Discovery Pathways"* involves 40 teachers at *DIDACTA 2021* in *GeoRisk* experimental method. It has been finally played in presence by about 400 students from Primary and Middle schools with their 20 teachers at the *"GeoRisk: let's play to learn about the Earth"* event during the *Futuro Remoto* Science Festival in Naples in the 2022 edition.

Classes competed by enhancing their *critical thinking* and their communicative, argumentative and deliberative practices to convince other team members of the strength of their theories to win. The collective learning experience let players become able to take responsibility, and to improve the quality of life by caring for others and the environment, to mutual benefit. (Muttarak &Lutz, 2014).

GeoRisk is an educational game also for... apprentice science disseminators! becomes a tool for the PCTOs held at Science City in Naples and titled "Apprentice science popularizers" to enhance and promote scientific knowledge at secondary school. 50 students from the "E. Torricelli" Scientific Liceum in Somma Vesuviana (Na) have been trained by the INGV researcher to use the game. They become science guides at the Science Centre playing *Risk Detective* with children who come to visit Science Center accompanied by their families during weekends. Then they use *Saving Yourself* App in order to best perform their science outreach activities. In this context, *GeoRisk* fosters the acquisition of transversal skills (working in groups, communicating knowledge) and geological skills, and becomes also a tool to raise awareness of seismic and hydrogeological hazards with the general public.

RESULTS

Communicating Science with images and through traditional and digital game has yielded exciting results in classes involved in "play, learn and grow together" on our research topics. Over than 600 students and about 40 Primary and Middle schools' teachers have experienced the *serious game Risk Detective*. The high relevance of the social objective is demonstrated by the satisfaction questionnaires always very positive during the scientific venues and also about the participatory planning phase with teachers and students involved. After all the activities we asked students to express their evaluation from 1 to 10. The students' satisfaction regarding the overall experience with *GeoRisk* (the learning environment, the *CLIL* approach and the use of smartphones) are fully positive (> 6; Fig. 5). A more detailed analysis shows in Tab. 1 the overall experience with *GeoRisk* evaluated as very positive by students with average rating of 8.2 (media = 8.2); the majority of students provided a value of 8 (mode = 8). The mean, median and mode data confirm that *GeoRisk*'s evaluation was not only excellent, but also received a strongly positive rating from almost all the subjects involved.

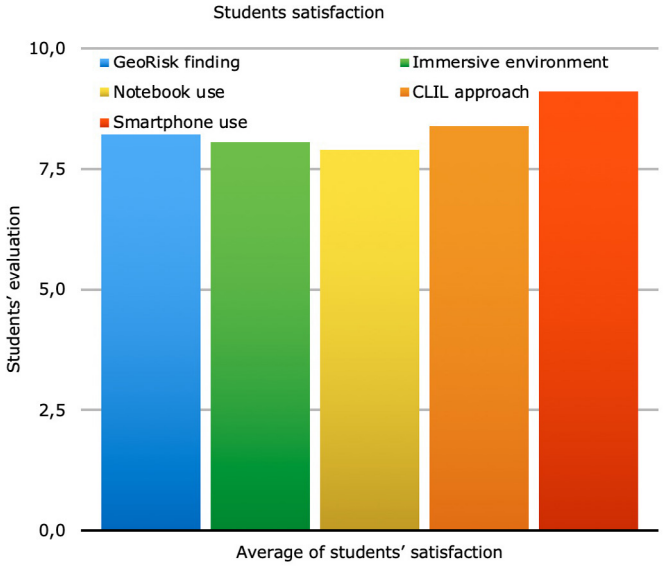

Fig. 5 - Students' satisfaction.

Table 1 - Media, median and mode values for students' satisfactions.

Students Satisfaction	GeoRisk finding	Immersive environment	Smartphone use
Media	8,2	8,2	9,1
Median	8	8	10
Mode	8	7	10

Seminars on *Risk detective* experience have been held at some universities in the frame of training of Science teachers. In particular, *"Interdisciplinary pathways for active and conscious citizenship"* and *"INGV activities for teachers"* seminars were held at the University of Camerino for the Summer School 2017 focused on the "Geoenvironmental Risks" for teachers of schools of all levels, and *"Experiments in the teaching of Geosciences for Natural Risk Education"* lesson was held at the University of Pavia for the *"Didactics of Geosciences"* course in A.A. 2019/2020. We have achieved the goals of providing teachers with new tools to foster education on natural hazards, active citizenship, dissemination of good practices for earthquake and hydrogeological risk mitigation, and sustainable development through play. We also aim to become the starting point for other works of this type for future educational activities and develop teachers' skills to design new educational paths based on the methodology of *game learning*. Educational innovation must also accompany innovation in authentic assessment, and *Risk Detective* still demonstrates to be a living and evolving tool. The evaluation of effectiveness as teaching through play using the method developed with *GeoRisk* is in full swing. Educational innovation in emergency preparedness and risk perception at school can be accompanied by an innovative authentic assessment carried out evaluating the effectiveness of learning through play with another game. After students have discovered natural hazards playing board game, the follow-up questions by the App are not the usual pre- and post-activity questionnaires, but colorful quizzes playing another game. It is a nice way to test what they have learned playing and to educate, not only about sustainability and respect for the environment, but also about the conscious use of technological tools in an *active learning* process. The traditional learning assessment (Fig. 6a) shows insufficient results, while the assessment carried out using the *GeoRisk* (Fig. 6b red) shows results attested to more than good outcomes. The advantages in the match of the two learning tools compared to *Risk Detective* serious team game or *Saving Yourself* APP single use is that to test the efficacy of our game learning activities, we use another game instead of a satisfaction questionnaire. This help us to avoid the loss of attention of the participants, because the assessment is developed during involvement. To evaluate skills with educational game means to remain in the challenging dimension mobilizing by the game. To win students use their knowledge and experience and activate their resources to look for different solutions. This is a stimulating learning environment for student that favor critical thinking development.

DISCUSSION AND CONCLUSIONS

Storytelling is an effective tool for learning: a story is easier to remember than an explanation and modern pedagogy rediscovered storytelling to enhance the effectiveness of information transmission and students' achievement (Kotluk & Kocakaya, 2017). Roleplaying could help students to reach their goals easily through cooperation to acquire disciplinary and transversal skills. Educational gamification is the use of game elements in non-game contexts to improve learning experiences, engaging the students in a social, emotional, and cognitive level. The use of student-centered game elements in non-game educational systems improves student experience, drives engagement with learning activities and models, teaches effective learner skills, and enhances student attitude and identity as a learner (Jantke & Hume, 2015). Until now, serious games are a significant step forward compared to many ways of using information technologies in education, which, as it happens with the traditional e-learning, have often repeated the transmissive model. We have experienced that when games together create other games, new effective teaching tools can be born. *GeoRisk* is the result: *a serious game* to educate about natural risk reduction at school with the aim of triggering interest about hazards and risks

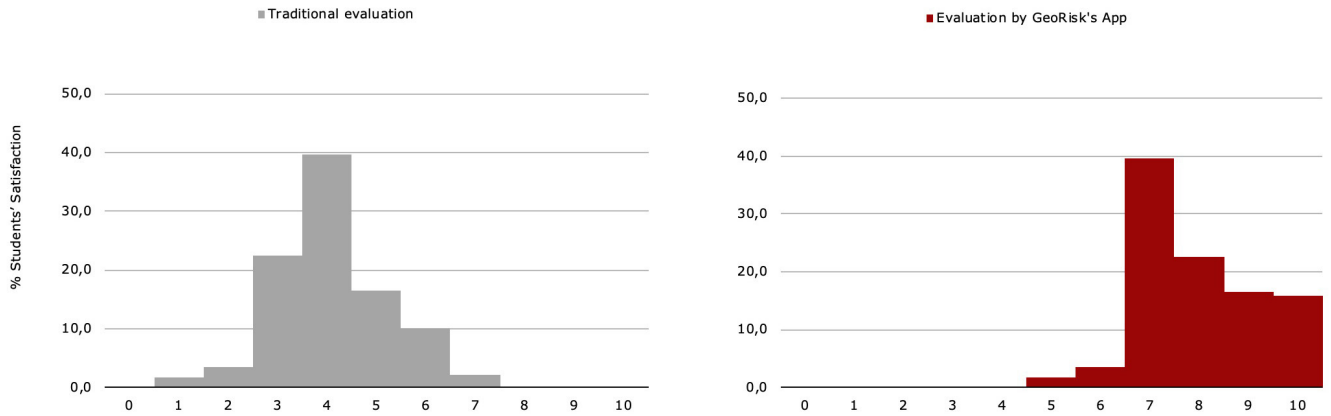

Fig. 6 - The traditional learning assessment (Fig. 6a grey) shows insufficient results, while the assessment carried out using GeoRisk (Fig. 6b red) shows results attested to more than good outcomes.

in their surroundings, promoting a proactive attitude toward safe behaviors, and increasing coping skills during the emergency phase of a disaster. Seismic and hydrogeological hazards were deliberately dealt with in separate tracks to encourage correct recall of safe behaviors, according to different emergencies. Science meets civil education for students lead to *critical thinking* in danger situation and to conscious choices for a safer Society. Eventually, students learn how to conduct investigations, and they also understand the processes used by researchers to develop knowledge. They became able to identify vulnerabilities and hazards in assessing risks and they learn how to choose safest solutions, after reflecting on the possible consequences of their choices.

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