



School of Advanced Studies

UNIVERSITÀ DEGLI STUDI DI CAMERINO

School of Advanced Studies

**Doctoral course in
“Science and Technology:
Physical and Chemical Processes in Earth Systems”
XXXI Cycle**

**Learning on Gaming with
Computer Class Role Playing Game:
GeoQuest Project**

PhD Student
Dott. Sabina Maraffi

Supervisor
Prof. Eleonora Paris

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Abstract

GeoQuest is a PhD research project in Geoscience education with a focus on Teaching and Learning Processes. It aims to answer both students' and teachers' needs in a fast-changing world, where, in particular, today's students need learning tools that use communication codes closer to them, as they are less accustomed to abstraction.

On the other hand, there is an increasing need to make the students more aware of the environment: in particular the geological hazards, in a fragile territory like the Italian one, too often put at risk population, property, infrastructure and the natural setting. The widespread lack of geoscience knowledge contributes negatively to keep correct behaviours towards the environment, increasing the danger caused by natural phenomena. Moreover, the decreasing interest in school for the Earth sciences (both from teachers and students) calls for a drastic change in the geoscience teaching, which could engage the students to acquire a passion or at least a stronger interest for the geosciences and in general for the environment.

Moreover, an increasingly interconnected and technological world requires students to have specific skills: knowledge of the disciplines founding cores in an interdisciplinary key is required, along with technical and technological skills, mastery of foreign languages, flexibility, attitude to teamwork, creativity and entrepreneurship. Scientific subjects, such as Science, Technology, Engineering and Mathematics (STEM subjects) need to be strengthened and studied through a laboratory approach. On the other hand, teachers pressed to keep up with modern teaching methods and topics, need user-friendly teaching tools, which can allow promote teamwork, laboratory teaching and CLIL (Content and Language Integrated learning) approach.

The aim of this work is therefore to prove that it is possible to treat geoscience topics in a modern and attractive way, at the same moment trying to reconcile the needs of teachers to have user-friendly teaching materials that do not require major adaptation, to the needs of students to have an effective training.

The best way to increase chances to obtain acceptance by the teachers to use different didactic approaches is the identification of the specific teachers' needs. The needs have been identified as following:

- to have well-structured, user-friendly teaching materials available. Innovative teaching materials must also allow an interdisciplinary and multilingual approach (CLIL approach), and must develop a learning environment allowing an effective skill assessment;

- to have teaching materials that use ICT, to enhance the digital competence of the students ensuring an effective student engagement and in the same way encouraging the teachers with user-friendly tools. The project started with an investigation of the existing literature about effective learning. Vygotsky (1978) believed that learning occurred within a learner's Zone of Proximal Development (ZPD). From the activities, a learner can independently master those challenges, which can be accomplished with the help of additional supports. Offering activities inside the players' ZPD will create a more appropriate challenge to their skill level than keeping them maximally engaged and in learning (Hamari et al., 2016). Problems that require the exercise of content and skills covered at school, presented as a game may be stimulants and not frustrating due to the controlled difficulties, and it may promote cognitive functions about targeted content: a key element for the enhancement of learning (Greenfield and Carbone, 1985). The difference between the narratives found in digital games and those found in other media, such as books and movies, changes the level of engagement. In books and videos, the person is engaged in the narrative although as a passive consumer and has no impact on the outcome of the narrative. On the other hand, an illusion is created whereby the players of a game perceive themselves as constructing the narrative of that game (Cohen, 2016) enhancing the engage level and effectiveness. These studies suggested to try to approach learning geosciences by gaming, using a new Computer Classroom Role Playing Game (CCRPG), GeoQuest, which has been developed in this PhD project.

GeoQuest is a digital game focused on Earth Sciences, that allows the class to interact with the game itself in cooperative learning: it creates an immersive learning environment, in which an interdisciplinary adventure

path develops, but containing related topics taken from the disciplines close to the students' age range. The immersive environment and interdisciplinary connections create an engagement that allows to deal ,even with complex topics, in a simple and effective way.

As an example of an Adventure Path, the GeoQuest Phlaegraean Fields path, is reported in the following. The path is a mix of geoscience topics intertwined with mythology and literature. The adventure begins underground, in a dark and quiet cave. There are no clues to understand where you are. The player/student is screened in a mystery story where he/she has to decide how to proceed. Players cross narrow tunnels and huge caverns, risk falling into the icy water, or being involved in earthquakes. They hear the unearthly dripping water and the gentle whisperings of lost souls. This adventure is located in the volcanic area of the Phlaegraean Fields. The environment that gradually reveals itself is full of significant elements that can be traced back to a volcanic site, inserted in a complex geodynamic situation. It is located in the Mediterranean area, specifically in Campania, where compressive and divergent geological events produced differentiated magmas and explosive volcanism. During the game, players can also discover where they are from the history of the characters they meet along their path. They meet Charon, the conductor of souls to the kingdom of deads, the Cumaean Sibyl, recounting her love affair with the god Apollo, and Flegra, whose legend was born in Thessaly and is implanted in Campania, naming the zone to Phlaegraean Fields. Lete, god of Sleep embodied in the river that flows near Lake of Avernus, relives through the verses of Ovid's *Metamorphoses*. There is also Pirithous, who dared to challenge Ade attempting to kidnap Persephone. The minerals, such as sanidine, biotite, pyroxene and magnetite, allow players to go back to an intrusive weakly acidic rock like syenite. Its presence in the crustal conduit, along with earthquakes, allows players to trace petrological environments typical of the Campania volcanism. An intrusive body such as the syenite provides a geodynamic origin by tectonic convergence. The volcanic area of Phlaegraean Fields is unique in the world and is beautifully described in the "Gigantomachy", which tells the story of the terrible Giants who were defeated and buried under volcanoes; their attempts to free themselves would trigger the volcanic convulsions of the Earth and explain the origin of earthquakes. Going back to the surface, players can recognise the tuffs, which attest the interaction between groundwaters and magma, typical of

the eruptions at Phlaegrean Fields. Finally, the players walk across some sulphur vapours which suggest that they are approaching the area under the Solfatara. They will have to connect the colour of sulphur crystals to their temperature in order to find the right exit towards the surface. GeoQuest deals therefore with topics of geology, volcanology, mineralogy, geodynamics, which are normally difficult to be understood for students and often for science teachers themselves. The interdisciplinary key in the game, connecting history, mythology, latin literature and so on, is used as a leverage to help going through Geosciences and other scientific disciplines, making use of the appeal that humanistic knowledge has among the students and teachers.

A multi-phase experimentation has been adopted to verify the effectiveness of CCRPG, which has been carried out for two years. The first step of the experimentation served to calibrate the experimentation itself, to define the experimental protocol and to make the modifications to the gaming activity, that became necessary following the practical verification in the classes. The total research sample consisted of 40 classes, from primary schools to university, for a total of 914 students. Within this sample, 32 classes (731 students) have experimented with the CCRPG and 8 classes (183 students) had a lesson with traditional methodology: frontal lesson, supported by interactive multimedia whiteboard, photos and videos. The experimentation allowed to evaluate and prove that the GeoQuest Project can contribute positively to science education, guaranteeing an effective acquisition of the key competences and the disciplinary ones requested by the modern Science and Technology. This has been demonstrated by the results obtained by the tests which show an improvement in learning levels obtained with the CCRPG of 269%, while the control sample using the traditional lesson shows only an improvement of 133% after the lesson. The GeoQuest Project has been also evaluated by the teachers as a good educational tool, since it is able to stimulate students' interest and keep their attention high during the entire duration of the teaching activity favouring their engagement in the learning process.

The final outcome suggests that GeoQuest Project can effectively match the needs identified by students and teachers, attracting the interest of the students on geoscience topics, treating them in a interdisciplinary way. Carrying out the experimentation in several phases

allowed us to calibrate and improve the approach , and allowed us to obtain rigorous and reliable results. The teaching tool perfectly complies with the demands of modern society. Above all, the results obtained allowed to answer positively to the research questions identified in teaching and learning processes in Science Education: to create an educational tool that ensures students to build knowledge of the disciplines founding cores in an interdisciplinary key, which allows them to acquire, at the same time, technical and technological skills, mastery of foreign languages, flexibility, creativity and entrepreneurship. Among the few weaknesses identified in the experimentation, it was evidenced by the teachers that the syntax used in the oral and written expression is very rich and sometimes complex for using with digital tools and with the short time characteristics of gaming and storytelling. For example, some phrases that appeared as screenshots were too long to read or contained too complex terms. As a consequence, a collaboration started on linguistic simplification in storytelling and gaming, collaborating with Prof. Johanna Monti, from the University L'Orientale of Naples, Italy. A PhD student is carrying out a Research Project on Linguistic Simplification in the Storytelling applied to Gaming, specifically for GeoQuest Project (PhD thesis title: "Development and effects that the use of Digital Storytelling, understood as a new art of narration, brings in the teaching of foreign languages and cultures"). As a first result, the GeoQuest Hawaii adventure pathway was created according to the canons of linguistic simplification, which will approach the problem identified. Since the beginning of the first experimentation and also as a result of the disclosure of this research work, the requests to try the game in many schools have multiplied. The five already existing pathways will soon be joined by others already requested. Some schools, in different Italian regions, have placed GeoQuest at the base of school projects to support learning or development of scientific and digital skills (Projects with Ministry of Education funds). Also, GeoQuest was chosen as a Joint Project between European countries by the executive board of Science on Stage Europe (<https://www.science-on-stage.eu>), which deals with the spread and sharing of innovative methodologies to teach Science. Science on Stage funded the exchange between Italy and Iceland for the diffusion of the CCRPG methodology. The final presentation of the results obtained during this European exchange will be carried out in Portugal.

The positive experience with the GeoQuest Project attracted the attention of educators at the national, EU and extra-EU levels, suggesting to continue to create a series of related projects, like new educational Apps to explain the correct behaviour to keep during emergencies, or the application of the CCRPG to tourism and to safety education, indicating that gaming can be used effectively also as a outreach and dissemination tool.

Chapter summary

Chapter I is an introduction, in which the initial idea and the analysis of the needs identified, a presentation of the learning on Gaming, the purpose of the research and the work plan are exposed. The analysis of the needs is done both on the students' learning needs and on the supports to be given to the teachers, in order to contribute to effectively innovate the teaching of Earth Sciences in school.

Chapter II: the educational background of the project is presented. The starting point of the research is to use the digital storytelling with an innovative methodological approach, based on inquiry. Modern pedagogy rediscovered storytelling and demonstrated that, even though not using technologically innovative teaching tools, storytelling enhances the effectiveness of information transmission. Moreover, the digital application of storytelling has been demonstrated to have a positive impact especially on students' achievement.

Chapter III: the CCRPG methodology is described, based on an original Engine, made specifically for this project. The description of the Game is presented, from a technical and didactic point of view. The illustration of the GeoQuest project, is presented through the analysis of one of the adventure trails created. The adventure pathway is described and, through the presentation of papers published in international Journals or on Conference Proceedings, the salient aspects are highlighted: the innovative character of the methodology, the applicability of GeoQuest project to the STEAM (Science, Technology, Engineering, Arts, Mathematics), the use of IBSE (Inquiry Based Science Education) and CLIL (Content and Language Integrated Learning) approaches. Other papers reported highlight the learning environment created by GeoQuest,

ideal for the assessment of skills, as it guarantees real-life tasks, provided by accessible design, creating an inclusive Educational Environment.

Chapter IV collects the results obtained during the teaching experimentation of the Computer Classroom Role Playing Game GeoQuest, where attention was focused on Earth Sciences topics, mediated by an interdisciplinary approach. Knowledge and skills in geology, volcanology and mineralogy were at the basis of the adventures paths produced. The results demonstrated positive responses showing that GeoQuest is able to guarantee an effective acquisition of the key competences and the disciplinary ones of Geoscience as well as, more generally, Science and Technology.

Chapter V contains the discussion of the innovative elements of the GeoQuest project. This research shows that the application of CCRPG does not require digital knowledge, it is user friendly, requires little preparation time by the teachers. Above all, the CCRPG can also be used without an internet connection and requires only a laptop, therefore easy to use in the classroom. On the other hand, the results obtained during the experimentation with students show that there are no difference in students' outcomes between primary, secondary and high school. From pupils to older students, the engage and the interest for the disciplinary topics is high and the results obtained are always very positive and the difference with traditional teaching is tangible.

Chapter VI illustrates the conclusions, which highlight the innovative elements and the solutions made using CCRPG, as well as illustrating the weaknesses emerged during the research path and possible solutions. The future developments of the project and the applicability of GeoQuest to different educational fields are also described.

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Acknowledgments

I would like to thank:

- ❖ my husband, Francesco Sacerdoti, who created the GeoQuest Engine for me, and who helped and supported GeoQuest Project;
- ❖ my supervisor, Prof. Eleonora Paris, for having liked, supported and strengthened my Research Project;
- ❖ my children, Andrea and Ludovica, if necessary English, Statistics and Style excellent experts;
- ❖ my friend and colleague Daniela Pennesi, for pushing me to do a research doctorate, after learning about GeoQuest;
- ❖ Alessandro Acqua and Lucia Stacchiotti, who, together with Daniela, cuddle me with love and hospitality;
- ❖ Andrea Bernagozzi, Alessia Cicconi, Giulietta Realdon, Marina Porta e Mila Erbisti, wonderful *journey* colleagues.

Abbreviations

CCRPG	Computer Classrooms Role-Playing Game
CLIL	Content Language Integrated Learning
DRPG	Digital Role-Playing Game
IBL	Inquiry-Based Learning
IBSE	Inquiry-Based Science Education
ICT	Information and Communication Technologies
IESO	International Olympiads of Earth Sciences
IGEO	International Geoscience Education Organisation
IWB	Interactive White Board
OCSE	Italian name of OECD
OECD	Organisation for Economic Co-operation and Development
RPG	Role-Playing Game
SEN	Special Educational Needs
STEAM	Science, Technology, Engineering, Mathematics, combined with Arts
STEM	Science, Technology, Engineering, Mathematics
SSH	Social Sciences & Humanities
PPT	Power Point

1. Chapter I - Introduction

1.1. Idea

The idea of this project arose probably due to Vermeer's influence: when I was looking at his *Astronomer* (Fig.1.1.1) and *Geographer* (Fig. 1.1.2) paintings at the National Museum of Ireland, I caught myself lost in thought. The two paintings were wisely displayed next to the *Astronomer*



Figure 1.1.1. *Astronomer*, by Johannes Vermeer, 1668.

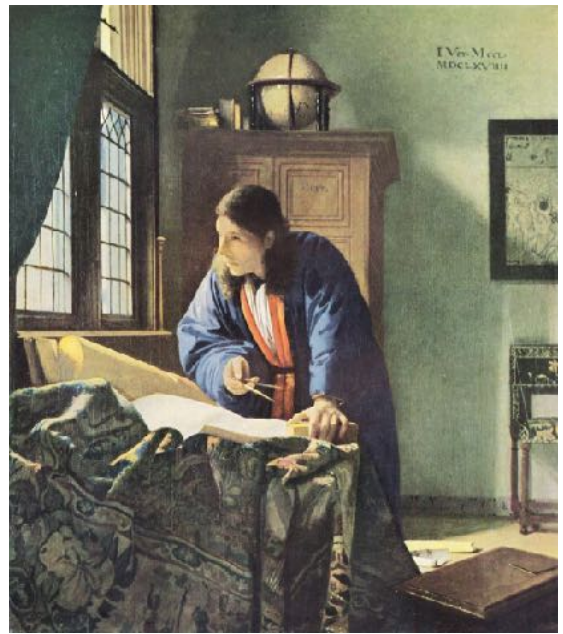


Figure 1.1.2. *Geographer*, by Johannes Vermeer, 1669.

by candlelight (Fig.1.1.3), painted by Gettir Dou in the same period, though they could not be more different one from the other. Dou's *Astronomer* carelessly holds a globe with one hand, but he is concentrated on a book, in a dark, closed environment, lit only by a candle. The *Astronomer* by Vermeer, despite having an open book himself, observes the globe and shows an attitude towards discovery in his gesture: the environment is bright and welcoming. Also the *Geographer* by Vermeer does not remain passive in front of a book, but holds a compass in his hand, as ready to make a measurement. Certainly it was not the intention of the authors, but those three paintings let me think of different ways of seeing Science. On one hand the speculative approach, of passive use of

informations transmitted by books. On the other hand the experiential



Figure 1.1.3. Astronomer by candlelight, by Gerrit Dou, 1665.

approach, of active and practical research of knowledge.

1.2. Educational needs analysis

In 2006, Michel Rocard, a member of the European Parliament and former Prime Minister of France, drawn attention on the decline in the interest of young people in science and mathematics that could lead to a decline in long-term innovation capacity of Europe and in quality of scientific research (Rocard et al., 2006). The world general trend of decreasing number of science graduates is shown in Fig. 1.2.1. This decrease is related to a forthcoming decline of innovation capacity and scientific research in Europe in the long-term.

The decreasing of interest for science among school students is a known issue and has been debated in several important documents as: "the Rose Project" (Sjøberg and Schreiner, 2010), "the Rocard

Report” (Rocard et al., 2006) and a “Critical Reflection on Science

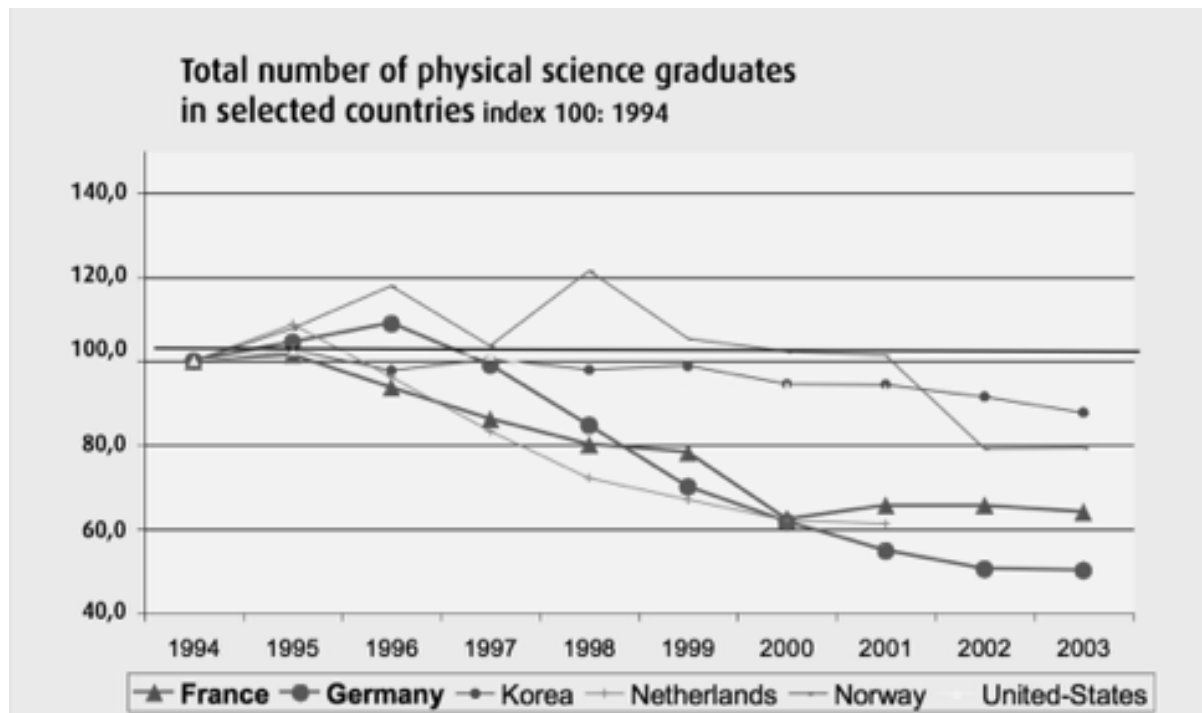


Fig.1.2.1. The decline in interest of young people in science and mathematics could lead to the decline in long-term innovation capacity of Europe and in the quality of scientific research (Rocard et al., 2007).

Education in Europe” (Osborne and Dillon, 2008.). Despite the numerous projects and actions that are being implemented to reverse this trend (Horizon 2020 strategy. Europe Commission, 2010), the signs of improvement are still modest. There is obviously a need to prepare young people for a future that will require *high scientific knowledge* and a *good understanding of technology* (Rocard, M., 2007). Europe suffers also from a cultural heritage that prefers theory to practice (Maraffi & Sacerdoti., 2017a). “Cultured Knowledge” is based on transmissive, sequential, deductive and standardized teaching, opposed to workshop activities, mainly focused on production and revenue. The misperception that intelligence was only the “rational logic” one has, channeled the awareness that culture was based on the mastery of complex theories, while the scientific and technological disciplines should only serve to support the craft activities (Maraffi & Sacerdoti., 2017a). Fig. 1.2.2 shows the percentage of students at each level of the overall scale of scientific literacy (OCSE, Database PISA 2015) The figure highlights that, compared to 2006, in 2015 there was a non-statistically significant decrease in Science literacy of 5 points. On the other hand, for Italy there is an average increase - compared to 2006 - of 5 points which, as for the OECD average, is not statistically significant. Italy is among the countries that in

2006 had a lower average than the OECD and that in the long run they did

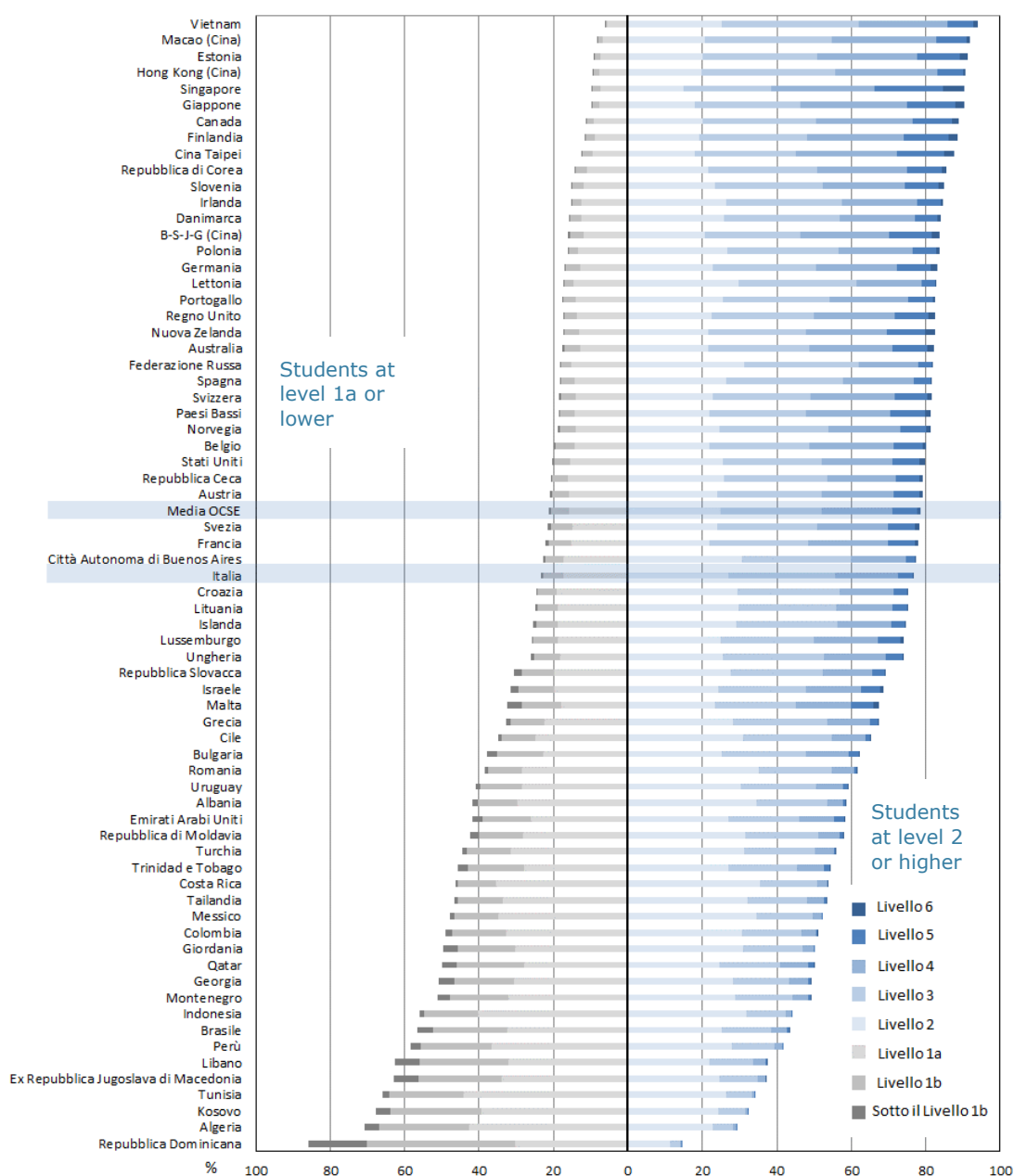


Fig.1.2.2. Percentage of students at each level of the overall scale of scientific literacy (OCSE, Database PISA 2015).

not register a significant change, even if positive. Compared to 2012, in 2015 there was a significant deterioration in Italy (-13 points), - 8 points at the middle OECD level. Italy has implemented, as a consequence, the *Scientific Degrees Plan (Piano Lauree Scientifiche, DM 976/2014)* to encourage enrollments in scientific degrees that aims not only as an orientation but also a co-design of activities with high schools.

1.3. The 2030 Agenda for Sustainable Development

European Union (EU) gives great importance to a better quality of higher education, since the knowledge and the skills of its future citizens, and hence European technology and industrial competitiveness, depend on education quality (Maraffi et al., 2017d). In analysing the needs, European Education Regulations (European Commission. The 2030 Agenda, 2015) are clear and precise in indicating the learning levels and the skills to be acquired by students in all European countries. The education guidelines, as focused by the EU Commission, are perfectly in line with the world leading educational instances (Rocard, 2007):

- *innovative teaching,*
- *information and communications technology (ICT),*
- *hands-on activities,*
- *lab activities, etc.*

The European Community has conveyed its recommendations to the national education systems (Maraffi et al., 2017d), which adopted the European guidelines in the local regulations, although not always the schools conformed to them. *"The innovative practices are driven by champion teachers, those that are willing to go one step beyond in the benefit of their students. School strategies are, in general, very exam-oriented and have to handle lots of bureaucratic work."* (Doran et al., 2016).

In the Key European actions supporting the 2030 Agenda for Sustainable Development, point n°4 states that is necessary to "Ensure inclusive and equitable quality education and promote life-long learning opportunities for all". The most important Commission's priorities contributing to this sustainable development goal have been determined as the following: jobs, growth and investment; a digital single market; a deeper and fairer economic and monetary union, a deeper and fairer internal market; a stronger global actor.

The Commission has adopted today a new and comprehensive **Skills Agenda for Europe** (European Commission. Skills Agenda for Europe, 2016). The aim is to ensure that people develop a broad set of skills from early on in life and to make the most of Europe's human capital, which will ultimately boost employability, competitiveness and growth in Europe. The 10 actions are designed to:

- improve the quality and relevance of training and other ways of acquiring skills
- make skills more visible and comparable
- improve information and understanding of trends and patterns in demands for skills and jobs (skills intelligence) to enable people make better career choices, find quality jobs and improve their life chances.

Concretely, the Commission proposes proposes 10 actions to be taken forward over the years 2016-2018, Formal education and training should equip everyone with a broad range of skills which opens doors to personal fulfilment and development, social inclusion, active citizenship and employment. These include *Science literacy*, and *foreign languages*, as well as *transversal skills* and key competences such as *digital competences*, *entrepreneurship*, *critical thinking*, *problem solving* or *learning to learn*. Early acquisition of these skills is the foundation for the development of higher, more complex skills which are needed to drive creativity and innovation (European Commission. Skills Agenda for Europe, 2016).

In particular, developing a strong digital talent pool and ensuring that individuals and the labour force in Europe are equipped with adequate *digital skills*, is highlighted as skills of primary importance. The rapid digital transformation of the economy means that almost all jobs now require some level of digital skills, as does participation in society at large. The collaborative economy is changing business models, opening up opportunities and new routes into work, demanding different skill sets, and bringing challenges such as accessing upskilling opportunities. Europe needs digitally smart people who are not only able to use but also to innovate and lead in using these technologies (European Commission. Skills Agenda for Europe, 2016).

Moreover, with regard to culture, the role of the EU is to help address common challenges in its Member States, such as the *promotion of cultural diversity*, including through education. As Party to the UNESCO 2005 Convention on the *Protection and Promotion of the Diversity of Cultural Expressions*, the EU promotes its implementation across all its policies (European Commission. The 2030 Agenda, 2015).

1.4. Teachers' needs analysis

From Horizon 2020 and from the 2030 Agenda for Sustainable Development, it is possible to derive that the globalisation in an increasingly interconnected and technological world, which requires people to have specific skills. These are the knowledge of the disciplines founding cores in an interdisciplinary key, the technical and technological skills, the mastery of foreign languages, the flexibility and the ability to reconvert, the attitude to team working, the creativity and the entrepreneurship (European Commission. 2010. *HORIZON 2020*; European Commission. 2015. *The 2030 Agenda and the Sustainable Development Goals*).

Teachers need to learn how to integrate these instances together with the innovative approaches into their classrooms. These approaches include:

- abandoning exclusive traditional lessons in favour of teaching laboratory,
- development of interdisciplinary modules and multidisciplinary approaches,
- use of CLIL (Content and Language Integrated Learning) approach,
- organisation of personalised lessons, to suit different cognitive styles, including those of students with SEN (Special Educational Needs),
- creation of situated and stimulating learning environments,

- improvement of key competences, including the basic skills in Science and basic Digital skills.

Therefore, a modern teaching approach shapes on new forms of learning: synthetic and multitasking. An innovative teaching technology combines *ICT*, traditional and new media, and social networks, where the game is a key element (Maraffi et al., 2017d). Teachers training and renovation efforts were also necessary to support the methodological change and to obtain the foreseen results (Maraffi & Sacerdoti, 2017a; Scapellato, 2014).

However, on the one hand the teachers seem to be resilient to change, on the other hand they ask for innovative yet convenient tools (Maraffi & Sacerdoti, 2018c). To achieve this goal, the key could be therefore to use the latest ICT techniques to create innovative educational products and to create new educational materials, user friendly for teachers, to effectively respond to the latest methodological guidelines and regulations.

1.5. Earth Science Education

In Italy, there is a low interest of the educational community towards Earth Sciences, as well as low interest of the Geosciences scientific community towards education (Occhipinti, 2014). The reasons for this lack of interest from both stakeholders groups are variegated, undoubtedly the cultural background of teachers, which in most cases are biologists and not geologists, but also a lack of contacts between teachers and universities. In addition, although Earth Sciences provide many interdisciplinary connections with physics, chemistry and geography, these are perceived by many teachers as non-specialistic topics of their profession.

A recent survey on geoscience teaching in the Italian high schools (Realdon et al., 2013) shows:

- poor compliance to Ministry guidelines;

- scarce use of laboratory and fieldwork activities;
- tendency to follow old teaching habits practices as well as high prevalence of theoretical teaching.

Finally, at least in Italy, the social pressure of the stakeholders (families and therefore school principals) is given to the life Sciences, as an integral part of the preliminary selective tests for admission to medicine university courses. This is in spite of the fact that Earth sciences are also taught in the last year of the high school, where they deserve time which is often taken for teaching Life sciences instead. Also regardless the fact that environmental protection is of high priority in the European programs. Moreover, Italy is a country affected by geological hazards of various types (seismic, hydrogeological and volcanic) and should instead be the leading country in the reappraisal and consideration of Earth Sciences.

To approach these problems, the Earth Sciences have been chosen as the main topic of this research activity on Science Education, even if in an interdisciplinary key, in order to stimulate the students' interest and curiosity towards this discipline and produce innovative teaching tools, that could win the teachers' reluctances and possible rejections in approaching Earth Sciences in more depth.

1.6. Learning on Gaming

The educational technology has to use the closer-to-pupils language to improve the teaching/learning process (Maraffi & Scamardella, 2016; Boniello et al., 2017). Gaming is a good vehicle for education since the acquisition of knowledge and the enhancing of skills now require more actual approaches to catch the interest of young generations (Maraffi, et al., 2017d). The use of tablets, smartphones, social networks, etc. is more comprehensible and funny for young people compared to traditional media. Educational gamification, which is the use of game elements in non-game contexts, improves learning experiences, engaging the students in a social, emotional, and cognitive level (Maraffi et al., 2016b). 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, providing content with rich combinations of texts, pictures and possibly video and audio, but with limited possibilities for effective interaction with the teacher and with other students" (Mori, 2012).

Computerised games are a formidable gym to exercise the "core capacities" involved in cognitive enhancement activities, because reaching the game objectives calls for the simultaneous and coordinated application of a large number of mental processes such as visual attention, processing visus-space, executive function, learning ability and memory, in addition to experiment with their coordinated use in the situation (Greenfield, 1995). The automatic feedback refers to the error handling strategies proposed in the game. While in school activities, the error is a potential source of frustration to be avoided at any costs, in the game it is a normal part of experience. After the error you can restart without any consequence, on the contrary, having learned something more than before (Trinchero, 2015). Also, role-playing could help students to reach their goals more easily through cooperation to acquire disciplinary and transversal skills.

1.7. Research aim

The aim of this research project is therefore the application to Earth Sciences of a learning on gaming (LoG) system and the promotion of a new Digital Game Based Learning (DGBL) approach, with the goal to create new educational games and innovative educational materials for teachers. Using a learning environment with game mechanisms will contribute to enhance engagement and acquisition of skills and to improve education outcomes. However, to obtain this goal it is necessary to test the games and verify their outcomes.

This Research Project applies the Learning on Gaming approach through an original Computer Classroom Role-Playing Game: the GeoQuest project. The main educational goal is to favoring the approach to Earth Science topics and fostering the scientific knowledge and a good understanding of technology. . GeoQuest wants to combine innovative teaching, information and communications technology (ICT), hands-on activities, labs activities.

GeoQuest is meant to be interactive, interdisciplinary and multilingual, so as to improve Science literacy, foreign languages, as well as transversal skills. The digital interactivity aims at supporting the key competences such as digital competences; the cooperative learning methodology favours entrepreneurship and critical thinking. The acquisition of knowledge takes place according to the investigative approach, so as to improve problem solving and learning to learn.

GeoQuest is based on adventure pathways organised as Digital Storytelling, through which an engaging and *situated* learning environment is created. The stories are set in different times and countries: this contributes to the promotion of cultural diversity, to the inclusion and the integration. GeoQuest is also planned to be user-friendly for teachers and designed for a personalized and inclusive education.

The research questions approached in the project aim at investigate in details the advantages and disadvantages of the GeoQuest project and can be expressed as following:

1. Could digital games foster acquisition of Science skills?
2. Could computer games be a vehicle for “in-situation” learning?
3. Could role-playing games support personalised learning?
4. Could game-based learning motivate teachers and renew their teaching styles or habits?
5. Could the GeoQuest Project play a role in improving the learning of Earth Sciences?

The purpose of this work is therefore to prove that it is possible to reconcile the needs of teachers to have user-friendly teaching materials, that do not require major adaptation, to the needs to have effective training for the students. The experimentation will allow to evaluate and prove if the GeoQuest Project can contribute positively to science education, both regarding teachers and students, guaranteeing an effective acquisition of the key competences and the disciplinary ones, as requested by the modern Science and Technology.

2. Chapter II - Background

In this chapter, at first, the educational background of the project is presented. The starting point of the research is to use digital storytelling with an innovative methodological approach, based on inquiry.

The *IBSE (Inquiry Based Science Education)* approach is analyzed, starting from Rocard methodological indications (Rocard, 2007) (par. 2.2) and the linguistic approach with CLIL (Content and Language Integrated Learning) methodology is presented (par. 2.3).

To explain the methodology used in this project, two papers, already published on these themes, are reported in their salient features. Based on these first strands of investigation, the methodology to be applied to this research has been refined and improved, compared with this first experimentation.

The contents of other papers published during the PhD have been used in the thesis although they have been summarized or, more often, dismembered. This is to avoid as much repetition on the general information as possible, inevitable in research papers, that must necessarily report the classic structure: background, methodology, experimentation and results, conclusions. When necessary, the use of the symbols “[...]” indicates where parts of the article have been removed.

2.1. Introduction

The ancient Romans had already understood that, to transmit their actions and successes to future memory and to avoid precious information to fall into oblivion, they had to record them efficiently. The Trajan column in Rome, which reports the most important events in the life and military successes of the Roman Emperor Traiano can be considered among the first effective form of storytelling, used both for propaganda and for educational purposes (Fig. 2.1.1). This tradition went on and became an established habit in the Christian churches, where the walls, decorated with frescoes and paintings of famous artists, illustrate the life of saints

and the events from the Old and New Testament with educational (in the time when few were able to read) and decorative purposes but also



Figure 2.1.1. The Reliefs of Trajan's Column by Conrad Cichorius. Plate number LXXXI: Troops entering camp (Scene CIX); Roman legionaries foraging (Scene CX).

celebrating the importance of the builders and economic supporters of the Church. Modern pedagogy rediscovered storytelling and demonstrated that, while not using technologically innovative teaching tools, storytelling enhances the effectiveness of information transmission (Parkin, 2010). Moreover, the digital application of storytelling has been demonstrated to have a positive impact especially on students' achievement. (Kotluk & Kocakaya, 2017). Why using the storytelling, or even digital storytelling, at school? Because it is an effective tool for learning: a story is more engaging and easier to remember than an explanation, but also because creating stories promotes the development of skills related to information, data literacy, communication (Piccione, 2014).

2.2. IBSE approach

IBSE, is the acronym of Inquiry-Based Science Education, or scientific education based on the investigation. The IBSE is not a single pedagogical method, but rather an approach to teaching and learning Sciences that

has key characteristics that can be implemented in various ways (Scapellato, 2014). "The objectives of education based on inquiry, require students to become more independent learners, which means that teachers develop new relationships with students, giving them the confidence to allow them to develop their own ideas" (Harlen, 2013). The centrality of teaching is not on "what we learn" but on "how we learn". The student is an active subject of his own learning. Students make direct experiences of the phenomena they are studying, usually in groups, where experiences are seen as an exercise in behavior. Through group work, students discover the benefits of mutual help, constructive confrontation, negotiation and choral success (Pennesi, 2017). Inquiry Based Science Education has proved its efficacy at both primary and secondary levels in increasing children's and students' interest and attainments levels while at the same time stimulating teacher motivation. IBSE is effective with all kinds of students from the weakest to the most capable and is fully compatible with excellence ambition (Rocard, 2007). From a depth personal experience of teaching with the IBSE approach, however, some points of weakness emerged with time: also teachers surveyed agree that the implementation of educational activities with IBSE methodology requires a massive planning stage, prolonged time and a variety of tools not always easy available. In short, while IBSE may improve the effectiveness of teaching, it often worsens the workload of teachers. This has been evidenced already by other authors (Acqua, 2018; Pennesi, 2017).

The CCRPG GeoQuest allows an IBSE experience, as adventure pathways are built according to the IBL (Inquiry Based Learning) approach. In fact, in GeoQuest students collect some data, from which, through an inquiry path (inductive), can be traced back to the more general concepts. The game leads the participants to discover the knowledge through the investigation. This educational tool has the advantage of being ready to use and easy to propose in the classroom.

In the following two publications are reported, the first describing the IBSE approach with GeoQuest Project (Maraffi et al., 2016b), and the second describing the comparison between the results obtained with the IBSE approach with the GQ game and those obtained with only hands-on activities (Maraffi et al., 2017b).

SoilQuest: an IBSE Approach with Computer Class Role Playing Game

Maraffi Sabina, Pennesi Daniela, Acqua Alessandro, Stacchiotti Lucia, Paris Eleonora
School of Science and Technology, Geology Division - University of Camerino, Italy

Abstract – SoilQuest is a class Role Playing Game to teach Earth Science in First Cycle of Education Schools. The educational technology is based on the idea of using language which is closer to pupils to improve the teaching/learning process. The game seems to be a perfect vehicle for education, even more when cooperative, since the acquisition of knowledge and enhancing skills now requires more actual approaches. The use of tablets, smartphones, social networks, etc. is more comprehensible and funny for young people compared to traditional media. The several roles allow everyone to enhance their own skills and are perfect for a full inclusion of Special Education Needs (SEN) students. One of the authors has already realized two role playing computer games called GeoQuest (Maraffi & Sacerdoti, 2016a) and GeoQuest Vesuvius (Maraffi et al., 2015) creating at the same time a Role Playing Engine (Sacerdoti & Maraffi, 2015) which involves all students to the game through their personal mobiles or tablets giving a total interaction of the whole class to the game. The outcome of the class experimentation were excellent, both for didactic and educational results obtained (Sacerdoti & Maraffi, 2015). This article is focused on our new computer class role- playing game based on soil, and specific for children 9-14 aged. Students are guided through a virtual journey from the city across agricultural fields to the woodland. In the role game progression pupils, guided by questions and simple experiments (www.earthlearningidea.com), learn the different crossed soils characteristics: urban soil, wood soil, agricultural intensive and organic farming soils. The features to be investigated are related to: the soil color, the pedogenetic structure and soil fauna (Pennesi et al., 2016). Different channels of perception will be stimulated with those activities and will be used multiple communication codes. In order to educate young people on environmental issues it is necessary to encourage diverse styles

of learning: cognitive, emotional and pragmatic one through the 3H-Head, Heart and Hands.

Keywords – Education Game, Role Play Game, Virtual Journey, 3H, Soil.

INTRODUCTION

The Computer Class Role Playing Game is a new technology designed for deeper learning of Earth Sciences, Physics, Chemistry, Environmental Sciences, improving the innovation and creative capacities of learners and supporting the new role of teacher as a coach of the learner, and it is based on new interfaces (the students use their own tablet or smartphone to interact with the game) and it is naturally a mixed reality learning environment (Fig. 2.2.2), giving to the students the feel “to be IN the

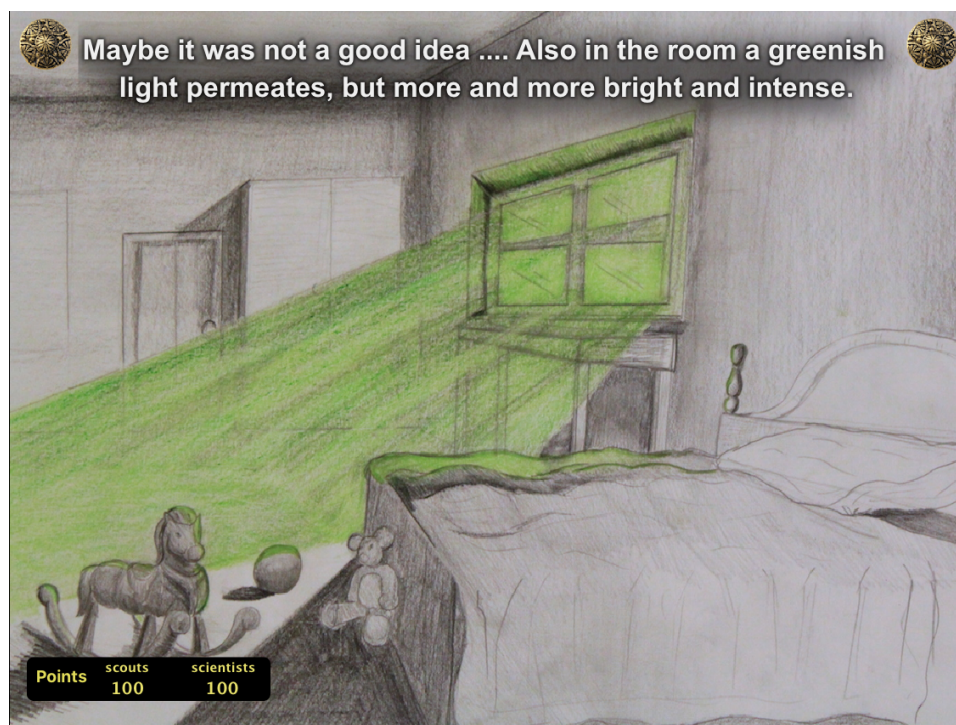


Figure 2.2.2. Game images are made to keep the student in- situation.

adventure environment” (Maraffi & Sacerdoti, 2016a). Teaching Earth Science in Italian schools is more challenging than teaching other science subjects because it meets with little interest and is perceived as marginal compared with other school subjects: processes remain substantially abstract and perceived as unconnected with reality (Venturini, 2009; Scapellato, 2014).

Priority given to initiatives that include a large diversity of practices in science teaching to respond to the diverse needs of children: problem based inquiry process; hands- on/minds-on activities (Fig. 2.2.3); team-work; independent work on open-ended questions; trans-disciplinary activities; showing relevance of science content (Rocard, 2007).

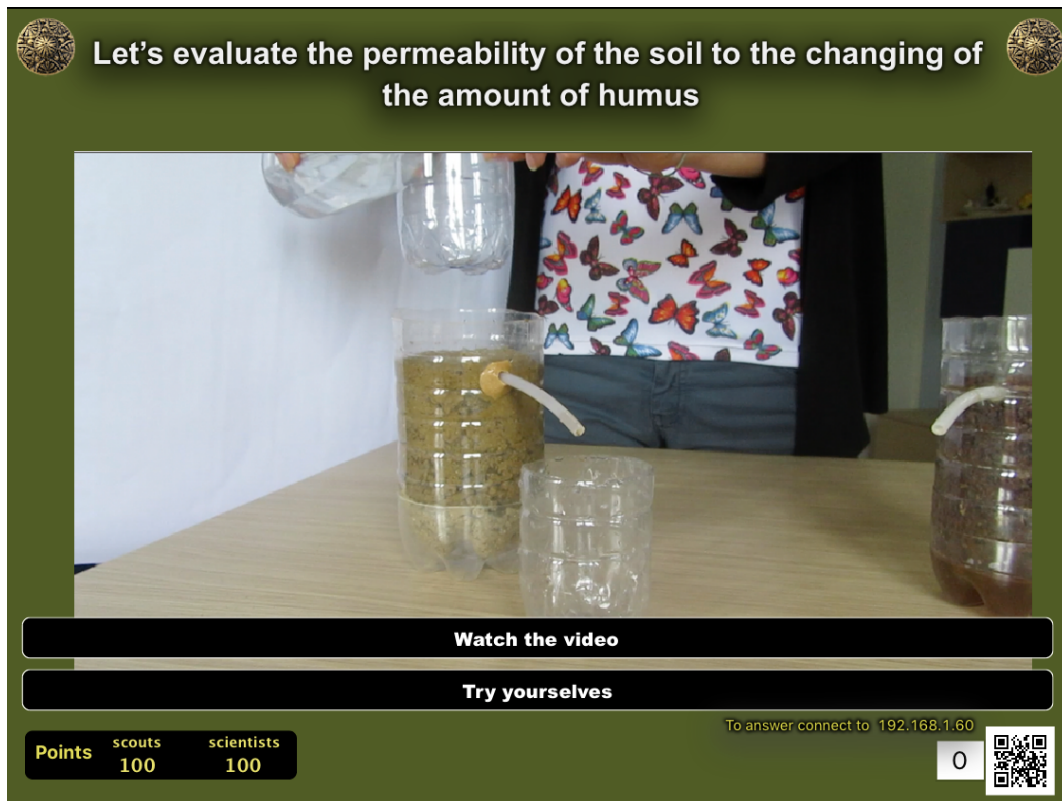


Figure 2.2.3. It's possible to watch the videos or to do hands on activities.

METHODOLOGY

Inquiry Based Science Education (IBSE) has proved its efficacy at both primary and secondary levels in increasing children's and students' interest and attainments levels while at the same time stimulating teacher motivation. IBSE is effective with all kinds of students from the weakest to the most able and is fully compatible with the ambition of excellence. Moreover IBSE is beneficial to promoting girls' interest and participation in science activities. Finally, IBSE and traditional deductive approaches are not mutually exclusive and they should be combined in any science classroom to accommodate different mindsets and age-group preferences (Rocard, 2007). In obligatory school levels, like in the long life learning, the game is an essential element and activity for the development of

everybody's personality, especially in the perspective of learning to learn (Key Skills). Learning to learn is recognized as a meta-skill which evolves with the student and becomes the thread that guides him to a successful assumption of responsibility for its own learning process. The most effective mode of realization of metacognitive teaching, it seems to be the self-regulating approach, in which students are helped in the process of recognition of the skills necessary for learning tasks and they are encouraged for the choice and for the most productive application of appropriate learning strategies (Maraffi et al., 2016a).

Our goal is to create an innovative methodology (Maraffi et al., 2015) based on the game, that enhances the interdisciplinarity, the informations retrieving and their decoding, for all levels of school. In the obligatory school levels, like in the long life learning, the game is an essential element and activity for the development of everybody's personality, especially in the perspective of learning to learn (Key Skills) (Maraffi et al., 2016a).

A. The Game

The participants live a graphic adventure in which they face several choices of different paths with different opportunities. Furthermore, often the students must solve questions or quests to go on. In role-playing games, players do not know where they are and the map of the location where they virtually move. Everything is revealed as players proceed: different choices create a new original game experience. Through a path choice or as output of some questions, the players change the experience. The students interact with the system using their own smart phones and tablets with a new technology (Sacerdoti & Maraffi, 2015) which collects the individual answers.

At the same time the system calculates the overall response according to the criterion of the majority: the ultimate responsibility for the next game step is therefore collective and class dependent. Given the age range of pupils, whose capacity for abstraction is not yet fully developed, the practical proposals in video activities facilitate learning through sensorial experience.

The added value of this game is in fact represented by such activities that are easily replicable in class with poor materials. Experiences have as

their ultimate goal to achieve predetermined educational goals: to understand that soil is a limited resource and as such it must be preserved. Experiments relate to permeability, layering and plasticity of the soil and the presence of air in its interior. Through questions of the game differences between urban soil, wood soil, agricultural intensive and organic farming soils are emphasized.

[...]

SOIL IS A RESOURCE: THREE TEACHING METHODS TO ACHIEVE ONE TARGET

Sabina Maraffi¹, Daniela Pennesi¹, Alessandro Acqua¹, Lucia Stacchiotti¹, Eleonora Paris²

¹School of Science and Technology, Geology Division, University of Camerino, Italy

²Geology Division, University of Camerino, Italy

The soil is usually little faced in Italian schools. From our previous experience as teachers we realized that soil is a resource usually taken for granted by students but it is actually limited and always in danger. The aim of this work is to figure out among three teaching methods which one lets pupils (10-11 years old) understand the most how important soil is, "it is a precious good and it is source of life for the living beings" (European paper of the Soils 1972). Moreover studying of Soil requires to enter in many details subtopics and it also allows many interdisciplinary connections, e.g. in biology, in chemistry; environmental education (the soil is a limited resource), nutrition. This case study was carried out in collaboration with some classes of the Marche Region and Campania Region (Italy). We compare three various educational approaches and the proposed contents are the same for all three teaching methods. Findings showed each approach has its strengths and weaknesses and all three are effective to let pupils understand Soil as a non-renewable resources, at least this is true for pupils in this age group.

Keywords: Educational Games, Teaching Approaches Comparing, Soil

INTRODUCTION

In 1997 the skills has been defined by the Organization for Cooperation and Economic Development (OECD) as "the ability to meet complex demands in a particular context activating psychosocial prerequisites (including cognitive and non-cognitive)". On this perspective "to get a skill not only means to have the resources that form it, but also to be able to properly activate and orchestrate them, at the right time, in a complex situation" (Richer & Salganik, 2007). This task presupposes a sequential development, from the proposal to the product, the introduction of necessary knowledges, of techniques and materials, the

organization of the working set, the definition of product and training results, the selection of the strategies to be adopted and relevant information, the heuristic error handling (Maraffi & Marinelli, 2016).

The aim of this work is to compare three various educational approaches: traditional lesson, cooperative laboratory and computer classroom role playing game. This comparison has been done to show which approach could help students to acquire disciplinary and transversal skills more easily. Further during the structuring of each approach attention has been set to the inclusiveness: traditional lesson ensured inclusiveness through drawing and images, Cooperative Laboratory through hands-on activities and SoilQuest provided it through multi-language tools.

On one hand Soil was chosen as topic because Marche is a rural region and in the last fifty years mechanization of the agriculture and the use of pesticide led to a loss of natural principles that regulated the proper management of soil and its protection (<http://suoli.regione.marche.it/>). On the other hand it was chosen because in Campania region there is an excessive urban concreting and a serious issue of soil pollution in Terra dei Fuochi (Giordano & Chiariello, 2015).

DESCRIPTION

Three teaching methods (traditional lesson, cooperative laboratory and role playing game) are used to show the same topic and notions simultaneously in parallel classes. The activities of the Cooperative Laboratory are the same as those carried out with the game and those shown in the SoilQuest videos. Six classes (three in Marche and three in Campania) were involved in the trial for a total of about 120 pupils. All three approaches were carried on in two hours. To assess efficacy of each activity the same individual pre-test and post- test were administered before and after each intervening.

Traditional lesson

Traditional lesson was performed using multi-media blackboard (MIB). On MIB Power-point file was displayed. Following it one of the authors, as teacher, explained what soil is, its structure and functions, soil

constituents and why soil is a non-renewable resource. Features of conventional and organic farming were also mentioned. During the lesson pupils were involved not only in watching FAO's videos for International year of Soil (<http://www.fao.org/soils-2015/en/>) but also in doing dictation and drawing. Pupils could also ask questions and elucidations about terms and words they did not know or understand; in this process teacher fostered peer-to-peer confrontation in order to reach scientifically correct and shared definitions. Further videos and slides about air presence in soil, permeability of soil and soil-dwelling were shown and explained. Every child worked on his own (Fig. 2.2.4).



Fig. 2.2.4. Traditional lesson Fig. 2.2.5 Computer game Fig. 2.2.6 Cooperative laboratory

SoilQuest: a Computer Class Role Playing Game

The educational technology uses closeness to pupils language to improve the teaching/learning process. Changing in Education is important because of changing in communication codes which passed from analogic and sequential world to digital and simultaneous one. Students are nowadays digital native, they grew up with computer Games instead of fairy tales. The game is a good vehicle for education since the acquisition of knowledge and enhancing of skills now requires more actual approaches. In fact Education goals are skills instead of knowledges, because in a progressive changing world people needs Learning to Learn, for Longlife Learning. Then teachers have to put students in situated learning, which reproduces reality with all its own facets. Game could be good to get situated learning in interdisciplinary and multi-languages way. Computer games reproduce virtual world with real images, as photos or videos, put players in situation through sound effects, and engage students through storytelling. Furthermore the use of tablets, smartphones, social networks, etc. is more comprehensible and funny for young people compared to traditional media. Further SoilQuest is designed

user friendly: it is multilanguage for using by foreigners students, it uses simplified language for best integrating Italian L2 speakers and it includes different communication channels (visual, audio, simplified ppt notes) for best inclusion of students with disabilities. In SoilQuest (Maraffi et al., 2016b) participants live a graphic adventure in which they face several choices of several paths with various opportunities. Students must solve questions or quests to go on through viewing the same experiences performed in cooperative laboratory. The players interact with the system using their own smartphones and tablets with a new technology which collects the individual answers (Fig. 2.2.5). At the same time the system calculates the overall response according to the criterion of the majority. Given the age range of pupils, whose capacity for abstraction is not yet fully developed, the practical proposals in video activities facilitated learning through sensorial experience. Through questions of the game differences between urban soil, wood soil, agricultural intensive and organic farming soils were emphasized. The adventure path was targeted on 10-11 aged pupils. Storytelling was centered on a little boy who goes to meet a friend of him, passing through different kinds of soils and some pictures were drawn with children style. Pupils could watch lab videos or make their own experiments in their classroom to understand differences between urban soil and farming soil. Then they could realize differences between soils with less or more anthropic transformations.

Cooperative laboratory

Cooperative laboratory path was organized considering the pedagogical and didactic aspects based on active and cooperative learning. The main purpose is to touch and observe what students commonly trample. Each experiment is easily replicable in class with poor materials. Pupils worked in group and performed experiments about air presence in soil, different permeability and color between different kind of soils (more or less rich in humus), soil components and differences between traditional farming and organic one (Fig. 2.2.6). Experiments were the same that were shown on role playing game only on as video (Figs. 2.2.7; 2.2.8; 2.2.9). The following table shows in detail various laboratory activities made with pupils (Table 2.2.1).

Table 2.2.1. Cooperative Laboratory Activities

TITLE	MATERIALS	DESCRIPTION	SPECIFIC AIM
"Ingredients of Soil"	Cardboard cut out in distinct circular sectors.	1.Match paper-slices with percentages of soil components 2. Reconstruction of the "Soil-cake" consisting of four different circular sectors; each one represents a various soil components.	1. To correlate angular width with percentages. 2. To let pupil know soil composition.
"Does Soil breathe?" (Fig. 3.4.10.)	-Transparent plastic glass - Water - Soil sample	Pour water into a full glass of Soil and observe bubbles that are produced on the surface by air-water switch.	To make pupils understand air is a soil component.
Soil color	- A rich in humus soil sample and a poor in humus one.	Observe two different soil samples.	To understand how much humus could change soil color.
Soil permeability (Fig. 3.4.11, Pennesi, D., 2017 PhD thesis)	-Two cut transparent plastic bottles. Each bottle has a hole and a pipe in its upper part. -A small pipe - A becker -Clayey soil (Sample a) -Soil (Sample b) -100 ml of water for each sample.	Put soil sample a in bottle 1 and soil sample b in bottle 2. Pour the same amount of water on two samples. Unabsorbed water will leak out of the pipe. Measure the amount of unabsorbed water using a graduated becker.	1. To acquire the concept of Soil permeability. 2. To understand which is the principal component influencing soil permeability.
Soil ability to retain water (Fig. 3.4.12)	-330 g rich in humus Soil (organic Soil) -330 g poor in humus Soil -Two cut transparent plastic bottles (1.5 l). Each bottle has holes in its bottom. -Two cut plastic bottom bottles. -Graduated cylinder. - A becker -100 ml of water for each sample.	Put soil sample 1 in bottle 1 and soil sample 2 in bottle 2. Pour water on each Soil sample. Measure collected water in bottles bottom. Do subtraction between poured and collected water.	1.To learn the importance of organic matter in soil ability to retain water. 2.To understand the consequences of two different kind of farming: traditional and organic.

RESULTS AND DISCUSSION

Findings highlight not only general remarks but also strengths and weaknesses of each approach as shown in Table 2.1.2.

Table 2.1.2. Strengths and weaknesses of three used approaches

	TRADITIONAL LESSON	COMPUTER ROLE PLAYING GAME	COOPERATIVE LAB
Strengths	Drawing Use of Ppt	Pupil's engage	Cooperative learning Hands-on experiences
Weaknesses	Individual activities	More focus on game than on content	Organization difficulties in the groups

Overall students demonstrated a high level of concentration in their activity, but also an emotional involvement. Moreover the study of the environment and the territory contributes to increase the awareness of the planet as a complex and fragile system. All three approaches gave the chance to correlate themselves with environmental education (which is a new requirement in Italian curriculum at school, Indicazioni Nazionali, 2012). The global comparison between pre-tests and post-tests was useful to emphasize the effectiveness of the chosen topic. Furthermore students' awareness that soil is a non-renewable resource shifts from 32,4% to 81,1% (Figs. 2.2.10 and 2.2.11).

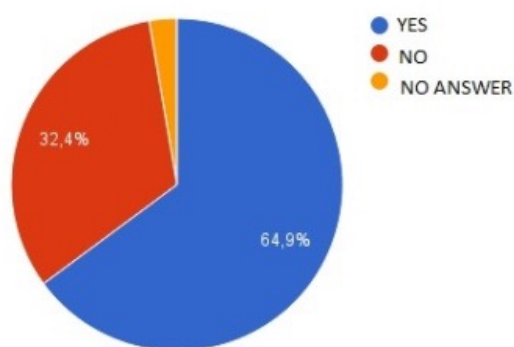


Figure 2.2.10. Answers before the activities about "Soil is a renewable resource".

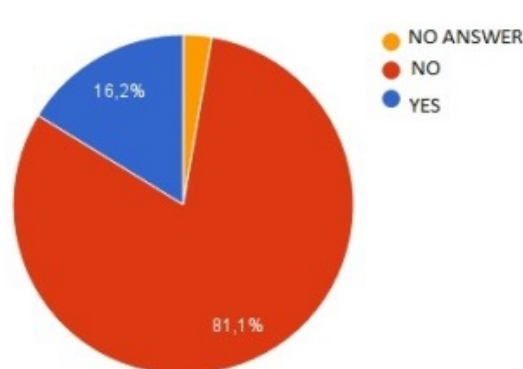


Figure 2.2.11. Answers after the activities about "Soil is a renewable resource".



Figure 2.2.7. Soil breath



a)



b)

Figure 2.2.8. Water draining depends on different amount of clay: a) rich in clay Soil water flows on surface; b) poor in clay Soil water is retained and collected in the bottom.



Figure 2.2.9. Organic Soil retains water

Traditional lesson

During the lesson pupils were particularly involved in viewing videos, in asking questions and looking for answers, in dictation and drawing. These activities contribute to stimulate active learning and to enhance students' motivation, increasing knowledge and competences. Students with learning difficulties or less prone to attention in the classroom found difficulties during the explanation of notions and specific language. However peer-to-peer discussion promoted a best understanding of the most complex parts of the topic for every student. Anyway, as far as we know this approach is effective to let pupils understand Soil as a nonrenewable resource.

Computer Class Role Playing Game

The Game is meant as a teaching tool is a situation-learning mode that requires the student to mobilize its resources to find solutions that require skills rather than simple knowledge (Maraffi & Sacerdoti, 2016a). Students are asked to recover their previous knowledge, there is an encouragement of the use of complex cognitive processes (reasoning, transfer, critical thinking, creative thinking) (Maraffi & Marinelli, 2016), learning into meaningful and real contexts, stimulation of students' interest and enhancement of students' abilities. In children aged 10 to 11 years SoilQuest proved to be a great tool of engage, to introduce the topic and capture students' interest. Experimental results are comparable with cooperative laboratory ones, since active teaching is good for engaging and fruitful Learning. Students showed much appreciation for interactivity: the chance of changing adventure's path, score growth and immediate answer feedbacks, kept attention alive for the whole activity.

Cooperative Laboratory

Active handling water, soil and mulch was the most involving phase in cooperative laboratory. Since some students were not use to work in groups some organization difficulties were detected such as timeliness and division of tasks within the group. Nevertheless cooperative laboratory contributes to stimulate active learning and to enhance students' motivation, increasing knowledge and competences.

CONCLUSION

It is important to point out that the chosen topic revealed to be of large interest in the schools. It is a transversal topic, suitable for all ages, even if we wanted to concentrate on the 10-11 aged group, because we think that environmental education early awareness is important. In fact, each approach has made great contribution to remove misconceptions about Soil, regardless of the kind of approach (Traditional lesson, Game Role Playing or Cooperative Laboratory). From the comparison among three teaching approaches we can see that approaches including real or

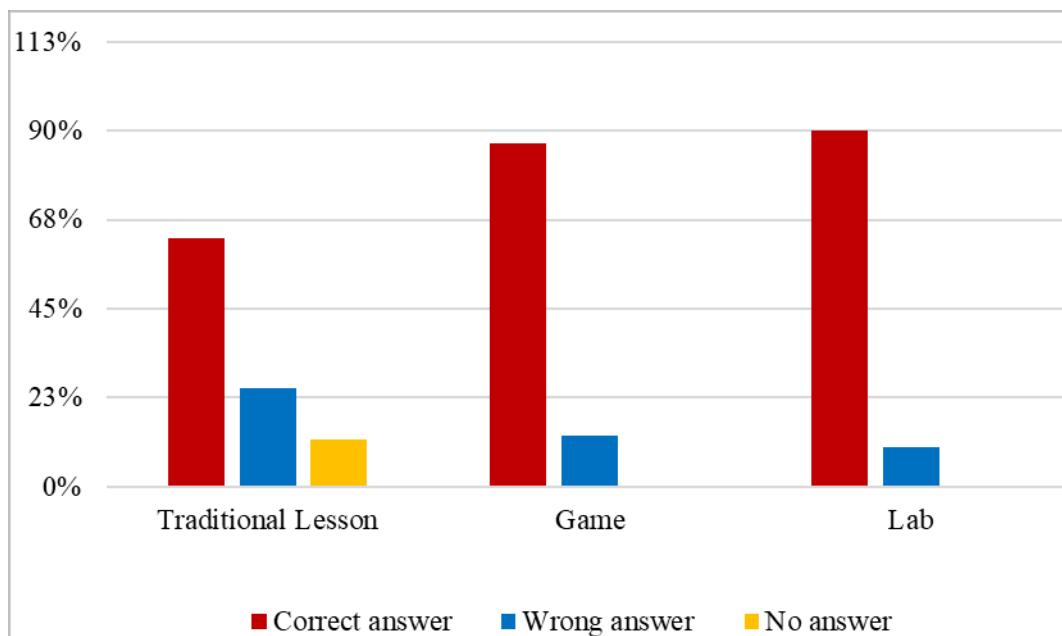


Figure 2.2.12. Compared outputs of three approaches.

virtual lab activities keep pupils interested and involved much longer (Fig. 2.2.12). They also contribute to achieve, rather than simple notions and knowledge, key-competences of citizenship (Recommendation 2006/962/EC on key competences for lifelong learning): Science and Technology skills (Soil features, lab and digital skills) and Social and Civic responsibility (environmental education and awareness of the anthropic alteration on the environment). Above all the acquisition of these competences is important considering the context of the schools that participated in the experimentation (Marche and Campania). Our future

goal will be to improve teaching actions to further increase awareness in tomorrow's citizens.

2.3. CLIL approach

CLIL (Content and Language Integrated Learning) is an immersive educational approach that aims to build language skills and communication skills in a foreign language together with the development and acquisition of disciplinary knowledge. The CLIL methodology has spread widespread in Europe, as evidenced by the Eurydice Keydata Report on Languages at school in Europe (2012) and the European Commission Recommendation Rethinking Education (2012), in which foreign language proficiency is defined as a key dimension for the modernization of European education systems and the CLIL methodology is represented as the engine of the renewal and improvement of school curricula. On March 25, 2017 the European leaders reiterated the goal of a Union where young people receive the best education and training and can study and find jobs across the continent (Declaration of the leaders of 27 member states and of the European Council, the European Parliament and the European Commission). Five scenarios were outlined for Europe by 2025 (White Paper, 2017). Within them, "as language is at the root of all learning, there can be no quality education without quality language and intercultural education. All teachers, at all levels, whatever subject they teach, have an important part to play in building their learners' linguistic and intercultural repertoires" (Languages at the heart of learning, Programme 2016-2019 of European Centre for the Modern Languages of the council of Europe). The planned projects are listed in the following.

I. *Digital literacy for the teaching and learning of languages*: "digital technology is still underused when it comes to language teaching and learning. This situation often arises from a lack of training. The GeoQuest project aims to address this teacher training need by providing the basis for a teaching methodology which integrates new technologies".

II. *Learning environments where modern languages flourish*: "by fostering learning environments where modern languages flourish, GeoQuest project aims to place languages right at the heart of developments in education policy. Through languages, it seeks to

strengthen the development of both social competences and competences for democratic citizenship. A network of project partner schools will support each other in developing innovative approaches to establishing language friendly learning environments through an exchange of relevant resources, research and practice”.

Already with the Paris Declaration – adopted at the Informal Meeting of the EU Education Ministers in Paris on 17 March 2015, European leaders wanted to boost EU-level cooperation on four overarching priorities:

A. Ensuring young people acquire social, civic and intercultural competences, by promoting democratic values and fundamental rights, social inclusion and non-discrimination, as well as active citizenship

B. Enhancing critical thinking and media literacy, particularly in the use of the Internet and social media, so as to develop resistance to of discrimination and indoctrination

C. Fostering the education of disadvantaged children and young people, by ensuring that our education and training systems address their needs

D. Promoting intercultural dialogue through all forms of learning in cooperation with other relevant policies and stakeholders. (Eurydice, 2016).

As part of its efforts to promote mobility and intercultural understanding, the EU has designated language learning as an important priority, and funds numerous programs and projects in this area. Multilingualism, in the EU’s view, is an important element in Europe’s competitiveness. One of the objectives of the EU’s language policy is therefore that every European citizen should master two other languages in addition to their mother tongue. Foreign language competence is regarded as one of the basic skills that all EU citizens need to acquire in order to improve their educational and employment opportunities. The EU therefore supports the idea that every citizen should master two foreign languages in addition to his or her mother tongue (COM(2008) 0566). (Franke & Mennella, 2017). Content and Language Integrated Learning (CLIL) refers to educational approaches that allow for improved foreign

language learning in combination with content learning in a variety of (non-language) subjects, e.g. Geography, History, Sports, Maths. CLIL strongly relates to other contextualized language teaching approaches such as immersion education or content-based language teaching. In CLIL situations, attention is shifted from 'the student must know that ...' to a focus on skills such as (thinking skills):

- processing and information skills: classify, select, sort, compare, analyze;
- reasoning skills: provide reasons for opinions, decisions, conclusions; use language in a precise way to explain one's own thought;
- research skills: ask (ask) relevant questions; pose (ask) and define problems; to suppose; plan what to do; link cause and effect; predict outcomes; anticipate consequences; find and test conclusions; improve your ideas;
- creative cognitive skills: generate ideas and apply imagination to search for alternative questions;
- evaluation skills: evaluating information and elaborating criteria to judge one's own and others' ideas (Coonan, 2006).

Despite having tested all the GeoQuest Project adventure pathways also in a foreign language, a work specifically dedicated to the CLIL approach is reported here in which the CLIL teaching methodologies and their implementation in the GeoQuest project are analyzed (Maraffi et al., 2017c). The game is called CrimeQuest and it is a highly interdisciplinary game, where the aspects of CLIL are used and have been experimented in several environments.



CrimeQuest, a CLIL approach of "Learning on Gaming" to improve Science Education and Language Learning

Sabina Maraffi - School of Science and Technology, Geology Division, University of Camerino, Italy

Francesco Maria Sacerdoti - e-voluzione s.r.l., Italy

Immacolata Ercolino - School of Bioscience and Veterinary Medicine, University of Camerino, Italy

Abstract

This work focuses on Science teaching in high school using the Content and Language Integrated Learning (CLIL) approach. Students need to be educated as science active citizens so that to be able to close the skills gap between science literacy and societal requirements. In fact it is important to combat misconceptions in order to face challenges that daily involve society and request skills and knowledge in science. Teachers need new insights to foster youngsters learning and to enhance digital literacy and competences and need to update them continuously. The authors have realized a role playing computer game called Crime Quest with a specific Role Playing Engine, which involves all students into the adventure through their personal mobiles or tablets, with a complete interaction of the whole class with the game. The students interact with the system using their own smartphones and tablets with a new technology, which collects the individual answers. At the same time the system calculates the overall response according to the criterion of majority voting. The game works without Internet and is realized with a specific software engine that interprets a text file as the adventure plot, with text-to speech multi-language voices. Learning on gaming through our Computer Class Role Playing Game is a way to realize "authentic learning": it lets students feel themselves on a Crime Scene, involving them in their own learning. In this way foreign language becomes a vehicular tool to discover new topics and their specific glossary: it is a CLIL approach, in which the not language subject is taught through a foreign language.

Keywords: Learning on Gaming, CLIL, Science Education, Forensic Science, CALL.

[...]

Methodology

We created an innovative methodology based on the game, that enhances the interdisciplinarity, the information retrieving and decoding, for all school levels. The Computer Class Role Playing Game (Fig. 2.3.1) is a new technology designed for deeper learning of Biology, Earth Sciences, Chemistry, Environmental Sciences, by improving the innovation and creative capacities of learners and by supporting the new role of teacher as a learner's coach.



Figure 2.3.1. Screenshot of CrimeQuest in classroom.

Our game uses EVO-RPGE (Role Playing Game Engine), a new engine (Sacerdoti & Maraffi, 2015) developed to easily build interactive role-playing games, which involve all students who participate in the game through their own mobile or tablet (Fig. 2.3.2), giving a global interaction of the class within the game. The game can be followed by the whole class with a IWB (Interactive White Board) or a projector. The game can be played in a laboratory to accomplish one or more hands-on activities or in a classroom simulating a workshop activity.

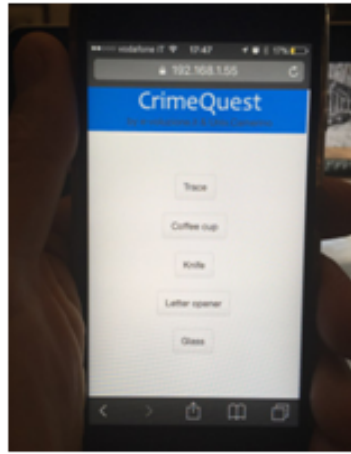


Figure 2.3.2. Screenshot of CrimeQuest interface on the smartphone.

Texts are spoken by a high quality synthesized computer voice in several different languages, so it is perfect for CLIL compliance. Teachers can create their own "adventure" writing a text file enriched with texts, image names, questions, jumps, fostering students' curiosity in their learning etc. The system is multi-language allowing different text files one for each idiom. In CrimeQuest we take advantage of storytelling (Fig. 2.3.3), which is a powerful tool to foster students' curiosity and to



Figure 2.3.3. Screenshot of the Crime Scene.

improve learning. Our game is interactive: we bring all the participants (or our students in a class) on a virtual crime scene in a lab. In the story, a researcher is found dead in a research lab: was it an accident or a suicide or a murder? "Who killed Prof. Maya Foster?". The students must solve forensic logic problems and they are involved in many hands-on activities

with “poor materials”: DNA profiling, digital fingerprints, hair comparison, analysis of sticky soil on killer’s shoes (players will compare different kinds of soil with an Earth Science hands-on Lab) and Luminol test on the crime scene. Students collect all the clues and the bodies of evidence on the Crime Scene and can have free access to materials that they found along the way, including original texts created on purpose, as a note-book about Biotechnology. Materials consultation is easy and immediate, since they are realized as synthetic PowerPoint presentations or PDF files rich of icons and pictures (Ercolino et al., 2016). Students can check their personal score, related to their role in the game, on their devices. In fact, players can choose a different “role” in the game: scientist or journalist. The system gives distinct scores to each group based on the “weight” each question has for the different roles played by participants. The progression of the game can be followed by students with different levels of knowledge and skills using the note-book as compensatory measure. The iconographic contributions, the use of different communication codes (visual and auditory) and the structuring of the questions are ideal for a personalized teaching, even in the case of Special Education Needs.

Conclusions

We presented CrimeQuest at Science on Stage festival 2017 and tested it with some high school classes: at present we are analyzing the experimentation results. The observation in the classrooms during the game gave very good results: students were interested and participated for the entire duration of the activity. In fact, the game is an activity aimed at promoting the development of everybody’s personality, especially in the perspective of learning to learn (Key Skills) (Maraffi & Sacerdoti, 2017a). We observed that CrimeQuest Game really engaged students in their learning.

2.4. Conclusions

On the basis of the experience gained with the experimentation reported in the previous papers, it was decided, for example, to refine the methodology of the CCRPG by investigating how to increase the laboratory contributions and the hands-on activities connected with the game.

Moreover, the effectiveness found with the CLIL approach pushed to make each adventure path in several languages and to deepen another line of research: the linguistic simplification in the foreign language approach, as it will be illustrated in Chapter 5.

3. Chapter III - Methodology

In this chapter it is described the CCRPG methodology, based on an original Engine, made specifically for this project, as reported in paragraph 3.1. Then the description of the Game is presented, from a technical and didactic point of view (par. 3.2 and 3.3) and to the illustration of the GeoQuest project (par. 3.4), also through the analysis of one of the adventure trails created. This chapter also contains some extracts from published papers, to highlight some of the most significant aspects of research: the STEM and STEAM approach, to support the scientific subjects' learning in an interdisciplinary key, and the innovative character of the CCRPG. The aspects of this innovative methodology to approach the topics of authentic evaluation and the special education needs, are reported in par 3.7. Final comments regarding this chapter are reported in par 3.8.

In the chapter, parts of several papers already published are used to illustrate the characteristics of the method and the possibilities offered to approach the themes presented. When necessary, the use of the symbols "[...]" indicates where parts of the article have been removed, to avoid redundancy.

3.1. The Engine

Vygotsky (1978) believed that learning occurred within a learner's Zone of Proximal Development (ZPD). From the activities, a learner can independently master to those challenges, which can be accomplished with the help of additional supports. Offering activities inside the players' ZPD will create a more appropriate challenge to their skill level than keeping them maximally engaged and in learning (Hamari et al., 2016). Problems that require the exercise of content and skills covered at school, presented as a game may be stimulants and not frustrating due to the controlled difficulties, and it may promote cognitive functions about targeted content: a key element for the enhancement of learning (Greenfield & Carbone, 1985). The difference between the narratives found in digital games and those found in other media, such as books and

movies, changes the level of engagement. In books and videos, the person is engaged in the narrative although as a passive consumer and has no impact on the outcome of the narrative. On the other hand, an illusion is created whereby the players of a game perceive themselves as constructing the narrative of that game (Cohen, 2016) enhancing the engage level and effectiveness.

The EVO-RPGE is the engine created for the use of the digital games (Sacerdoti & Maraffi, 2015) to easily build interactive role-playing games: it allows to involve all the students of a class to participate to the game through their personal mobile or tablet (Sacerdoti & Pagliara, 2013) giving a total interaction of the whole class to the game (Maraffi et al., 2015) (Fig 3.1.1).



Figure 3.1.1. Students of a class to participate to the game through their personal mobile or tablet.

The teachers can create their own "adventure" by writing a text file with texts, images, names, questions, different levels and jump possibilities, etc. The system is multi-language, allowing different text files, one for each idiom. The system has also a translation help module. The role playing games are based on a "class" subdivision in roles. The students, for example, can be divided into physicist, chemists, disseminators, technicians, historians, etc. to highlight the topics from many points of view and the personal responsibility related to the choices made during the game, as well as emphasizing the importance of cooperation to achieve results.

During the game, the students have to answer questions and pass some tests in teamwork. The tests allow assessment and represent the main sharing/disclosure of the next levels of the game. The levels allow to modulate the activities according to a single lesson, teaching unit, module.

Features

1. The system allows students to participate all together to the game as an active group, providing real-time feedbacks and evaluations.
2. Role-playing helps students to reach their goals easily through cooperation; this in order to avoid the risk of loneliness of Inquiry Based Science Education, preserving entirely the educational value.
3. The system can be easily adapted to different scenarios and it is multi-language in order to be adopted all over the world.
4. Science Research now is based on field expert interaction: the role-playing game categories allow the students, by impersonating a professional figure, to impersonate the personage and better achieve the team goal.
5. The game features are also ideal for a personalized teaching to be used as compensatory measures for a full inclusion of Special Education Needs (SEN) students, saving the cooperative learning.

3.2. The Game

The EVO-RPGE engine supports the digital classroom game: in particular the Computer Classroom Role Playing Game (CCRPG). GeoQuest was the prototype, with a focus on Vesuvius, as described in the paper presented at the *New Perspectives in Science Education Conference* (Maraffi & Scamardella, 2016). In the following there is a brief excerpt.



GeoQuest Vesuvius an Interdisciplinary Role Playing Game

Sabina Maraffi*

Alessandra Scamardella**

*School of Science and Technology, Geology division - University of Camerino
Via Gentile III da Varano, Camerino 62032, Italy

sabina.maraffi@unicam.it

**LS G.Galilei, Napoli - Italy

ale.scamardella@alice.it

[...] GeoQuest Vesuvius is a class interactive role-playing computer game which goal is to teach Earth Science. The participants live a graphic adventure (Fig. 3.2.1) in which they face several choices of different paths



Figure 3.2.1. Class role playing game.

with different opportunities. Furthermore, often the students must solve questions or quests to go on. In role-playing games, players do not know where they are and the map of the location where they virtually move. Everything is revealed as players proceed: different choices create a new original game experience. Through a path choice or as output of some questions, the players change the experience. In our game the players-

students of a class meet some mythological and historical figures along the way. They tell their story introducing the player in an atmosphere of mystery and dramas. Myths and stories belong to the place and time in which the game is set, and these are correlated to the path the players will reconstruct. While the path is revealed through the stories told by mythological characters, players proceed and find some clues to discover the final event. The clues are based on scientific evidence, with topics and questions based on mineralogy, volcanology, geodynamics, history and mythology.

The adventure begins in a dark forest. There are no clues to understand where the students are and so they are now screened in a mystery story and they have to decide how to proceed. Players follow rough paths through the Valley of Hell, slopes of a volcano; face the pitfalls of scoriaceous lava flows, meet characters of fantasy, as Amelia, the enemy of Scrooge.

This game story is set at Mt. Somma-Vesuvius volcano. The environment that gradually reveals itself to the players is full of significant elements that can be traced back to a volcanic site, inserted in a complex geodynamic situation. The volcano is located in the Mediterranean area, in Campania region, where there have been compressive and divergent geological events, which produced differentiated magmas and explosive volcanism. During their trip the students approach these topics and have to answer some questions to proceed. Players may discover where they are also from the stories of the characters as told during the path.

The Questions

The questions are in the form of multiple choice, so players can proceed even without detailed knowledge of the matter. In this way the game facilitates the participation of all the students and avoid feelings of frustration related to the lack of prerequisites.

Players respond individually with their smartphones or tablets, but the system (Maraffi & Sacerdoti, 2015) proceeds according to the criterion of the majority, to demonstrate the collective responsibility. At the same time each player can evaluate his/her own results, regardless of the decision of the majority. If the response of the majority is not correct, the system displays the error and the right answer, but still continues in the

path, to avoid breaking the rhythm of the game and the students' attention.

During the game, both scientific and humanistic questions are asked, to enhance the interdisciplinarity of the activity and the attention of the students, also those less prone to geoscience topics. As an example of scientific topics, the questions of mineralogy are enriched with photos taken in the most important mineralogical museums in the world, so students can appreciate the shape, the crystal habit, the color of the mineral. A good knowledge of the classification of minerals allows players to be able to distinguish the mineralogical association and then go back to the rock they have been presented to recognize it.

Game features

Students have free access to the materials they found along the way, including texts created on purpose, for example as notes about mineralogy, petrography and volcanology (Fig. 3.2.2). Their consultation is

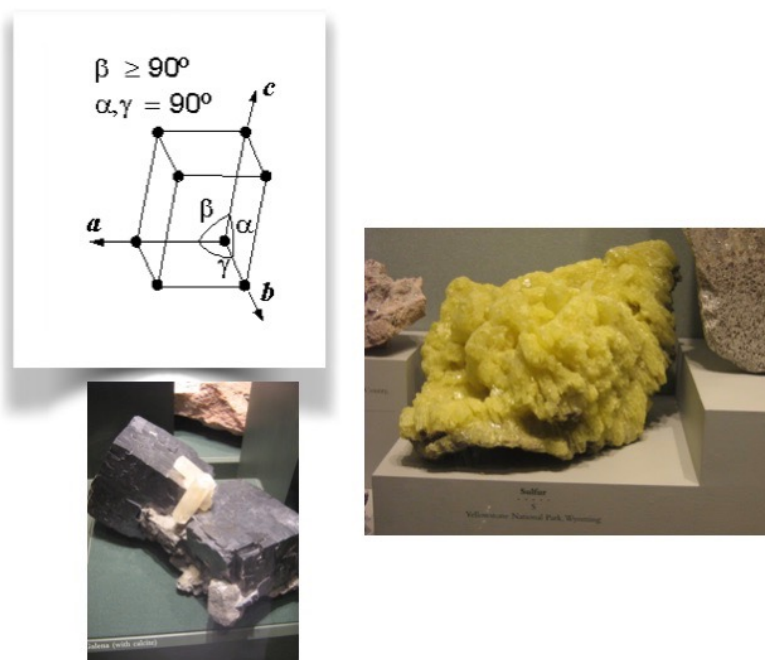


Figure 3.2.2. Minerals and Crystal Lattice.

easy and immediate since they are realized as synthetic Power Point presentations or PDF files full of icons and pictures (Maraffi et al., 2015). The mineralogy and petrography notebook contains an atlas on the physical and chemical properties of minerals. For example, each crystal

system is described in its basic characteristics and complemented by images of typical minerals. Texts are spoken by an high quality synthesized computer voice in several different languages, so the activity is perfect for CLIL compliance.

Sound effects enhance the sensations during the gaming and there are several recited classic texts and original music tracks (diversified communication codes). The students interact with the system using their own smartphones and tablets with a new technology (Sacerdoti & Pagliara, 2013) which collects the individual answers. Students can follow their personal score, related to their role in the game, on their devices. The game can be followed by the whole class with a IWB (Interactive White Board) or a projector. The game can be played in a laboratory to accompany one or more hands-on activities or in the classroom simulating a workshop activity. The students are divided into groups, giving them special professional roles: chemists, physicists, historians, engineers, advisers. The system gives distinct scores to each group based on the "weight" the single questions have for each role played. The path of play can be followed by students with different levels of knowledge and skills using the notebook as compensatory measures. The iconographic contributions, the use of different communication codes (visual and auditory) and the structuring of the questions are ideal for a personalized didactic, even in the case of Special Education Needs.

3.3. Strengths

3.3.1. Opportunity for engagement

Mobile technology is reshaping science teaching: smartphones (Fig 3.3.1.1) and tablets have made a deep change in the way people access,

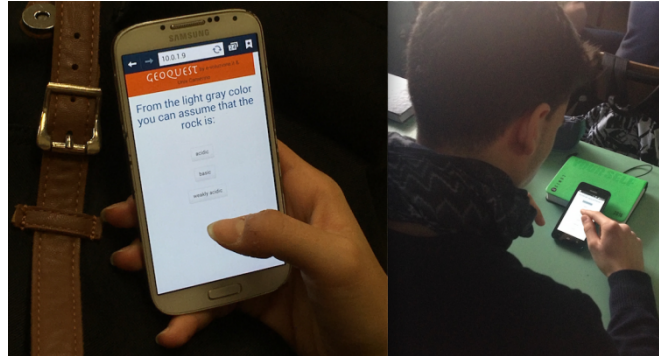


Figure 3.3.1.1. Players interact with the software with their own smartphones.

use and share information. Sophisticated mobile devices and powerful digital applications enable users to access in different fields from the health care to the financial transactions. However, there was no possibility of using the smartphones or the tablets as *Web Answering*. A patent (IT0001422138) has been deposited which belongs to the Company *evoluzione srl* (Naples, Italy), which then also realized the original EvoQuest software, specifically for the GeoQuest Project (par. 3.4) and kindly made available.

3.3.2. Opportunity for a correct use of personal devices

It may seem obvious, but smartphones and tablets have a very strong appeal on students, as we will see later in the presentation of the results (Chapter 5). It is also useful to learn how to use these tools, not only to effectively increase engagement, but also to educate students to the correct and effective use of technologies. The use of ICT in teaching is a great opportunity because it allows to create immersive and involving learning environments, increases student interest, maintains high attention, thanks to the interaction that the use of smartphones and tablets allows. Furthermore, these technologies allow to have an accessible design for SEN (Special Educational Needs), creating an inclusive Educational Environment, thanks to the dispensatory measures and compensatory tools that ICT can easily guarantee.

3.4. GeoQuest Project

GeoQuest is a CCRPG that recreates a virtual reality in which players advance all together without knowing the path as a typical adventure game. The game requires a single computer, which displays on a whiteboard the adventure pathway to the whole class. The players are guided by a narrator voice (game master) that accompanies them through the story. They live an unknown outcome experience that changes every time according to players' choices. The use of a narrator voice, together with the subtitles, enhances the integration of students. The voice can be also slowed down to simplify participation and increase comprehension of the story to "non mother-tongue" students. The game is realized as a two-dimensional (2D) adventure game projected on the wall and controlled by the players with a simple browser on their smartphones or tablets, connected via Local Area Network (LAN) and does not require any Internet connection. The computer game plays as a "web server" for the students and the local web page works as an "answering machine". All the GeoQuest Project main features are summarized in Table 3.4.1.

Table. 3.4.1. GeoQuest Project Characteristics.

Characteristics	CCRPG
Immersion	Narrator speaking voice, sounds effects, photo, original designs and music create a totally immersive environment.
Engage	Thanks to storytelling, mystery and suspense.
Changing environments	Adventure pathways change depending on the players' choices.
Mystery	Each path may have a different end and fantasy is blended with real world.
Shared experiences	All players follow the game on the same multi-media whiteboard or other screen.
Cooperative learning	Shared experiences foster cooperative learning.
Lab	Possibility to have lab activities or watch related videos.
Immediate feedback	Game engine indicates immediately whether the answer provided by the player is correct or wrong. In the latter case, the exact answer is indicated.
Interactivity	Players interact with the game trough their own smartphones or tablets, using a LAN.
Inter-disciplinarity	Science topics are treated along with humanities.
Multi-language	Adventures pathways are available in any language.
Inclusion	Accessible design creates an inclusive educational environment: different communication codes (video and audio), notebooks
User friendly	Software is specific for this CCRPG and it can also be used by non-experienced teachers.

3.5. Description of a game path

The construction of the game paths (Fig. 3.5.1) was made following the techniques of digital storytelling, drawing on the numerous mythological tradition always linked to natural phenomena. The core topic is the Earth Sciences: in particular the first adventure pathways have been

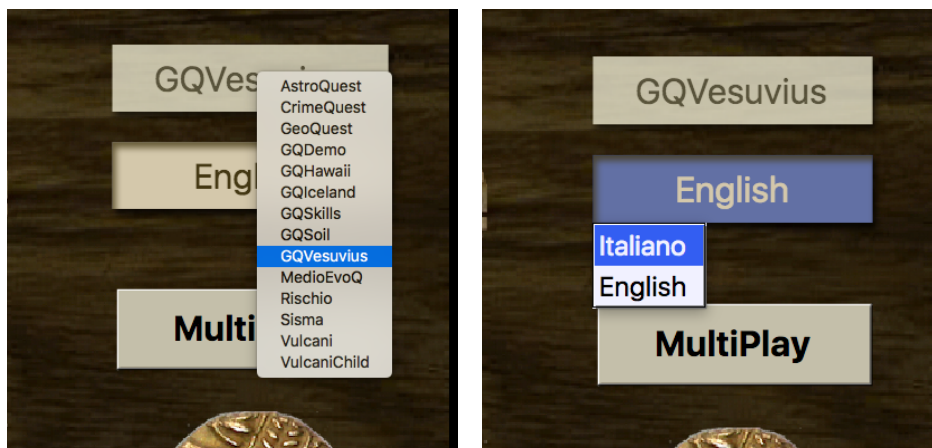
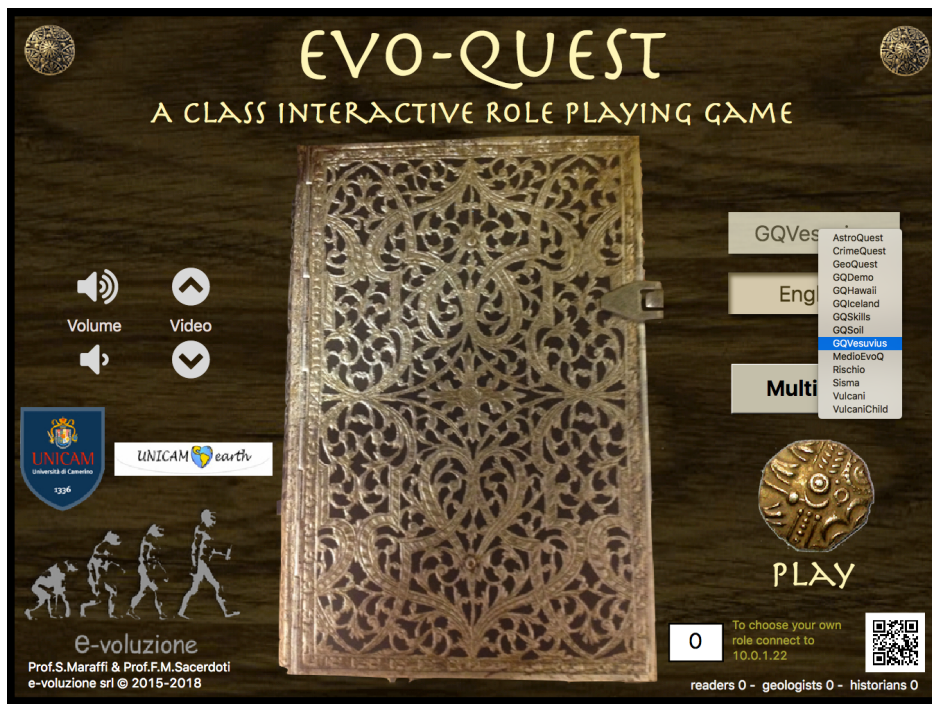


Figure 3.5.1. An example of the GeoQuest interface. It is possible to choose the adventure pathway (below on the left) and the game language (below on the right).

elaborated about geologic, volcanology and mineralogy topics. The students are attracted by the stories of mythological heroes, incredibly

linked to geological phenomena: in mythology the volcanic activity of the Campi Flegrei, for example, is described with the deeds of the Giants, who rebel with rage for being driven from their home. The phreatomagmatic eruptions of the Vesuvius are described through the exploits of Hercules, who rips off the top of the mountain forcibly corked by the Caco demon. Furthermore, literary texts with a scientific subject are reported in the adventure paths, such as the letters of Plinio the Younger or the wonderful descriptions of Goethe in the "Journey to Italy". Some of the most significant pieces are offered to the players' interpretation, so that, through the game, they can derive the right meaning of the text.

The multidisciplinary approach is increasingly required in the new teaching frontiers school: it is not simply the "connection" between scientific, historical, literary, mythological topics through interesting and captivating textual references. The aim is pursuing the educational goal of motivation to the interdisciplinary study inside the *New Forms of Teaching* (Rocard, 2007), and to improve understanding of the literary and scientific texts. Several recent OECD (Organization for Economic Cooperation and Development) surveys show the difficulties on texts understanding, both literary and scientific ones, as a cause of students failure. In Table 3.5.1 some interdisciplinary links of GeoQuest are summarized. The table is followed by a publication describing the articulation of the game path (Maraffi et al., 2016a).

Table 3.5.1. GeoQuest Project interdisciplinary links.

	GeoQuest Phlaegraean Fields	GeoQuest Vesuvius	SoilQuest	GeoQuest Hawaii	Crime Quest
Astronomy				• Constellations; • Orientation	
Chemistry	• Chemical elements of magmas	• Chemical elements of magmas	• Chemical elements of soil	• Chemical elements of magmas	Forensic chemistry
Phisycs			• Propagation of sound waves • Permeability	• Physical states of substances • Density and viscosity	
Geology	• Plate tectonic • Hydrogeology	• Plate tectonic	• Pedology	• Plate tectonic • Hot spots	
Mineralogy & Petrography	• Crystalline systems; • Silicate mineralogy; • Magmatic rocks • Texture of magmatic rocks • Pyroclastic rocks	• Petrography of magmas; • Mineralogy; • Crystallography of silicates • Magmatic rocks • Texture of magmatic rocks • Pyroclastic rocks		• Silicate mineralogy; • Magmatic rocks • Texture of magmatic rocks	
Volcanology	• Phlaegraean volcanism • Eruptive styles	• Vesuvian volcanism • Pyroclastic flows		• Hawaiian volcanoes • Lavas	
Biology					Proteomics
Biotechnology					DNA Fingerprinting
Literature	• <i>Inferno</i> (Dante) • <i>Eneide</i> (Virgilio) • <i>Gigantomachia</i> (Teodoro Siculo) • <i>Teogonia</i> (Esiodo) • <i>La casa del sonno, Metamorfosi</i> (Ovidio)	• <i>Naturalis historia</i> (Plinio the Older) • <i>Epigrammi</i> (Marziale) • <i>Trattazione Geografica</i> (Strabone) • <i>Eneide</i> (Virgilio) • <i>Inferno</i> (Dante) • <i>Epistola VI</i> (Plinio the Younger) • <i>Second letter to Tacito</i> (Plinio the Younger) • <i>Journey to Italy</i> (W.Goethe) • <i>Gradiva</i> (W.Jensen) • <i>La ginestra</i> (G. Leopardi) • <i>Pictures from Italy</i> (C. Dickens) • <i>Il corricolo</i> (A.Dumas) • <i>Ecloghe piscatorie</i> (B. Rota) • <i>Diary of Sir W. Hamilton</i>			
Geography & History	Campanian Plane	Roman history	Soil and agriculture	• Geografic coordinates • Astronomical coordinates	



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GeoQuest VESUVIUS a Class Role Playing Game

Maraffi Sabina*
Sacerdoti Francesco M.**
Scamardella Alessandra***

*School of Science and Technology, Geology Division - University of Camerino
Via Gentile III da Varano, Camerino 62032, Italy
sabina.maraffi@unicam.it

** Department of Biology, Temple University - Philadelphia (USA)
francesco.sacerdoti@temple.edu

***LS G.Galilei, Napoli - Italy
ale.scamardella@alice.it

[...]

Needs analysis

Learning processes

In current and modern learning society technologies and socio-cultural progress seem to have given a big boost to the improvement of condition and lifestyle. Paradoxically, our society still suffers a considerable inadequacy of young and less young people compared to the demands of job world and civil society in general. And, regardless of the different national realities, this is directly bound with school failure. Primarily due to the inability in decoding written text, and then to the difficulty in properly retrieving information, in order to build skills then. The international surveys, which have highlighted the gaps in students' knowledge, skills and abilities, inspire a proper definition of literacy: "reading literacy is understanding, using and reflecting on written texts, in order to achieve one's goals, to develop one's knowledge and potential

and to participate in society” (Pisa Framework 2006). To repeat the text’s content, even well, doesn’t imply at all that the meaning absorption happened (Kintsch, 1998). At the base of correct understanding of a text there is the ability to build a semantic representation coherent and well-formed (Kintsch, 1998); (Levorato, 1988); (Gernsbacher, 1994); (Padovani, 2006). In the school practice it is often given more importance to the elaborative inferences, necessary to personal interpretation (Graesser et al., 1994), rather than the true understanding of text: students are encouraged in an interpretive activity, where there are no requirements for local understanding. It is therefore necessary encouraging teachers and researchers to develop instructional strategies to foster these literacy skills.

Interdisciplinarity

We would highlight what the multidisciplinary approach is increasingly required in the new teaching frontiers school: not only the simply "connection" between scientific and historical, literary, mythological topics through interesting and captivating textual references, but also the educational goal of "motivation" to the interdisciplinary study inside the "New forms of teaching". Our goal is to create an innovative learning methodology based on gaming, that enhances the interdisciplinarity and the role of Earth Science.

Why a Game?

In the obligatory school levels, like in the lifelong learning, the game is an essential element and activity for the development of everybody’s personality, especially in the perspective of learning to learn (Key Skills). Learning to learn is recognized as a meta-skill which evolves with the student and becomes the thread that guides him to a successful assumption of responsibility for its own learning process. The most effective mode of realization of metacognitive teaching, it seems to be the self-regulating approach, in which students are helped in the process of recognition of the skills necessary for learning tasks and they are encouraged for the choice and for the most productive application of appropriate learning strategies (<http://www.pavonerisorse.it/meta/gioco/gioco2.htm>).

When it can be useful to use a game?

- At the beginning of a Teaching Unit, to introduce new elements;
- At the end of a lesson, for learning reinforcement and "relaxing" activities after a particularly challenging phase (<http://www.webalice.it/jack.rota/ilgioco.htm>).

In a not didactic situation, through a set of conditions that allow the student to take control of the situation, the teacher allows a devolution of the situation. Devolution is not only introducing to students the game that the teacher wants him to play, but also making students feel responsible, in the sense of knowledge and not the guilt, for the result that he must look for. Devolution appeals to student motivation, which [...] must seek the best strategies that allow him to win. In conclusion, devolution is the act by which the teacher makes the student accept responsibility for a learning situation (a-didactic) or for a problem, and makes itself accept the consequences of this transfer (Spagnolo, 1998). The teaching looks to the game and to problem solving mainly from two points of view:

1. The problem as a vehicle: use the problem in order to get knowledge realizing a "teaching for problems", creating every time problematic situations, even as a game, from which draw out ideas; in this case, then the problem solving is a vehicle, a methodological tool to be used to achieve learning objectives.

2. The problem as an objective: a teaching which develops in students the aptitude for problem solving; problem solving, then, becomes a purpose, id est, that is itself an objective for teaching intervention.

Socialization implies the ability to relate to other people and the discovery of the communication, that is the cultural attitude. The knowledge and the discovery of own abilities (which are not only the typically scholastic ones) is a fundamental step for self-acceptance and for the planning about oneself. Matching this discovery with the one outside of surrounding reality is the delicate, but strategic step to feel protagonist and to face own development tasks (Montanari, 1998).

Until now, serious games are a significant step forward compared to many ways of using informatics technologies in education, which, as it happens with the traditional e-learning, have often repeated the transmissive model, providing content with rich combinations of texts,

pictures and sometimes video and audio, but with limited possibilities for effective interaction between teacher and students (Mori, 2012).

Why a Role Playing Game

What is a role playing game? In a role playing game you can play a character, the tale is shared staying around a table (tabletop or multimedia whiteboard) (Fig. 3.5.2). Sharing is the most important aspect that distinguishes the role play by any other computer game, including those which make use of avatars and virtual world. Even in them, in fact, the player carries on his own quest alone (you can talk about contemporary solitudes a maximum, if all students of the same class practice the virtual game at the same time).

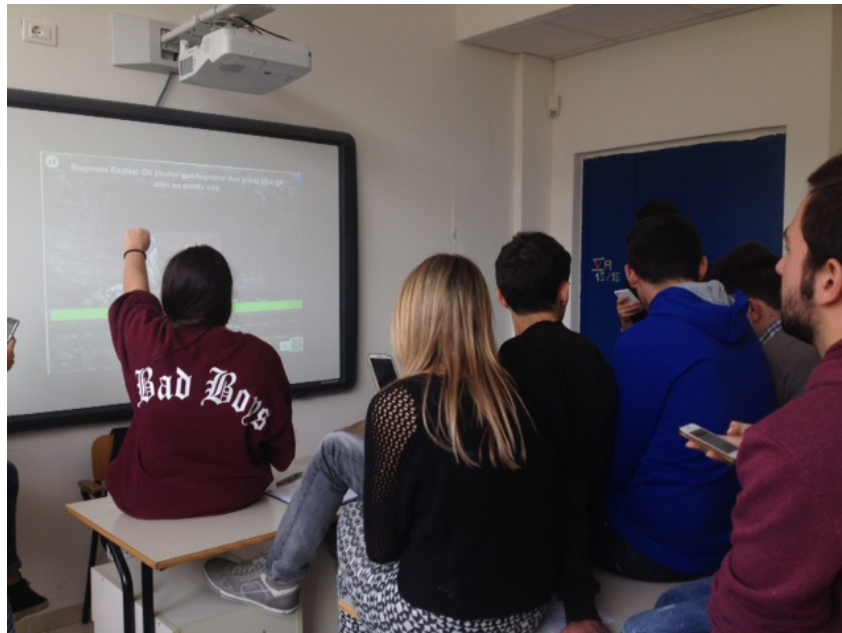


Fig. 3.5.2. Students play together in classroom with GeoQuest.

The most current literature about this subject (Mori, 2012) highlights the following important aspects of the role play game in the educational field:

1. Motivation: if there is a desire to play unexpected resources may grow.
2. Cooperation: collaboration between characters (virtual world) collaboration between players (real world)
3. Identification: interpretation and comparison of different points of view.

4. Narration: same story from different points of view, same story with different unprovided narrative outcomes. Descriptions: places and characters.

5. Exploration: pretext for historical/scientific deepening. Possibility of "exploring" environments and situations in a way that the front lesson hardly allows.

6. Review: possibility of living possible situations but not real; ability to evaluate different outcomes.

7. Planning: analysis of situations, environments, interactions, personality (Bisanti & Ligabue, 2015).

Why a Computer Game

Computer game means a game that makes use of a computer as the main support and it is played using a keyboard, a mouse or a joystick and a screen. Computerized games are a formidable gym to exercise the "core capacities" involved in cognitive enhancement activities, because reaching the game objectives calls for the simultaneous and coordinated application of a large number of mental processes such as visual attention, processing visus-space, executive function, learning ability and memory, in addition to experiment with their coordinated use in the situation (Greenfield, 1995). All computer games can offer a rich cognitive stimulation, but it doesn't mean that the pure spontaneous use of those games is a vehicle to promote learning. Planning and/or using a computer game to promote academic success therefore asks you to respect some measures dictated by empirical research about Scholastic Achievement. Problems that require the exercise of content and skills covered at school, but presented as a game, with controlled difficulty, may be stimulants, but not frustrating, and thus they may promote cognitive functions about targeted content, a key element for the enhancement of learning (Trinchero, 2015).

Mediation has a key role. Among the main forms of mediation involved in computer game there is the automatic feedback: it refers to the error handling strategies proposed in the game. While in school activities the error is a potential source of frustration to be avoided at any costs, in the game it is a normal part of experience. After the error you can restart without any consequence, and on the contrary, having learned something (Trinchero, 2015).

Our game

GeoQuest Vesuvius is a Class Interactive Role-Playing Computer Game. Which kind of game?

Class Role-Playing Game: it allows students to achieve a complex goal through cooperation. Unlike other games or virtual paths, which are carried out individually by each student/player, with the role play the class group must cooperate. The participants live a graphic adventure in which they face several choices of different paths with different opportunities. Furthermore, the students must solve questions or quests to go on. In role-playing games, players do not know where they are and the map of the location where they virtually move. Everything is revealed as players proceed: different choices create a new original game experience. Through a path choice or as output of some questions, the players change the experience. In our game the players-students of a class meet some mythological and historical figures along the way. They tell their story introducing the player in an atmosphere of mystery and dramas. The myths and stories belong to the place and time in which the game is set, and these are correlated to the path the players will reconstruct. While the path is revealed through the stories heard by mythological characters, players proceed and find some clues to discover a final event. The clues are based on scientific evidence, mineralogy, volcanology, geodynamics, history and myths (Maraffi & Scamardella, 2016).

In this work we would like to improve understanding of the literary and scientific texts. Several recent OECD surveys show, in fact, the difficulties on texts understanding, both literary and scientific one. It is our intention, in part already begun in this work, to continue in this direction. The humanistic way of this work plots historical, mythological and literary aspects through appropriate textual references (Fig. 3.5.3). This shows the mythological and geographical origin through the work of Strabo and other ancient authors, not only of "Sterminator Vesèvo", but of the whole Campanian volcanic plain. Is intertwined here, the myth of the loving marriage between young Vesèvo and Capri, and then it connects the mythological origin of Herculaneum area through the narration of the hero, who seems to have given the opening words to the entire area: Hercules. There are ad hoc episodes and literary references on the propulsive force of the mythological hero about the described places. The chosen literary passages are not chronological, but transversal and

diachronic sort of story in the story, aimed at connecting knowledge of the



Figure 3.5.3. An extract of the GeoQuest interface. Here players can choose one of the three authors and they will have an excerpt from a literary text: "La Ginestra", by Leopardi, "Pictures from Italy", by Dickens, "Il corricolo", by Dumas.

students with the gradual pace of the game.

Large space is dedicated to the eruption of 79 AD through the sources by Plinio and the references by Tacito: the anthology section is focused both on the volcanic event description, as perceived by his contemporaries, and the educational material of the scientific topics inserted into the game, with a clear exposition. We would like also emphasized that the excerpt of literary passages chosen are taken from great narrative calibre sources. The work of Plinio has been used also in the coming centuries by historians and scientists as essential reference of volcanic event, because it is considered a direct evidence unfiltered by the passage of the next memory.

The representation of Dante's Hell Valley is connected with some of its mythological characters and the place found by Dante corresponds to the area affected by the path of magma and, as happened in the first part of our work about the Campi Flegrei, references borrowed expressly from Comedy are perfectly functional in educational objectives. As "frame" we put in the game specific elements of art history and historical events.

Project Strengths

- Multi-language (CLIL compliance)
- Ease of create new adventures also on different topics
- Interdisciplinary between “sciences” and “humanities”
- A total new didactic approach.

Expected outcomes

- Development of new games and new teaching methods in general.
 - Strengthening of Earth Science into science education.
 - Increase in the teaching of the last generation ICT.
 - Teaching support, through the use of materials that meet all of the latest instances of standards and methodologies.
 - Teaching support with CLIL, with the ability to have all the materials in any language.
 - Personalised teaching support (also in case of Special Educational Needs).
 - Spreading a truly interdisciplinary training culture, exceeding the dichotomy science/humanities.
 - Facilitation of learning, since the material created is usable both in the laboratory, either in place of the laboratory and downstream of the development of a learning unit (as a conclusion and verification), or upstream (as a stimulus).
 - Ability to use the Didactic Projector also for the skills assessment, as it can record the progress of each student.
-

3.5.1. Hands-on activities

In the GeoQuest's adventures students can do hands-on activities: they are presented with simple cards that guide players to make experiences with easy to find material. For example, they can experience the difference between more or less viscous fluids by comparing tea and honey; blowing with a straw in both fluids, players can realize that the more viscous fluids retain the gases more and link this experience to the petrography of magmas and to the eruptive styles. It is also possible to see short videos of the same activities, as well as, through the videos, the most complex concepts are conveyed.

3.5.2. Animations

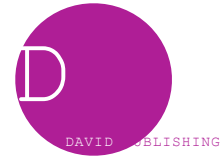
Videos and animations are precious tools for understanding concepts: in the adventures of GeoQuest players see the effusive and explosive eruptions, the geometry of the crystalline lattices, the tectonic dynamics of the convergent, divergent and transcurrent margins and much more.

3.6. STEAM approach

STEAM is an educational approach to learning, which uses Science, Technology, Engineering, Arts and Maths to guide students on inquiry, dialogue and critical thinking. The expected results are students which engage in experiential learning, apply problem-solving, embrace collaboration and work through the creative process. This kind of multidisciplinary approach is required in the new teaching frontiers school: it is much more than a simple “connection” between scientific and historical, literary, mythological topics through interesting and captivating textual references. The contribution of GeoQuest Project to STEAM education is described in Maraffi & Sacerdoti, 2016a. The paper reports the results of a first experimentation, which will then be defined in detail in chapter 5, proving useful in order to further define the STEAM aspects of the Game and to calibrate the subsequent experimentation phase. In Table. 3.6.1 we can see an example of Geology and Myth in GeoQuest Project.

Table 3.6.1. Geology and Myth in GeoQuest Project-1

	Geology	Mith
GeoQuest Phlaegraean Fields	Hydrothermal activity and solfataras	Caronte and kingdom of the dead
	Phlaegraean Fields	Flegra, as woman and as geographic element
	Volcanic area of Campania	Giants mito (Gigantomachia)
	Lava dome of Cuma	Cuman Sybil
	Sulphureous vapors	Vaticination of the Sibyl
	Pyrite	Piritoo’s mith
	Calcite	Astral travels
	Birth of the Phlaegraean Fields	Gea & Tifone with Giants
	Crater lake of Averno	Dante’s Inferno
GeoQuest Vesuvius	Somma-Vesuvius eruptions	Ercole & Caco mith
	Somma-Vesuvius eruptions	Vesevo & Sebeto
	Capri’s origin	Leucopetra
GeoQuest Hawaii	Hot spots origin	Goddess Pele mith



GeoQuest Project Computer Class Role Playing Game as Innovative Teaching Methodology to Foster STEAM Education

Sabina Maraffi¹ and Francesco Maria Sacerdoti²

¹ School of Science and Technology, Department of Geology, University of Camerino, Camerino (MC), Italy

² e-voluzione s.r.l., R&D Department, Naples 80125, Italy

[...]

Introduction

This new technology is designed for deeper learning of Science, Technology, Engineering, Mathematics, combined with Arts (STEAM) and Social Sciences & Humanities (SSH), improving the innovation and creative capacities of learners and supporting the new role of teacher as a coach of the learner. It's naturally a mixed reality learning environment, giving the students the feel "to be IN adventure environment". The student interaction is realised by using new interfaces: students use their own tablet or smartphone to interact with the game. In recent years, many studies have highlighted an alarming decline in young people's interest for key science studies and mathematics (Eurobarometer Standard, 2005; Eurobarometer Standard, 2010; OECD, 2006; OECD, 2009). Despite the numerous projects and actions that are being implemented to reverse this trend, the signs of improvement are still modest. There is obviously a need to prepare young people for a future that will require high scientific knowledge and a good understanding of technology (Rocard, 2007).

Science Education

In 2006, Michel Rocard, a member of the European Parliament and former Prime Minister of France, drawn attention on the decline in the interest of young people in science and mathematics that could lead to decline in long-term innovation capacity of Europe and in quality of scientific research (Scapellato, 2014). There is firm evidence which indicates a connection between attitudes towards science and the way science is taught (Rocard, 2007). In 2008, it emerged that in Italian schools, laboratory teaching has a marginal presence in science education at all school levels, as indicated in the research conducted by a working group established by the Italian Education Ministry (Scapellato, 2014). The report indicated that the absence of laboratory activities was primarily due to a lack of or poorly equipped laboratories, as well as the difficulties of teachers in doing experimentations with students. Moreover, teaching Earth Science in Italian secondary schools is more challenging than teaching other science subjects since it meets with little interest and is perceived as marginal compared with other school subjects: contents are rote-learned and processes remain substantially abstract and perceived as unconnected with reality (Scapellato, 2014; Venturini, 2009).

The existing scientific literature, in the field of Earth Sciences coming from several universities distributed in the world, is however, primarily focused on the development of content, on research and new fields of discovery and investigation, more than on research of new and effective educational approaches. In fact, the literature rarely considers the education approach, the need to make the acquired contents and new discoveries easier to be understood by a non-specialist public. As a consequence, this lack produces an absence of elaboration and of abstraction of the discipline itself, not focused on a disciplinary epistemology and weakly comparable with other sciences (Occhipinti, 2014).

Science Teaching

Eurydice report (Eurydice, 2006) points out that “there is substantial variation in the status and prestige of science teachers across Europe. The research suggests that it is the quality of the teacher that is the major determinant of student engagement with science. Recruiting and retaining the highest caliber science teachers is, therefore, a critical factor in improving and sustaining the quality of school science education.” Some

experiences where the teachers have been actively involved, were analyzed by Occhipinti (2014), including the participation to the and to the IGEO (International Geoscience Education Organisation).

- IESO (International Olympiads of Earth Sciences)
- IGEO (International Geoscience Education Organisation)

The results highlight that the most important factors for the students' success in the international competitions like IESO (as also collected during the IGEO international meetings), seem to be:

- the importance of socio-economical attention to STEM. Particularly the interest addressed by institutions, companies and families to scientific culture and its development by schools which evidently led to a greater involvement of students in the international test;
- the teachers training in universities, training courses in professional development for teachers on methodology (e.g. Taiwan, USA), different methodologies for the development of operational skills, and in particular the support to teachers' work;
- the internships organized for selected students;
- much less important is the use of innovative methodological approaches. Instead, teachers with high professionalism or involved in active teaching-learning approaches, seem to be the best candidates to increase teaching outcomes.

The final observation of the study is that teacher support should be a priority to obtain good results in science education (Occhipinti, 2014).

Europe Engaging

As stated by the European Commission in the report “Key competences for lifelong learning” (Recommendation 2006/962/CE), the European Union is working hard to move beyond the crisis to create the conditions for a more competitive economy and higher employment rate. The Europe 2020 strategy is focused on three mutually reinforcing priorities:

- *Smart growth*: developing an economy based on knowledge and innovation.
- *Sustainable growth*: promoting a more resource efficient, greener and more competitive economy.
- *Inclusive growth*: fostering a high-employment economy delivering social and territorial cohesion.

Smart growth promotes:

- I. education: encouraging people to learn, study and update their skills;
- II. research/innovation: creating new products/services that generate growth and jobs to help address social challenges;
- III. digital society: using information and communication technologies.

Sustainable growth means:

- I. building a more competitive low-carbon economy that makes efficient, sustainable use of resources;
- II. protecting the environment, reducing emissions and preventing biodiversity loss;
- III. capitalizing on Europe's leadership in developing new green technologies and production methods;
- IV. introducing efficient smart electricity grids;
- V. harnessing EU-scale networks to give our businesses an additional competitive advantage;

VI. improving the business environment, in particular for SMEs;

VII. helping consumers make well-informed choices.

Inclusive growth focuses on:

I. raising Europe's employment rate – more and better jobs, especially for women, young people and older workers;

II. helping people of all ages to anticipate and manage change through investment in skills & training ;

III. modernizing labour markets and welfare systems;

IV. ensuring the benefits of growth reach all parts of the EU.

Environment Management

Activities in this Challenge will help increase European competitiveness, raw materials security and improve well-being. At the same time, they will assure environmental integrity, resilience and sustainability. To ensure EU added value and given the transnational and global nature of the climate and the environment, their scale and complexity, and the international dimension of the raw materials supply chain, activities have to be carried out at and beyond the Union level. Reducing resource use and environmental impacts, whilst increasing competitiveness, will require a decisive societal and technological transition to an economy based on a sustainable relationship between nature and human well-being. Innovation in these fields will provide opportunities for growth and jobs, as well as innovative options involving science, technology including of ICT, the economy, society, policy and governance.

Research and innovation will cover the following broad lines of activities:

- Climate Action-Informed decisions for a climate-resilient low-carbon society;
- Cultural Heritage-Engaging a new cultural heritage agenda for economic growth;
- Earth Observations-Crucial info on climate, energy, natural hazards and other societal challenge;

- Nature-Based Solutions-Providing viable solutions of natural ecosystems;
- Systemic Eco-Innovation-Generating and sharing economic and environmental benefits (European Commission,, 2010, "HORIZON 2020 - The EU Framework Programme for Research and Innovation").

Education Technology

In most European countries, and also in Italy (VV. AA., 2007), Science teaching methods are still mostly deductive, which means that the presentation of concepts come first and are followed by examples of applications, while experiments are confirmative mainly as a teacher's demonstration. This approach is also referred to as top-down transmission. On the contrary, the inductive approach gives more space to observation, experimentation and to the construction by the children of their own knowledge whereas the teacher has the role of facilitator of learning. This is also described as a bottom-up approach (Rocard, 2007). The terminology changed over time and also the concepts refined. Today the inductive approach is most often referred to as Inquiry-Based Learning (IBL) or, in Europe, Inquiry-Based Science Education (IBSE) (Rocard, 2007). In the official definition of the eight key competences on European Parliament and Council Recommendation of 18 December 2006 (2006/962/EC), the competence in science refers to the ability and willingness to use the body of knowledge and methodologies held to explain the world around us to identify questions and to draw conclusions that are based on proven facts. In 2015, the definition of Scientific Literacy (OECD, 2015. Programme for International Student Assessment - INVALSI 2015) is changed to best fitting last instances: "Scientific Literacy is the ability to engage with science-related issues and with the ideas of science, as a reflective citizen". A scientifically literate person is willing to engage in reasoned discourse about science and technology which requires the competencies to:

- explain phenomena scientifically: recognize, offer and evaluate explanations for a range of natural and technological phenomena;
- evaluate and design scientific enquiry: describe and appraise scientific investigations and propose ways of addressing questions scientifically;

- interpret data and evidence scientifically: analyse and evaluate data, claims and arguments in a variety of representations and draw appropriate scientific conclusions.

Many on-going initiatives in Europe actively contribute to the renewal of science education. Nevertheless, they are often small-scale and do not actively take advantage of European support measures for dissemination and integration. Priority given to initiatives that include a large diversity of practices in science teaching to respond to the diverse needs of children: problem based inquiry process, hands-on/minds-on activities, team-work, independent work on open-ended questions, trans-disciplinary activities and showing relevance of science content (Rocard, 2007).

Earth Sciences at School

It was very hard to find useful bibliography, due to low interest of the educational community towards Earth Sciences as well as low interest of the geosciences scientific community towards education (Occhipinti, 2014). Some reasons for this lack of interest is undoubtedly the cultural background of teachers, which in most cases are biologists and not geologists. In addition, Earth Sciences provide many interdisciplinary connections with physics, chemistry and geography, perceived by many teachers as non-specialistic topics of their profession.

In Italy, a recent survey (Realdon et al.2013) shows:

- poor compliance to Ministry guidelines;
- scarce use of laboratory and fieldwork activities;
- tendency to follow old teaching habits practices as well as high prevalence of theoretical teaching.

Material and Methods

In addition to structural education and training system reforms, there has been substantial methodology changes (Avvisati et al., 2013) based on:

- Use of Information and Communication Technologies (ICT);
- Laboratory Didactics;

- Cooperative Learning;
- Group Investigation;
- Peer Tutoring;
- Peer Collaboration.

Innovative Teaching

Educational technology is based on the use of language closer to pupils to improve the teaching/learning process. Transferring online traditional teaching practices does not produce an improvement in learning, as well as the digital conversion of the transmission model of knowledge does not generate educational innovation. (Avvisati et al., 2013).

The lesson conducted using a digital presentation (PPT) is practically a frontal lesson; the simple use of Interactive Whiteboard (IWB) which cannot guarantee education does not remain merely transmissive. To go beyond the traditional teaching is not sufficient the use of digital technology and the web, but it's necessary to create a learning environment focused on "communication" with active interaction among all members of the educational community so that "everyone can give according his abilities and receive according to his needs" (Marini, 2016). It's necessary therefore to overcome the transmissive teaching with an approach which is not deductive, but inductive, that manages to combine laboratory activities, cooperative learning, peer education, using ICT as a tool to expand the potential of student investigation in inquiry process.

Teacher Role

About teaching and education, De Benedetti (1998) claims that competence in school is developed as a task dilated over time, so that the students, with their different intelligences and abilities find all the available learning conditions. The teacher, as a trainer, supports and models students' behavior with examples and suggestions. The teacher enables the development of metacognition, provides information as positive feed-back, facilitates in students' construction process of knowing how to act in each situation and compares learning ways of other students. The positive experience of the Flipped Classroom (Maraffi & Sacerdoti, 2016b) ensured us that it is not necessary that the class

activity follows the theory: the class activity may instead be a stimulus for the investigation by the students, led by the teacher.

[...]

STEAM Education

Daily teachers live on their skin than they change the learning ability of the children and perceive a world of constant and rapid change. The school task would contribute to the improvement of society and not to restore a 'status quo',persuading the school to rethink itself versus a traditional teaching, not more strictly focused on the disciplines, but able to embrace more cross paths that can convey the reasons guys, tools and methods for continuous training (Zini, 2014).

STEAM is an educational approach that uses Science, Technology, Engineering, Arts and Mathematics (STEAM) as access points for guiding student inquiry, dialogue, and critical thinking. The end results are students who take thoughtful risks, engage in experiential learning, persist in problem-solving, embrace collaboration and work through the creative process. In the new teaching frontiers school multidisciplinary approach requires STEAM and Social Sciences & Humanities (SSH) cross correlation is increasingly required. With the international surveys highlighting the gaps in students' knowledge, skills and abilities, it was set up a proper definition of literacy: "reading literacy is understanding, using and reflecting on written texts, in order to achieve one's goals, to develop one's knowledge and potential and to participate in society" (OECD, 2006). We can repeat the text content very well, but it doesn't imply that the meaning is absorbed and the true understanding of text is gained (Avvisati et al., 2013). At the base of correct understanding of a text, there is the ability to build a coherent and well-formed semantic representation (Kintsch, 1998; Levorato, 1988; Padovani, 2006).

Original texts. Most of the GeoQuest adventures present texts from literature that has to be interpreted: students must decode the right meaning to proceed successfully. School failure or abandon, in fact, seems to be related primarily to the inability in decoding written texts, than the difficulty in properly retrieving information in order to build skills. In the school practice, it is often given more importance to the elaborative inferences, necessary to personal interpretation (Graesser et al., 1994), rather than the understanding of texts: students are encouraged to

interpretive activities, where perhaps there are no requirements for punctual understanding. It is therefore necessary to encourage teachers and researchers to develop instructional strategies to foster these literacy skills.

Results and Discussion

The Game has been experimented in several classes of different school grades to have a scientific outcome of the innovative methodology. The adventures paths used for the experimentation has been played in a laboratory environment (with real hands-on activities integrated into the adventures) and also in normal classrooms with simulating the hands-on activities showing a video.

Experimental Methodology

It seems essential to carry out an application that works on the pursuit of interdisciplinary teaching: all the latest publications in teaching emphasize the need of a multidisciplinary and multilingual approach. Everything collides with the framework provided by the leading international surveys which highlighted the dramatic lacking of textual competence of pupils (Evers et al., 1998) seen as wrong understanding of texts, regarding both humanistic and scientific topics. Therefore, this is the central point: carrying out research in the field of interdisciplinary teaching provides operational lines and a guide about the development of teaching units and structured pathways which contributes to the multidisciplinary of the texts. Currently, it necessitates a synergistic action aimed at developing innovative material that can support a theoretical research and the paradigm on how to practice interdisciplinary teaching interventions.

Types of Classrooms Involved

Given the characteristics of the different game adventures, the trial can be performed into multiple types of classes:

- I. Classes of primary schools;
- II. Traditional classes of secondary schools;
- III. Traditional classes of high schools (Scientific and Technical);
- IV. Traditional classes of high school with CLIL methodology.

The aim of the trial was:

- explore (the student makes virtual direct experience);
- process (the student deepens and strengthens the understanding of what she/he has learned, applying it in new situations);
- evaluate (the student self-assess the own understanding and skills acquired).

V. Flipped classrooms: as an instructional strategy and a type of blended learning that reverse the traditional educational arrangement by delivering instructional content, online, outside of the classroom (Evers et al., 1998). It moves activities, including those that may have traditionally been considered homework, into the classroom. In a flipped classroom, students watch online lectures, collaborate in online discussions, or carry out research at home and engage in concepts in the classroom with the guidance of a mentor.

VI. Open classrooms (Cuban, 2004): as student-centered classrooms design format which became popular in the United States in the 1970s. The idea of the open classroom was that a large group of students of varying skill levels would be in a single, large classroom with several teachers overseeing them. It is ultimately derived from the one-room schoolhouse, but sometimes expanded to include more than two hundred students in a single multi-age and multi-grade classroom. Rather than having one teacher lecture to the entire group at once, students are typically divided into different groups for each subject according to their skill level for that subject.

The students then work in small groups to achieve their assigned goal. Teachers serve as both facilitators and instructors.

The experimentation started with:

- 5 classes secondary school 1st degree (92 students, age 12-13);
- 6 classrooms from secondary schools 2nd degree (105 students, age 14-18);
- 2 classrooms from high scientific schools (Lyceum: 38 students, age 16-18)

- 2 classrooms from high technical schools (39 students, age 14-16)
- 2 flipped classrooms from high technical schools (41 students, age 14-16)

Experimental Protocol

The Experimental protocol foresees different phases:

- A. Questionnaire design and preparation;
- B. Class experimentation;
- C. Questionnaire administration (students and teachers);
- D. Data Analysis.

The questionnaire design aims to:

- making questions concise and understandable;
- eliminate redundant or insignificant details;
- ensure relevance to the data to be collected.

Questionnaires for student have been designed to be delivered just at the end of playing each adventure and regard (ANNEX A):

- Evaluation of the Adventure Educational Experience;
- Comparison between Traditional and Innovative lessons;
- Evaluation of the Immersive Experience.
- Student Experience Evaluation;
- Comparison between Traditional and Innovative lessons: Educational Outcomes by means of the Adventure Experience;
- Numerical evaluation, which reflects an evaluation index between 1 and 10.

The feedbacks, if not expressed numerically in the questionnaire, have been reported in numerical evaluations, using conversion grids between the number of positive factors (i.e: predominantly negative

factors: less than 5; prevalence positive factors: higher than 5). The answers related to the same topic are reported as their average value.

Structure of the data processing and experimental results.

The data processing tables (see table data fig. 3.6.1) collect the same data for each class type, school type, etc (Fig. 3.6.1).

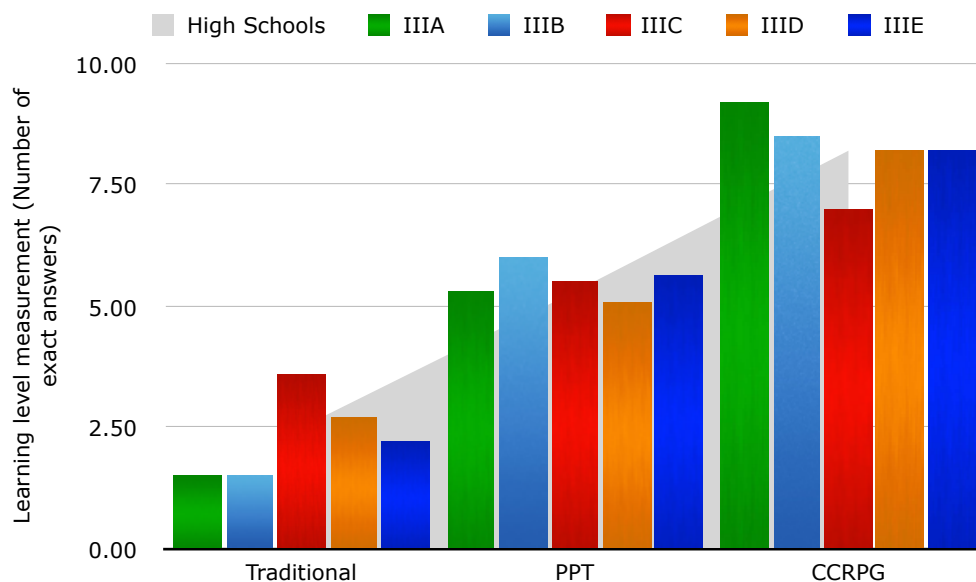


Figure 3.6.1. Teaching methodologies' outcomes of 5 secondary school's classes and, in grey, high school's average results.

Table 3.6.2. Data fig. 3.6.1

	Traditional	PPT	CCRPG
High Schools	2.5	5.3	8.2
IIIA	1.5	5.3	9.2
IIIB	1.5	6	8.5
IIIC	3.6	5.5	7
IIID	2.7	5.1	8.2
IIIE	2.2	5.6	8.2

A first very interesting result is highlighted by pie graphic representation of global average (Fig. 3.6.2) about didactic methodologies. Traditional lessons evaluation is at 15%, PPT lessons evaluation is at 33% and Role Playing Game (RPG) evaluation is at 51%. It is clear that lessons PPT in respect of normal frontal lessons are easier

to follow by students, but in any case are frontal lessons. Instead RPG, the only interactive activity, exceeds 50% of the satisfaction. The teachers of each class were asked to evaluate the outcome after a month from the

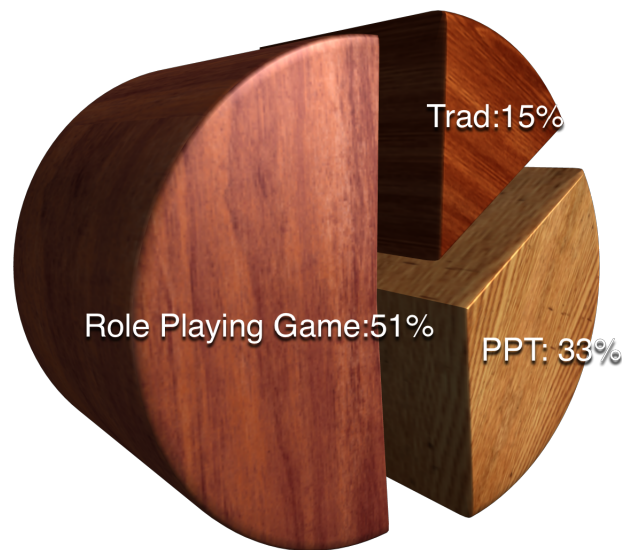


Figure 3.6.2. Pie graphic representation of global average about didactic methodologies: Trad=traditional lessons, PPT=Powerpoint supported lessons, RPG=Role

experience with the RPG. It's been considered in the evaluation: the active

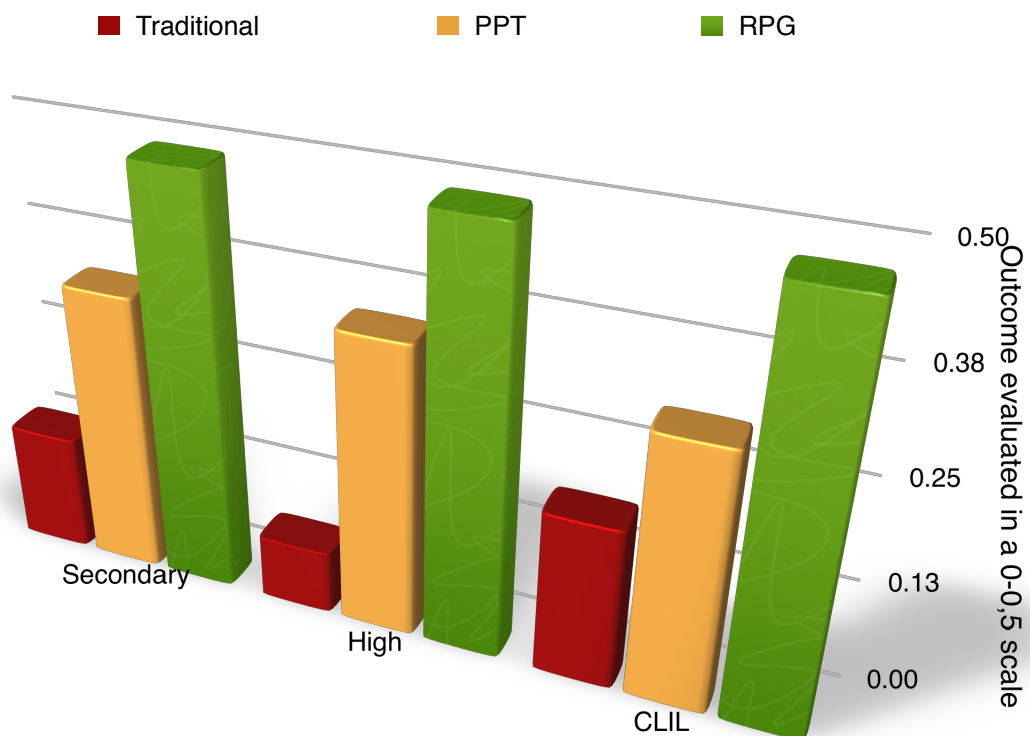


Figure 3.6.3. Efficacy of interactive methodologies, also in case of CLIL methodologies (Content and Learning Integrated Learning), in respect to Traditional and PPT lessons and independently by the school degree.

participation of the students to the game, the comprehension of specific topics, the ability to convey complex topics, the ability in mastering the learning in a foreign language. In Fig. 3.6.3, it is possible to highlight the efficacy of interactive

Table 3.6.3. Data fig. 3.6.3			
	Traditional	PPT	CCRPG
Secondary	0.1	0.3	0.5
High	0.1	0.4	0.6
CLIL	0.2	0.3	0.5

methodologies, also in case of CLIL methodologies, in respect to Traditional and PPT lessons and independently by the school degree. In this case, the game virtual voice, that speaks perfect British English in RPG, is the optimum to best gets the Communication in Foreign Languages skills (European Commission. 2006. "Key competences for lifelong learning" Recommendation 2006/962/CE).

Students of secondary schools are 11-14 years old, students of high schools are 14-18 years old. Results of CLIL methodologies (Content and Learning Integrated Learning) in respect to Traditional and PPT lessons are independently by school degree and students' age.

[...]

Conclusion

GeoQuest Project improves the innovation and creative capacities of learners and supporting the new role of teacher as a learner coach. It responds to European instances about education (encouraging people to learn, study

and update their skills; research/innovation (creating new products/services); improving the digital competences of the society (using information communication technologies). Moreover, these adventure game paths help supporting the European recommendations about the awareness of the environmental hazards (European Commission, 2010), by enhancing the study of Earth Sciences engaging the students and arising their interest in the discipline. Also, this Computer Class Game

helps exploit the potential of ICT, with a bottom-up approach and it ensures the benefits of Inquiry Based Science learning without burdening the load work of the teachers. On the contrary, it helps the teachers to fill the digital divide with their students. It leverages the latest achievements in the field of information technology, which allow overcoming the loneliness of the subject in learning, a weakness inherent in the use of the virtual games and computer games. The game as a teaching tool represent a situations-learning mode that requires the student to mobilize personal resources to find solutions, in which the nature of proposed tasks requires to be connected to their significance.

The use of educational games allows to reach task performances related to different fields of knowledge, useful to re-read the highlighted characters in relation to the following steps to (Maraffi & Marinelli, 2016):

- ask the students to recover their previous knowledge;
- encourage the use of complex cognitive processes (reasoning, transfer, critical thinking, creative thinking);
- being inserted into meaningful and real contexts;
- stimulate students' interest;
- being open to solving different paths;
- challenge students' ability.

The experimental results were successful and prove the achievement of these goals:

- development of games for new teaching methods;
- Earth Science strengthening into science education;
- Teaching of the last generation ICT increase;
- Support to the teacher, through the use of teaching materials updated to the latest standards and methodologies;
- CLIL Teaching support, allowing teaching materials in any language;
- Personalized teaching support also in case of Special Educational Needs (SEN), best for a complete inclusion;

- Spreading a truly interdisciplinary training culture, exceeding the dichotomy STEAM and SSH.
-

3.7. Innovative teaching methodology

To go beyond the traditional teaching is not sufficient with the use of digital technology and the web, but it's necessary to create a learning environment focused on "communication" with active interaction among all members of the educational community.

Situated learning is when learners acquire knowledge and skills by performing activities in real, interactive situations; this enables them to rationally and meaningfully interpret the knowledge and skills acquired during the process. The new knowledge acquired by learners through situated learning is not isolated or fragmented but complete and is truly mastered following reorganization (Huang et al., 2016). Effective game-based learning should provide a 2D learning environment, immersive and digital made. The design takes advantage of the benefits of games that provide immersion-in-context, rewards for correctness, and immediate feedback in response to student interaction (Bursztyn et al., 2016). Experimental results and classrooms observations agree to demonstrate that teaching activity with CCRPG create a situated learning environment, profitable for collaborative learning and acquiring skills in STEM education.

In the following publications (Maraffi & Sacerdoti, 2017a; Maraffi & Sacerdoti, 2017b) the innovative character of the CCRPG methodology is analyzed, in creating a stimulating learning environment, suitable for an authentic assessment of skills and in line with the needs of students with learning difficulties.

“Learning on Gaming” Improves Science Learning in a STEAM Interdisciplinary Approach

Sabina Maraffi¹ and Francesco Maria Sacerdoti²

¹ School of Science and Technology, Department of Geology, University of Camerino, Italy

² e-voluzione s.r.l., R&D Department, Naples 80125, Italy

[...]

Introduction

[...] It is necessary encouraging teachers and researchers to develop instructional strategies to foster these literacy skills. Learning to learn is a meta-skill which evolves with the student and guides him to a successfully learning process. The educational technology uses the closer to pupils language to improve the teaching/learning process. The game is a good vehicle for education since the acquisition of knowledge and enhancing skills now requires more actual approaches. The use of tablets, smartphones, social networks, etc.. is more comprehensible and funny for young people compared to traditional media. Until now, serious games are a significant step forward compared to many ways of using information



Figure 3.7.1. Some game images are taken by Sir William Hamilton's original book together with original texts. Science and literature together in a multidisciplinary approach.

technologies in education, which, as it happens with the traditional e-

learning, have often repeated the transmissive model, providing content with rich combinations of texts, pictures (Fig 3.7.1) and possibly video and audio, but with limited possibilities for effective interaction with the teacher and with other students (Mori, 2012).

The aim of this work is to use the latest ICT techniques to create innovative educational products and to create new educational materials for teachers, to effectively respond to the latest methodological guidelines and regulations. Roleplaying could help students to reach their goals easily through cooperation to acquire disciplinary and transversal skills.

Interest for Science and Educational Technology

Europe suffers from a cultural heritage that prefers theory to practice. "Cultured Knowledge" is based on transmissive, sequential, deductive and standardized teaching, opposed to workshop activities, mainly focused on production and revenue. The misperception that intelligence is only the "rational logic" one channels the awareness that culture is based on the mastery of complex theories, while the scientific and technological disciplines would serve only to support the craft activities. The discovery of different forms of intelligence (Gardner, 1983), all of equal importance and effectiveness, shifts the focus from deductive logic-rational learning to diversified forms of learning, using different knowledge channels. At the same time, knowledge develops from analytic to synthetic, mainly due to new multimedia communication systems. Therefore, a modern teaching approach shapes on new forms of learning: synthetic and multitasking. The European Community has conveyed its recommendations to the national education systems, adopting the European guidelines in the local regulations, but not always schools are conformed to. [...]

The STEAM Approach and Gaming

STEAM is an educational approach to learning, which uses Science, Technology, Engineering, Arts and Mathematics to guide students on inquiry, dialogue and critical thinking. The end results are students which engage in experiential learning, apply problem-solving, embrace collaboration and work through the creative process. This kind of multidisciplinary approach is required in the new teaching frontiers.

Gaming is an essential element and activity at all school levels as in the lifelong learning, for development of everybody's personality, in the

perspective of “learning to learn” (Key Skills). Learning to learn is recognized as a meta-skill which evolves with the student and becomes the thread that guides to a successful assumption of responsibility for its own learning process. The most effective metacognitive teaching is the self-regulating approach, in which students are helped in the process of recognition of skills to learn tasks. They are encouraged to choose the most productive application of appropriate learning strategies (Valentini, 2009).

Gaming allows devolution from “teachers” to “coaches of students”. “Devolution is the act by which the teacher makes the student accept responsibility for a learning situation (a-didactic) or for a problem, and makes itself accept the consequences of this transfer. Devolution is not only introducing to students the game that the teacher wants him to play, but also making students feel responsible, in the sense of knowledge and not the guilt, for the result that he must look for.” (Spagnolo, 2002).

The knowledge and the discovery of own abilities (not only scholastic ones) is a fundamental step for self-acceptance and for future planning. Socialization implies the ability to relate and the communication with other people: this is the delicate, but strategic step to feel protagonist and to face own development tasks (Montanari, 1998). Serious gaming is a significant step forward compared to the use of other information technologies in education. The e-learning, which often repeats the traditional transmissive model, provides content with rich combinations of texts, pictures, video and audio, but with very limited possibilities for effective interaction with teacher and other students (Mori, 2012). Edutainment (Educational Entertainment) is content designed both to educate and to entertain: especially in recent years the use of computer resources in schools allows the spread of this type of education. “Gaming to Learn” consists in playing a game and consequently getting a learning goal: play a game, even not specifically didactic to derive a learning outcome. “Game-Based Learning” consists of tips, techniques and tools that apply the principles of game design to the learning process—a dynamic way to engage learners and help educators assess learning. The authors’ “Learning on Gaming” is a different approach: you learn “while” you play. The adventure game hides the didactic purpose inside.

Problem-Solving Skills and Spatial Thinking in Computer Games

Computerized games are a terrifying gym to exercise the “core capacities” involving in cognitive enhancement activities. To reach the game objectives requires simultaneous and coordinated application of a large number of mental processes such as visual attention, processing visus-space, executive function, learning ability and memory, in addition to experiment with their coordinated use in the situation (Bisanti & Ligabue, 2015) (Fig. 3.7.2). The elements contributing to educational values of digital games are sensual stimuli. Planning and/or using a computer game to promote academic success therefore ask you to respect some measures dictated by empirical research about Scholastic Achievement. Problems that require the exercise of content and skills covered at school, presented as a game may be stimulants and not frustrating due to the controlled difficulties and it may promote cognitive functions about targeted content:



Figure 3.7.2. Game images are chosen to keep the student in-situation.

a key element for the enhancement of learning (Greenfield & Carbone, 1985). In order to acquire problem solving competence by an inquiry based learning approach - science educators identify it as one of the key skills to face the challenges of the future - it is necessary for learners to follow different steps and to exercise several spatial abilities (Tiemann et al., 2016). Spatial thinking is considered as a significant ability for STEAM disciplines: lack of spatial thinking acts as a barrier for students leading

them to dropout (Uttal & Cohen, 2012). Except from STEAM fields, spatial thinking is also associated with social sciences, humanities (Goodchild & Janelle, 2010) and education (Baglatzi et al., 2015), demonstrating in that way its interdisciplinary character.

Mediation with Automatic Feedback

Among the main forms of mediation involved in computer games, a key role is the automatic feedback: the error handling strategies proposed in many games. While during school activities, errors are potential sources of frustration to be avoided at any cost. In the computer games, it is a normal part of experience (Fig. 3.7.3): after any error you can continue or restart without any consequence but having learned something (Trinchero, 2014).

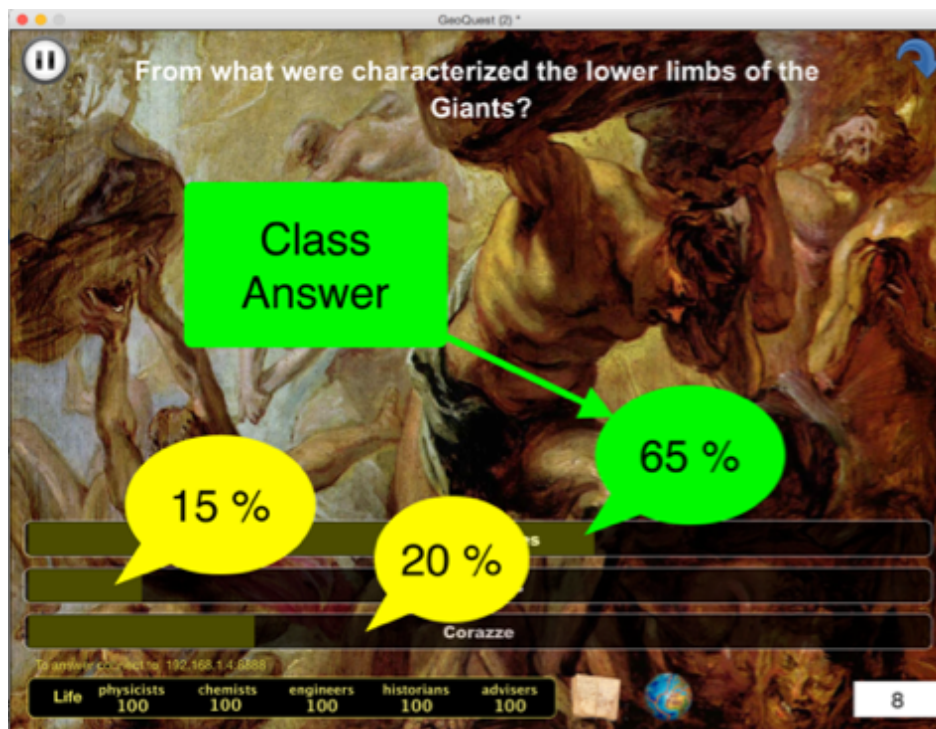


Figure 3.7.3. The game system evaluates the answer given by the majority.

Immediate reward (and feedback) is a major motivational factor, whether it is translated as game entities (more life power, access to new levels, etc..) or as neurological impulses (happiness, feeling of achievement, etc..) (Rugelj, 2016).

Learning on Gaming Strengths

Marshall McLuhan, a famous Canadian philosopher of communication theory, predicted World Wide Web in sixties. He stated about a "global village",: "Anyone who makes a distinction between games and learning doesn't know the first thing about either." The constructivist problem-based and active learning methods indicate the success of learning in the context of challenging, open-ended problems. The elements contributing to educational values of digital games are sensual stimuli (visual and audio representations of learning material), fantasy (context presented in imaginary setting), challenge (demanding or stimulating situation) and curiosity (desire to know or learn). These elements must be incorporated on an integrated platform, to structure objectives and rules, a context of meaningful learning, an appealing story, immediate feedback, a high level of interactivity, challenge and competition, random elements of surprise and rich environments for learning.

Methodology



Figure 3.7.4. Game interface is shown to entire group through Projector or WIB.



Figure 3.7.5. Charon: his mythology is correlated to volcanism of Phlaegrean Fields.

Authors' solution to realize a "Learning on Gaming" is GeoQuest Project (Figs. 3.7.4; 3.7.5).

Adventures already realized

- GeoQuest: below the Phlaegrean Fields, combining Myth, History, Earth Science, Volcanology, Mineralogy (Fig. 3.7.6), Petrography, Physics and Chemistry (Maraffi et al., 2015);



Figure 3.7.6. Example of game notebooks.

- GQ Vesuvius: at Mount Vesuvius across the millennia, combining Archeology, Volcanology, Mineralogy, Myth, History, Latin Literature, Greek Literature, Italian and Foreign Literature from the Middle Ages to Contemporary Art (Maraffi et al., 2016a);
- SoilQuest: within the soil, which includes Earth Science, Mineralogy, Soil Science, Physics, Chemistry, Environmental Protection (Maraffi et al., 2016b).
- HawaiiQuest: includes Volcanology, Geodynamics, Mineralogy, Myth, History, Geography, Ethnography, Literature, Art (Maraffi & Sacerdoti, 2018b);
- IcelandQuest: combines Volcanology, Geodynamics, Mineralogy, Nordic Mythology, History, Geography, Ethnography, Literature, Art, Energy-

saving, Environmental Protection (Maraffi & Sacerdoti, 2018b; Sacerdoti et al., 2018);

- CrimeQuest: at the crime scene, which includes Biology, Biotechnology, Genetics, Physics, Chemistry, Forensic Chemistry.

Adventures in preparation

- HumanQuest: inside the human body, which include Biology, Anatomy, Genetics, Physics, Chemistry, Health education;
- Giant's causeway: which includes Myth, History, Earth Science, Volcanology, Mineralogy, Petrography, Physics, Chemistry;
- EtnaQuest: combines Myth, History, Literature, Earth Science, Volcanology, Mineralogy, Petrography, Physics, Chemistry;
- AustroQuest: Southern Hemisphere astronomy adventure, which includes Myth, History, Earth Science, Physics, Chemistry, Ethnography, Cultural Anthropology;
- CaveQuest: a travel inside the Pertosa Caves which includes Geology, Medieval History, Prehistoric, Art and Literature
- CodeQuest: coding adventures to test the code capacity of the students.
- SafetyQuest: adventure to learn safety and security procedures
- HotelQuest: adventure for tourist operator and Hotel receptionist, to simulate hosts of several countries.

An Example of Adventure Path: GeoQuest

The adventure begins in a dark and quiet cave. There are no clues to understand where you are. The player/students are screened in a mystery story where they have to decide how to proceed. Players cross narrow tunnels and huge caverns, risk falling into the icy water, or to be involved in earthquakes. They hear the unearthly dripping water and the gentle whisperings of lost souls. This adventure is under the Phlaegrean Fields. The environment that gradually reveals itself is full of significant elements that can be traced back to a volcanic site, inserted in a complex geodynamic situation. It is located in the Mediterranean area, specifically in Campania, where there was compressive and divergent geological

events, producing differentiated magmas and explosive volcanism. Players can also discover where they are from the story of the characters on their path. They meet Charon, the conductor of souls to the kingdom of dead, the Cumaean Sibyl, recounting his love affair with the god Apollo, and Flegra, whose legend was born in Thessaly and is implanted in Campania, naming the zone to Phlaegrean Fields. Lete, god of sleep embodied in the river that flows near Lake of Avernus, relives through the verses of Ovid's *Metamorphoses*. There is also Pirithous, who dared to challenge Ade attempting to kidnap Persephone. The mineralogical data, such as sanidine, biotite, pyroxene and magnetite, allow players to go back to an intrusive weakly acidic rock: the syenite. Its presence in the lithosphere bowels, along with earthquakes, allows players to trace environment typical of Campania volcanism. An intrusive body such as the syenite provides a geodynamic origin by tectonic convergence. The volcanic area of Phlaegrean Fields is unique in the world and is beautifully described in the "Gigantomachy", which tells the story of the terrible Giants who were defeated and buried under volcanoes; their attempts to free themselves would trigger the volcanic convulsions of the Earth and they are the origin of earthquakes. Going back to the surface, players can recognize the tuffs, which attest the contamination of ground water and magma, typical of monogenic eruptions of Phlaegrean Fields. Finally, the players walk across some sulfur vapors which suggest that the group is coming under the Solfatara. They will have to connect the color of sulfur crystals to their temperature in order to find the right exit.

Scientific Questions

The questions of mineralogy (Fig. 3.7.7) are enriched with photos taken in the most important mineralogical museums in the world (Natural History Museum of New York, USA; the Smithsonian's National Museum of Natural History of Washington, USA; Naturhistorisches Museum of Vienna, Austria; Museum of Natural History of Genève, Switzerland). Next to the photo images of the crystal are shown the relative lattices, for a better classification. The questions are aimed to determine the mineralogical classification; furthermore, if the crystal is a silicate, they have also to determine mafic or felsic character, based on color and other features described in the query. A good classification of minerals allows players to be able to recognize the mineralogical association and then go back to the rock they are going through.

The path is enriched with structural and textural features, so you can find

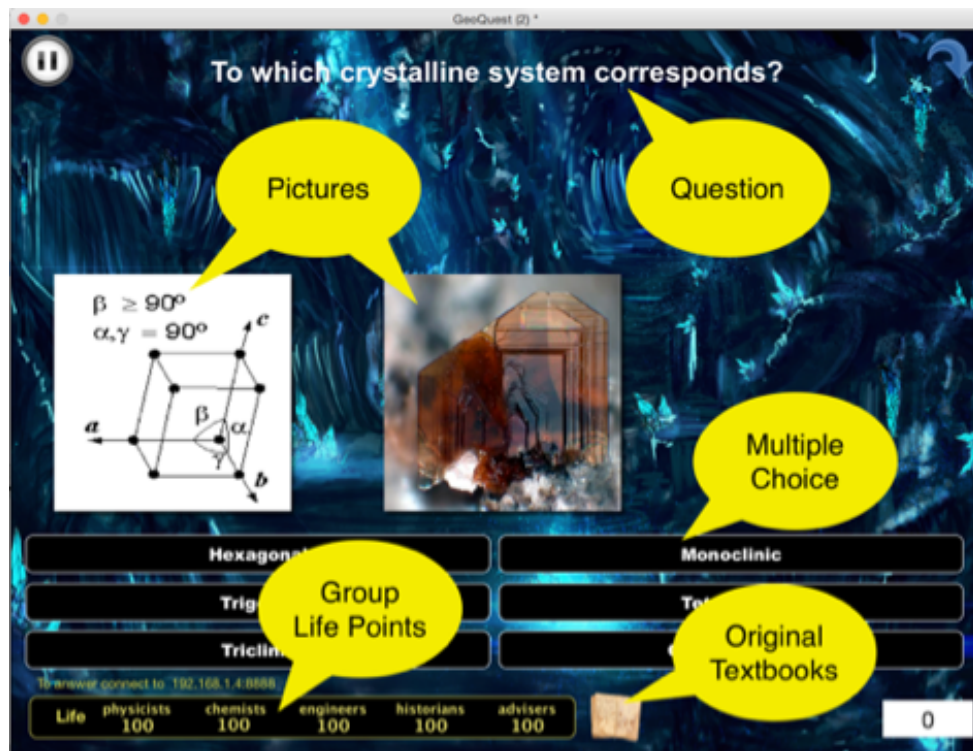


Figure 3.7.7. Example of game interface. Students can appreciate perfectly the shape, the crystal habit and the color of the mineral.

the correspondence between rock and geodynamic environment. In this way, the resolution of questions brings the players to find the deep interconnections between Mineralogy, Petrology, Volcanology and Geology.

Humanistic Questions

The authors' game aims to teach Earth Science through interdisciplinarity. The game creates strong interconnections between Earth Science and the humanities.

In the game, texts from Greek and Latin Classics are proposed; some of them are conveyed by the characters encountered along the way. There are also questions focused on these texts.

[...]

Discussion

Sociologists attribute to role play the triple value of:

- storytelling games (expression, communication, creativity);

- cooperative games (teamwork, tolerance, mutual understanding, listening);
- flexible games (different ages, different interests).

CLIL compliance

CLIL is an immersive learning approach that aims to build language and communication skills in a foreign language along with the development and acquisition of topic knowledge.

The best environment to learning both language and non-linguistic contents is certainly the teaching laboratory through a cooperative learning, since it will involve the “construction” of knowledge and not only its transmission. In authors’ games, it can be easily changed the game language compliance to CLIL recommendations.

Special Education Needs

- Different student levels: the path of play can be followed by students with different levels of knowledge and skills using the note books as compensatory measures;
- Visual impairment: a talking voice guides the players all over the game;
- Audio impairment: iconographic contributions, text on the question buttons and on speaking as subtitles.

All are ideal for a personalized didactic, even in the case of Special Education Needs. Technology enhanced learning environments have great potential to provide equality on diffusion of knowledge, sharing resources, social involvement and participation of the disabled learners within the society. Reaching out learning facilities with the support of technology, learners with special needs can enrich their potential for their learning experience anytime and anywhere. (Altınay et al., 2016). GeoQuest design is a particular type of Serious Games. Characteristics of serious games include: a storyline (or some story-based elements), types of goals (short-term, medium-term or long-term), types of rewards (such as feedback on response accuracy, rewards for correct responses or cumulative point systems across trials), increasing levels of difficulty over time (or some potential difficulty increases), and individualized learning (including

individualized starting points, some provisions of choice or presence of clinician/teacher facilitators). (Whyte et al., 2015). Serious games are designed to foster learning of targeted skills that are particularly difficult and not rewarding for participants. A central goal of serious games is that the learning in the game generalizes to improve real life outcomes. Serious games accomplish these goals, in part, by employing principles of video game design to create enjoyable and immersive environments but, importantly, they are also grounded in theories of learning and development. (De Freitas, 2006). GeoQuest design is also a nice example of Digital Storytelling. The story-driven goals (especially when designed to be meaningful to the individual playing the game) can increase affective engagement and are thus critical for providing a rationale for driving game play. (Baranowski et al., 2008). A narrative storyline that elucidates the motivations of why characters in the game might be angry (and what behaviors should follow the correct identifying the expression) is essential for linking knowledge of an emotional expression to actionable social and communicative behaviour. As noted, players can be motivated by their own curiosity when the game's storyline provides mysteries that allow for exploration. (Garris et al., 2002).

Skills Assessment

The educational game mobilizes demanding learning situations for students, which contain a challenging dimension in relation to their knowledge and experience and which solicit the activation of their resources and lend themselves to different ways of solution. This form of learning is based on the definition of a complex thought, not purely reproductive or mechanical, where the path of action is not fully specified a priori, since it involves self-regulating processes of thinking (Maraffi & Marinelli, 2016). The system that controls GeoQuest can recognize answers of each student, therefore can be used for the skills assessment: the score validation is guaranteed by learning "in situation", typical of gaming.

3.7.1. Learning Environments for an Authentic Evaluation

By competence we mean (Pellerey, 2011) the demonstrated ability to use knowledge, skills and personal attitudes, both social and methodological, in situations of work or study and in professional or personal development, to face and solve a problem. The identification of competence appears, therefore, as a priority of the evaluative activity since learning consists in the appropriate and pertinent application of what students can do with what they know within real sense contexts that propose to them problems and tasks to carry out responsibly. The educational game mobilizes demanding learning situations, which contain a challenging dimension in relation to students' knowledge and experience, and which solicit the activation of personal resources and lend themselves to different ways of solution. The use of educational game is the "custody of a task performance" related to different fields of knowledge, useful to re-read the highlighted characters in relation to:

- ask students to recover their previous knowledge;
- encourage the use of complex cognitive processes (reasoning, transfer, critical thinking, creative thinking);
- be inserted into meaningful and real contexts;
- be open to solving different paths.

In the following Maraffi & Marinelli (2016) you can see how our CCRPG can be effective for skills assessment.



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12, 2016 HAWAII PRINCE HOTEL WAIKIKI, HONOLULU

VALUQuest: a Role Playing game FOR SKILLS ASSESSMENT

Sabina Maraffi* & Anna Lisa Marinelli**

*School of Science and Technology, Geology division - University of Camerino
Via Gentile III da Varano, Camerino 62032, Italy
sabina.maraffi@unicam.it

**Direzione Didattica Statale 3°Circolo, Aversa, Caserta - Italy
annalisa.marinelli@libero.it

[...]

Introduction

The debate on skills, so relevant today, entered the school when it was necessary to rethink systematically and systemically the relationship between the dimension of knowledge and the one of education. From learning the basic skills (reading, writing and arithmetic), it moved to the competence, as an expression of the value of socialization and the promotion of valid models for the future citizen, over the family ones. In the era of digitization competence is defined as the "creative and intelligent capabilities of knowledge, to make them the generative source of others" direct to operate in certain situations.

Skills assessment in primary school

The problem of school in general and specifically of primary school is, therefore, in being able to envisage the most suitable tools for individualizing generative pedagogical opportunities to employ, as well as strategies useful to transfer, but also the possibility of being able to evaluate them in students. Considering the various schools of psychology, from behaviorism to cognitivism, we come up to constructivism, for which knowledge does not exist independently from the person. Constructivism considers the complex tasks not only cognitive, characterized by non-linear forms of rationality, and it considers learning as interaction,

operation and set of continuously processed performances. The experience moves according viewpoints, individual history, emotion, personal styles that persist even in the rational stage; therefore, in this perspective the significance of competence assumes a great depth and responsibility for the person and for any practical action whether occasional or deliberately willed. Guy Le Boterf (2005), as part of the definition of the concept of competence, proposes the "experiential cycle" as putting focus on dynamics of commissioning situation, formalization, conceptualization, transfer, contextualization and re-contextualization of personal experience. These variables evolve from two centers of reference:

One of situations characterized by repetition, simplicity, execution of the order, strictly prescribed steps where competence is limited to the knowing how to do it and to knowing how to play out; One of situations characterized by unexpected, innovation, need for quality, complexity, resourcefulness, where you can define knowing how to act and react, what to do, when and how, that is the operating way of knowing how to be."

The role of the teacher

About teaching and education (Fig. 3.7.1.1), De Benedetti (1998) claims that competence in school is developed as a task dilated over time,



Figure 3.7.1.1. Students have an immersive experience to be "in situation" for an authentic evaluation.

so that the students, with their different intelligences and abilities find all the conditions of learning. This task presupposes a sequential development, from the proposal to the product, the introduction of necessary knowledge, of techniques and materials, the organization of the working set, the definition of product and training results, the selection of the strategies to be adopted and relevant information, the heuristic error handling. Then the teacher, who as a trainer supports and model student's behavior (Fig. 3.7.1.2), with examples and suggestions, enables the development of metacognition, provides information as positive feed-back, facilitates in students the construction process of knowing how to act in



Figure 3.7.1.2. Teachers are trainer and support for students.

the situation, compares learning ways of the other students. According to this perspective, the competence may be defined as an operational or behavior pattern, a set of experiences and inference processes which allow to adapt to situations and to the many complicated contexts you may face. Then you realize the competence when knowledge, skills, qualities, culture, emotional resources, formalized cognition intersect and make an operating plan that must be first thought and then realized (Le Boterf, 2000; Pellerey, 2002).

What to evaluate?

In socio-cultural constructivist context, the learning provides a project proposals made education, efficient laboratories, involving experiences so as to encourage the non-stop restructuring of mind

through continuous exploration, experience, reflection; it must be able to promote forms of self-awareness which involve the student constantly renewed capacity to interpret reality. So the strategies of teaching suggested by constructivist education are cognitive/conceptual maps, models network, timelines and procedural structures, stories/biographies cognitive, cooperation moments between the various contributions of disciplines.

In conclusion, it is possible to suggest a complex definition appeared in last researches about education: competence is not only technique dexterity performance and not only abstract knowledge, but it comes out from an agreement of knowledge and actions, personal dynamic factors, efficient-effective forms of control over procedures, over adopted tools, over results achieved.

Design an educational path for the evaluation of skills

From this definition it emerges that: to design a teaching program based on the skills to achieve and to evaluate them, you need to understand two conditions:

a) that skills are the result of paths where students acquire knowledge and skills, but also bring into play as people in their ways to reuse and repurpose those knowledge and skills in a personal way;

b) that assessment of skills springs from qualitative and quantitative sum of surveys and investigations carried out during the training path.

Taking up a psychoanalytic suggestion, some authors have proposed to represent the competence like an iceberg, in order to highlight the duplicity of components in its detection: a visible component, explicit, expressed through observable performance that refer mainly to the property of knowledge and skills possessed from the subject; a latent component, implied, which requires an exploration of inner dimensions related to motivational, volitional, social-emotional processes of the student. Then evaluate the skills means to adopt modalities and tools by which to go under the surface and probe the subjective and internal components of the learning process.

How to evaluate the skills?

The traditional docimological instrumentation encounters great difficulty in facing skills assessment-linked challenges: the learning tests, more or less structured, provide useful devices to verify the knowledge and skills possessed by the student. But Pellerey argues that the recognition of a complex reality requires activation and comparing of several levels of observation, to allow an articulated and multi-perspective reconstruction of the object of analysis. The polymorphic nature of the concept of competence thus provides, in observation aimed at assessing the competence, more dimensions. This perspective of the competence assessment also requires that the rules for construction of the evaluative test are directed to consider reality tasks and complex and meaningful contexts. In fact, the traditional forms of assessment (both through not structured tests than through structured ones):

- tend to be retroactive, ie based on the assessment of what the student has learned, and not proactive, able to guide the student towards the improvement of his own learning;
- are based almost exclusively on extrinsic factors of motivation (score, academic achievement, competition between classmates etc.) than intrinsic factors (interest, pleasure of learning, curiosity, etc..);
- tend to be centered on an inert knowledge, not much transferable and applicable to real-life contexts.

Consequently, the assessment is poorly predictive of what the student is able to do with what he knows. From that the need to assess the skills no longer based on the reproduction of knowledge, but on active development of knowledge favored by authentic and challenging tasks, oriented to require students to use their knowledge and skills, to elaborate responses to meaningful and real contexts-linked tasks.

Assess skills with educational game

The educational game mobilizes demanding learning situations for the student, which contain a challenging dimension in relation to his knowledge and experience, and which solicit the activation of his

resources and lend themselves to different ways of solution. This form of learning is based on the definition of a complex thought, not purely reproductive or mechanical, where the path of action is not fully specified a priori, since it involves self-regulating processes of thinking. Through the game you can evaluate:

- content knowledge, ie declarative knowledge at the disposal of the subject on cultural objects that have to be evaluated;
- processes and skills, or procedural knowledge related to both dealt with cultural content, and to more general methods of knowledge processing (reflection, creativity, cooperation with other ones, decision making, etc..);
- provisions or habits of mind, ie the meta-cognitive, motivational and attributional processes that affect the ways in which the subject is placed into the learning experience.

[...]

3.7.2. Learning Environment for Special Educational Needs

Children with SEN participate equally, with the same commitment and dedication than the others and acquire the same learning experiences. (Martins et al., 2007) states that "it is necessary to question, reflect, interact with other children and the teacher, answering questions, planning ways to test previous ideas, confronting opinions, so you can create a practical activity that is intellectually challenging for the child, so that he keeps wanting to understand phenomena, relate situations, develop interpretations and make forecasts" (p.38). The teachers have the role of providing discovery situations and developing an attitude of interest, appreciation and fondness for practical-experimental activities (Neves et al., 2014).

Technology enhanced learning environments have great potential to provide equality on diffusion of knowledge, sharing resources, social involvement and participation of the disabled learners within the society. Reaching out learning facilities with the support of technology, learners with special needs can enrich their potential for their learning experience anytime and anywhere (Altınay et al., 2016). People with developmental disabilities generally need a significant amount of time and repetitive practice to master a task because of their difficulty with memory, motivation and attention (Turnbull et al., 2012).

Serious game are embedded with special education teaching/learning strategies and other elements that satisfy the special needs of persons with developmental disabilities because they utilize learning and teaching strategies commonly used in special education as an effective training method (Kwon & Lee, 2016). Kato et al. (2008) show that games can increase self-efficacy of children with health disabilities and ultimately lead to behavior change.

Strengths:

I. *Repetition*. Repetition is known to be the strongest factor influencing memory retention (Hintzman, 1976), making it one of the most important methods for learning among persons with developmental disabilities, achieving mastery of tasks through repetition and reducing the short-term cognitive load by automating the skills (Sweller, 2003).

II. *Narrative contest*. Lee et al. (2006) stated that having a narrative in game playing vastly reduces the player's cognitive load. Creating a narrative for a task increases efficiency, and improves the motivation and ability to solve complex problems (Goldman & Hasselbring, 1997).

III. *Memory retention*. It is best when information is embedded in context (Schank & Abelson, 1995; Zumbach & Mohraz, 2008). Without the context, the learner's cognitive load increases and his/her learning efficiency decreases.

IV. *Coherent feedback* (Ritterfeld et al., 2009). Immediate feedback reduces subsequent errors, helps with independent learning (Dihoff et al., 2005), and allows longer retention of the learned material (Epstein et al., 2003). Immediate feedback also assists in controlling one's own learning, thus increasing motivation (Butler & Winne, 1995). In serious games, feedback on the player's success or failure is presented visually and/or audibly.

V. *Serious games simulate the physical world*. Sitzmann (2011) conducted a meta-analysis of 65 studies on serious games, and reported that people who had been trained through games made better transitions to performing the actual tasks than did those trained with traditional approaches.

VI. *Serious games allow persons with disabilities to practice task completion skills in a physically safe environment* (Aldrich, 2009; Boulos et al., 2007; Coles et al., 2007).

VII. Games also utilize alarms and important cues such as hotspot, media controls, sound cues, guide, noise, abstraction, alert, switch, mouse-over, scaffolding, and game tips to help the player perform accurately (Aldrich, 2009; Gee, 2007).

VIII. The *visual modality*, which is considered to be effective in enabling persons with developmental disabilities to enhance understanding and remember information (Lee et al., 2006).

Narratives that integrate the storyline with goal learning increase enjoyment, immersion in the learning context, and learner motivation. Participants can develop emotional connections with characters. Continuous feedback and rewards for progress are critical for shaping behavior in serious games as learners work towards achieving challenging

goals (Whyte et al., 2015). Players can be motivated by their own curiosity when the game's storyline provides mysteries that allow for exploration (Garris et al. 2002).

Learning on Gaming in a New Digital Educational Environment is the topic of following publication (Maraffi & Sacerdoti, 2017b).



Learning on Gaming in a New Digital Educational Environment

Sabina Maraffi* & Francesco M. Sacerdoti**

*School of Science and Technology, Geology Division, University of Camerino, Italy - sabina.maraffi@unicam.it

**e-voluzione s.r.l. - sacerdoti@e-voluzione.it

[...]

Introduction

Innovative teaching technologies combines ICT, traditional and new media, and social networks, where gaming is a key element. It is now acknowledged the inadequacy of the traditional teaching methodologies, as the frontal lesson, which involves the master's role of the teacher with his communicative and argumentative skills and a receptive function by the student, through common or formal scientific language. Research shows that young people (10–17) have negative attitudes toward science and no interest toward engaging with science (European Commission, 2015). In a review study, Osborne et al. (2003) concluded that students' interest and attitudes to science declines when entering secondary school. What's more interesting in the findings of this study is that students' attitudes toward science in general are positive, but toward school science are not. A review of the literature shows that one approach to addressing the problem of young people's disengagement with science is by exploring alternative and attractive modes of communicating science (Prins et al., 2017). Chapman and Rich (2017) claim that games might encourage students to spend more time in studying, be more engaged and, as a result, learn more. Game designers should emphasize challenge and engagement while considering players' skills, which also contribute to the engagement and immersion (Hamari et al., 2016). Research has explicitly related the sense of presence, being there, immersion, or flow in different virtual reality interfaces with positive learning outcomes (Abrantes & Gouveia, 2012; Fassbender et al., 2012).

Learning on Gaming is a new teaching approach, in which didactic is hidden within the game: the didactic contents are designed specifically for the game and integrated into it (Maraffi & Sacerdoti, 2016b). This approach is based on a new didactic methodology: a Computer Class Role Playing Game (CCRPG), which has already given more than satisfactory results, both in the age range of primary and secondary school education (Maraffi et al., 2016a; Maraffi & Sacerdoti, 2016a; Maraffi et al., 2017d). Based on this considerations, the purpose of this study is verify if our CCRPG provides a new digital educational environments to improve STEM education.

Theoretical Framework

Games increased reported enjoyment levels, especially in subjects where students reported the greatest anxiety about learning, and this is correlated positively with improvements in deep learning and higher-order thinking (Crocco et al., 2016). Most students find that their skills improve slightly with game based learning. A lot of students feel that they learn a lot about effectively communicating science (Mercer et al., 2017). The acquisition of skills needs of a situated learning environment, since competence is the ability to make decisions and know how to act and react in a pertinent and valid way in contextualized and specific situations. According to the Guidelines, competence can be "assured by using tasks of reality" (MIUR, Guidelines for the certification of competences in the first cycle of education). Situated learning is when learners acquire knowledge and skills by performing activities in real, interactive situations; this enables them to rationally and meaningfully interpret the knowledge and skills acquired during this process. The new knowledge acquired by learners through situated learning is not isolated or fragmented but complete and is truly mastered following reorganization (Huang et al., 2016). Many teachers think that 3D learning environment is a guarantee of situated learning. It is not true.

[...]

Gamification and game-based learning are not only areas worthy of further inquiry but may reveal a way for higher education to combat declining enrollments through the innovative use of interactive games and simulations within the classroom and the overall tertiary educational experience (Wiggins, 2016).

The Higher Education environment must be prepared to meet the needs of the cultural shift in learning by embracing the concept of non-traditional teaching through non-traditional strategies. In many current and future classrooms, digital natives will be engaged using their own mobile devices. The classroom will no longer be a prohibitive space for innovation and technology engagement. Educators will and should seek innovative ways to engage students by incorporating technology (e.g. devices) in the curriculum. As a result, teaching and learning will be transformed from traditional approaches and engagement to innovative, unconventional forms of knowledge transfer (Spangler & Kiernan, 2016). Therefore, our research questions are:

- Does CCRPG provide a new digital educational environments to improve STEM education?
- Does Learning on Gaming foster CLIL approach?
- Does the learning environment perception change with students' age?
- Are experimental results, obtained in school education, inferring for higher education?

Methods

Research tool: CCRPG [...]

Experimental Observations

During the experimental activities were collected (Maraffi et al., 2017d) qualitative data about students' engagement and learning environment. With the teachers' and students' consent, we record a video with the classroom activities. This observation and video data served for triangulation purposes for the post-tests data, which contributes to the validity of the findings (Prins et al., 2017).

Findings

Figure 3.7.2.1 shows one of the comparison between pre-test and post-test questions in testing of SoilQuest with 8-12 aged students (Maraffi et al., 2016b).

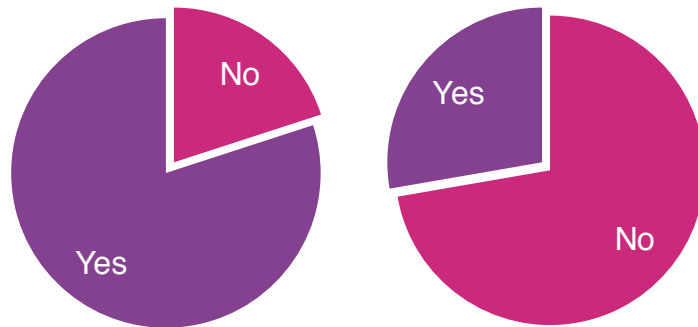


Figure 3.7.2.1. Students' answers to question: "Is the soil a renewable resource?" before playing SoilQuest (left pie) and after playing (right pie).

Figure 3.7.2.2 refers to a very common misconception, existing also among people with a medium-high education degree: that tectonic

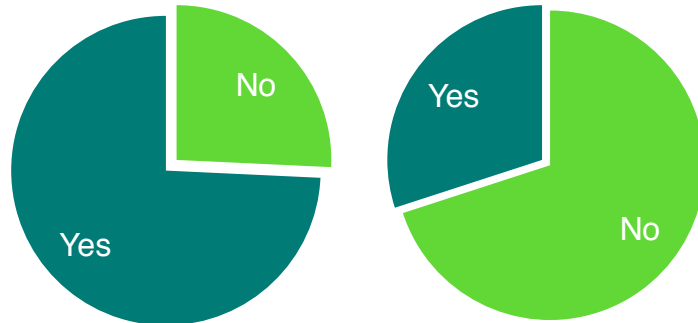


Figure 3.7.2.2. Students' answers to question: "Are tectonic earthquakes precursors of volcanic eruptions?" before playing GeoQuest (left pie) and after playing (right pie).

earthquakes can be precursors of volcanic eruptions. After playing with CCRPG, most students removed the incorrect information.

Observations in Classrooms

Classrooms observations and video-recordings (see Table 3.7.2.1) were analyzed in order to obtain information about:

- Collaboration of students

- Interaction among students and teacher
- Question response time
- Interaction between students
- The results were matched with the satisfaction questionnaires.

Table 3.7.2.1. Observations in Classrooms.

Interaction and short response times indicate full engagement; the percentage answer distribution over time rate indicates whether the involvement was persistent.

Observations in Classrooms	Frontal Teaching Activity	Multimedia Didactic Activities (PPT)	CCRPG
Collaboration of students	none	none	high
Interaction among students and teacher	episodic	low	productive
Question response time (measurable by game engine)	_____	high	immediate
Percentage answers distribution over time (measurable by game engine)	_____	decreases	persistent

In Figure 3.7.2.3 it can be seen a graphical representation of what it

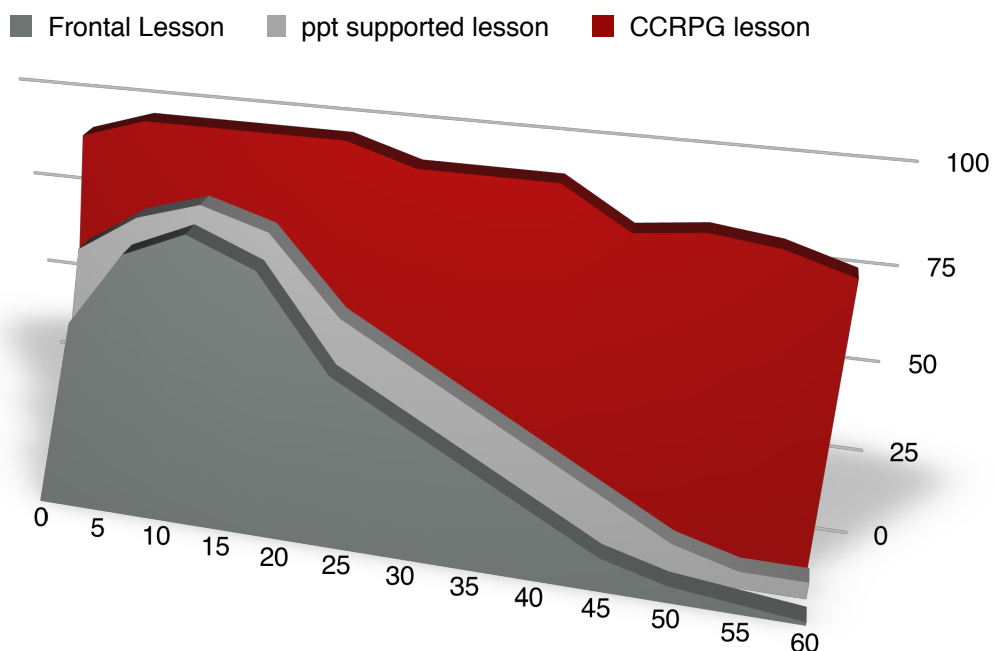


Figure 3.7.2.3. Percentage of attention level measured after frontal teaching activity (grey), after multimedia teaching activities supported by PowerPoint (light) and after GeoQuest teaching activities (red). Average calculated on 26 classes.

has been observed in the classrooms. In all the experimental groups the

highest level of attention lasted longer, interaction was greater and answer time were persistently faster.

Table 3.7.2.2. Data fig. 3.7.2.3

Time of teaching activity in minutes	Frontal Lesson	ppt supported lesson	CCRPG lesson
	Percentage of attention level measured through the percentage of interactions made by pupils with their own devices.		
0	0	0	0
5	55	70	95
10	75	80	100
15	82	85	100
20	75	80	100
25	50	60	100
30	40	50	95
35	30	40	95
40	20	30	95
45	10	20	85
50	5	10	87
55	3	5	85
60	1	5	80

Discussion

Experimental observation evidences show that CCRPG seems to be the most effective Game Based Learning typology to improve student learning. First of all, digital storytelling enhances a student engagement, in agreement with Akkerman et al. (2009), which found that 'storify' history using mobile games had a positive effect on student engagement. Aktas and Yurt (2017) found that digital storytelling has a positive effect on permanent learning too.

Experimental results and classrooms observations agree to demonstrate that teaching activity with CCRPG creates a situated learning environment, profitable for collaborative learning and acquiring skills in

STEM education. It is interesting to look carefully at figure 5. The level of attention in the control classes (front lesson and multimedia lesson) has been estimated through the response time to the questions asked by the teacher during the teaching activities. Questions are similar to those in the game. The level of attention related to CCRPG activity has been assessed by measuring students' response times to game questions: both skill questions and those to choose the path to follow. It is clear that attention rate for the frontal lesson and the one related to the multimedia lesson are similar: the multimedia activities (ppt supported) allow only a degree of attention slightly larger. This may be the contribution of the multimedia tool, which increases the students' perception, but with the same small attention duration and the same drop out. Instead, the CCRPG allows a significantly greater attention, with a persistent attention during the whole game.

We can conclude that it is not the multimedia tool itself to give a more profitable learning environment, but the engaging and the interactivity. They derive from a wise combination of digital and multimedia elements glued by storytelling and Learning on Gaming approaches, as shown in Table 1, as in our CCRPG GeoQuest Project. Situated learning environment makes the use of the foreign language as a communication vehicle and attention is shifted to the elements of the mystery and playing improves its learning. Findings do not differ by students' age, indeed, the first observations probably will fit higher educational group too.

3.8. Conclusions

In the light of what has been illustrated in this chapter, the GeoQuest project has been refined and constantly improved on the basis of what emerged in the first experimental phase and the observations made in the classes where the experiments have been carried out. In the next phase, it will be illustrated that the work has been the subject of some European projects (chapter 4) which provided further experimental data.

4. Chapter IV - Experimental Results

In the previous chapters, different elements and aspects of the GeoQuest project have been reported as experimented in separate contexts and environments. In this chapter, instead, the experimental protocol is reported, as it was used for the final verification of the project. The results obtained during the teaching experimentation of the Computer Classroom Role Playing Game GeoQuest are presented. Paragraph 4.1 reports the work plan, which shows that the experimentation took place in two phases. In a first phase the results were taken into account to calibrate the experimental protocol and to improve and rationalize the teaching technology.

The results obtained during the first phase have been published and are reported in two articles: Maraffi & Sacerdoti (2016b) and Maraffi et al. (2017d). Extracts from these papers are given in the paragraph 4.2. The second phase of the experimentation and the final results are presented in the paragraph 4.3.

4.1. Work plan

The Work Plan of this research project is shown graphically in figure 4.1.1. and in details in Table 4.1.1. The organization of the research activity started from the identification of both the students' and the teachers' needs. In order to identify the students' educational needs, the data of the OECD-PISA surveys, the objectives of Horizon 2020, as reviewed by 2030 Agenda for Sustainable Development were analyzed. Teachers' needs were collected through three surveys on 581 teachers (Maraffi & Sacerdoti, 2018c). Based on the data collected, a first adventure pathway of the CCRPG GeoQuest was implemented. We then moved on to the validation of the experimental protocol; the first phase of experimentation was used to test and calibrate the methodology. LEVA SPAZIO in particular, the initial experimentation with the prototype of the game included the following steps:

- A. Testing the experimental protocol;

- B. Calibrating the experimental protocol;
- C. Validating the experimental protocol;
- D. Verifying applicability in different situations;
- E. Performing of first qualitative and quantitative experimentations
- F. Developing a rigorous experimental protocol.

Then, new adventure pathways were implemented and this phase was followed by the final tests, which were used for collecting the data for the final evaluations, specifically:

- A. Validation of the final experimental protocol;
- B. Quantitative experimentation in classroom;
- C. Experimentation with teachers in training;
- D. Definitive quantitative experimentation.

The project proceeded then by presenting and publishing the results. The project timeline is shown in Table 4.1.2.

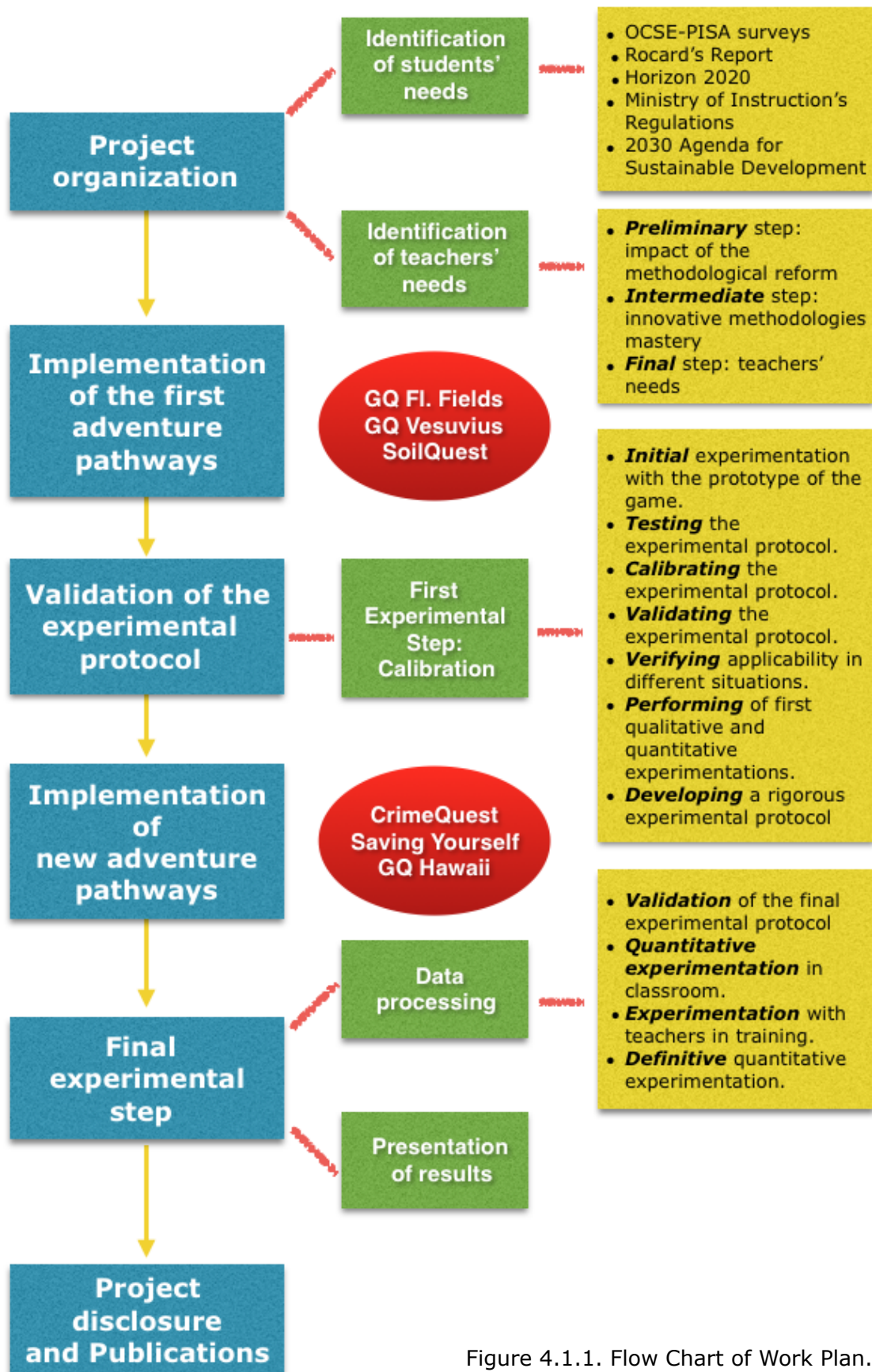
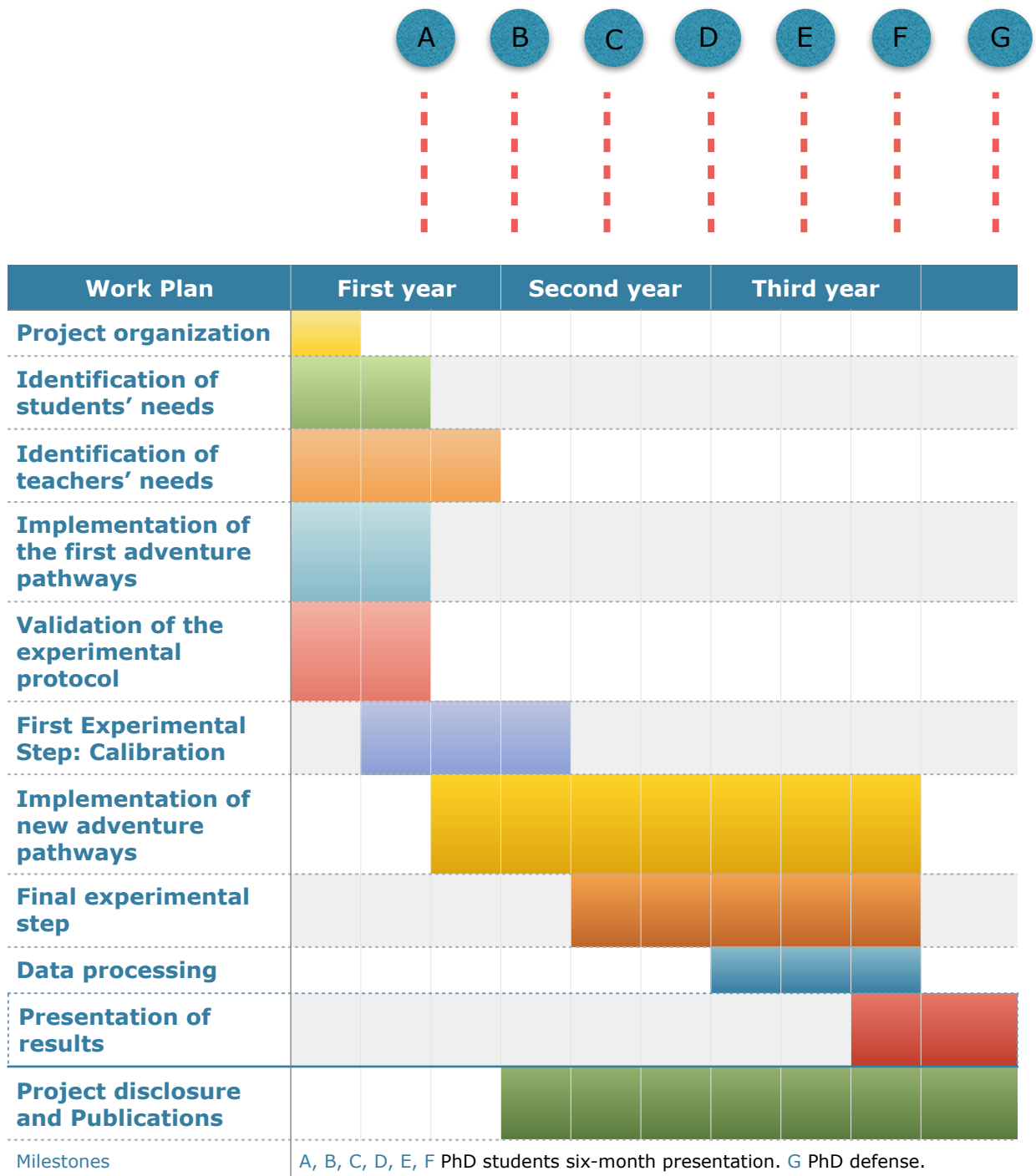


Figure 4.1.1. Flow Chart of Work Plan.

Table 4.1.1. Work Plan

Work Plan	Steps			
Project organization	Idea	Purpose	Aims	Solution
Identification of students' needs	OCSE-PISA surveys	Rocards Report (2007)	Horizon 2020; Ministry of Instruction's Regulations	2030 Agenda for Sustainable Development
Identification of teachers' needs	Preliminary step: impact of the methodological reform	Intermediate step: innovative methodologies mastery	Final step: teachers' needs	Calibration step: first verification
Implementation of the first adventure pathways	<i>GeoQuest Phlaegraean Phields</i>	* <i>GeoQuest Vesuvius</i> * <i>SoilQuest</i>		
Validation of the experimental protocol	Initial experimentation with the prototype of the game.	Testing the experimental protocol.	Calibrating the experimental protocol.	Validating the experimental protocol.
First Experimental Step: Calibration	<i>Processing and improvement</i> Calibrate and evaluate the impact and effectiveness of CCRPG methodology in order to make all the necessary changes to the learning environment: software characteristics, player interactions, game features, and enhancements to the stories already completed.	Verifying applicability in different situations, school types, class types, and student ages.	Performing of first qualitative and quantitative experimentations.	Developing a rigorous experimental protocol to be used in the final phase of the experimentation.
Implementation of new adventure pathways	* <i>GeoQuest Phlaegraean Phields</i> (improved and optimized)	* <i>GeoQuest Vesuvius</i> * <i>SoilQuest</i> (improved and optimized)	* <i>CrimeQuest</i> * <i>Saving yourself</i> (Apps) * <i>GeoQuest Hawaii</i>	* <i>GeoQuest Iceland</i> (Joint Project Italy-Iceland, Science in Stage Europe)
Project disclosure and Publications	Collaboration with other PhD students to create adventure pathways for all students'ages.	Participation and winning of the Ministry of Education's competition for the implementation of innovative teaching methods through GeoQuest Project	Joint Project Italy-Iceland won by Science on Stage Europe Executive Board: sharing of CCRPG and implementation of <i>GeoQuest Iceland</i> by Icelandic high school team	Sharing Apps for Emergency; implementation of CCRPG for security and tourism.
Final experimental step	Validation of the final experimental protocol	Quantitative experimentation in classroom: students and teachers.	Experimentation with teachers in training.	Definitive quantitative experimentation.
Data processing	Data analysis	Data representation	Findings	Discussion
Presentation of results	Disclosure	Publications	Workshops	Thesis

Table 4.1.2. Research Project Timeline



4.2. Identification of teachers' needs

Preliminary step: impact of the methodological reform

In the initial phase of the research, interviews were conducted with teachers to collect the actual and perceived needs for the implementation of innovative teaching methods. The sample interviewed consisted of 120 teachers: 40 from primary schools, 40 from secondary schools (teaching the first grade, consisting of 11-14-year-old students) and 40 from high schools. The questions expected an affirmative or negative answer. The questions posed and the results, expressed as a percentage, are summarized in Table 4.2.1. While an in-depth analysis of all the answers provided and a careful evaluation of the implications underlying the answers themselves would be cumbersome, we can summarize the obtained results as in the following table 4.2.1. Primary school teachers' pupils are 6-10 years old; secondary school teachers' students are 11-13 years old; high school teachers' students are 14-18 years old. In yellow are highlighted questions of Fig. 4.2.1.

Table 4.2.1. First step - teachers' survey: interview about innovative teaching implementation.-1. Primary school: pupils age 6-10; secondary school: students age 11-13; high school: students age 14-18. In yellow questions of Fig. 4.2.1.

		Primary		Secondary		High		Ave	Ave
	Questions	Yes	No	Yes	No	Yes	No	Yes	No
Innovation	Do you think the incentive towards a methodological innovation in teaching is positive?	72	28	65	35	57	43	64.7	35.3
	Do you feel adequate to the use of new teaching methods?	16	84	29	71	34	66	26.3	73.7
	Do you think you could change the way they teach with the aid of training courses?	75	25	61	39	52	48	62.7	37.3
	Are you willing to take refresher courses to improve your professional skills?	66	34	55	45	41	59	54.0	46.0
	Are you willing to take refresher courses to improve your students' learning outcomes?	66	34	53	47	31	69	50.0	50.0
ICT	Do you consider your preparation adequate to provide your students with the scientific skills required by the current world?	45	55	69	31	83	17	65.7	34.3
	Are you willing to update yourself to effectively use IT tools in teaching?	32	68	29	71	18	82	26.3	73.7
	Are you willing to update yourself to effectively use IT tools in your professional practice?	25	75	20	80	13	87	19.3	80.7
	Do you regularly use your email for your work communication?	15	85	33	67	41	59	29.7	70.3
	Do you regularly use the web to keep yourself professionally updated?	19	81	26	74	61	39	35.3	64.7
New approaches	Do you think to be able to apply the CLIL approach to your teaching?	5	95	11	89	18	82	11.3	88.7
	Do you think the linguistic competence of a teacher of a different discipline could be effective for students to learn a foreign language?	2	98	3	97	7	93	4.0	96.0
	Do you think more teachers team-working in a classroom could be effective?	69	31	24	76	19	81	37.3	62.7
	Would you like to have innovative user-friendly teaching materials?	85	15	83	17	86	14	84.7	15.3
	Would you like to have teaching materials that provide the possibility of an authentic evaluation?	91	9	88	12	72	38	83.7	19.7

In general, the teachers consider positively the incentive towards methodological innovation, though with some reservations. They believe this innovation could require teacher training through refresher courses, but not all of them would be available to undergo the update voluntarily. Here a series of factors intervenes, among which the workload to which the teachers are subjected and the attitude to question themselves:

- Regarding new technologies, teachers feel adequately prepared to provide students the scientific skills required by modern society. Given the choice, they would not undergo refresher courses on ICT (Information and Communication Technologies); however, this seems in contrast with the declarations provided by the majority of the teachers, , indicating that they do not use computer tools, neither for professional updating, nor for communications (email, etc..).

- As for the requests to use a new methodological approach, such as CLIL (Content and Language Integrated Learning) and as teaching planning and skill assessment, teachers believe to feel themselves not appropriate to support them. They assert that, especially for the CLIL, although prepared and certified by MIUR refresher courses, foreign language learning requires the linguistic mastery exclusive to mother tongue teachers, or at least to the teachers dedicated to this professional purpose.

- Among the issues discussed with the teachers, it was decided to focus on three questions, the results of which are shown in the diagrams in Figure 4.2.1. The teachers believe that they are poorly suited to the use of new teaching methods (Figure 4.2.1 a, b, c), but are not willing to voluntarily undergo refresher courses, especially on the use of ICT in teaching (Figure 4.2.1 d, e, f). On the other hand, they would rather appreciate innovative teaching material already structured and easy to use (Figure 4.2.1 g, h, i).

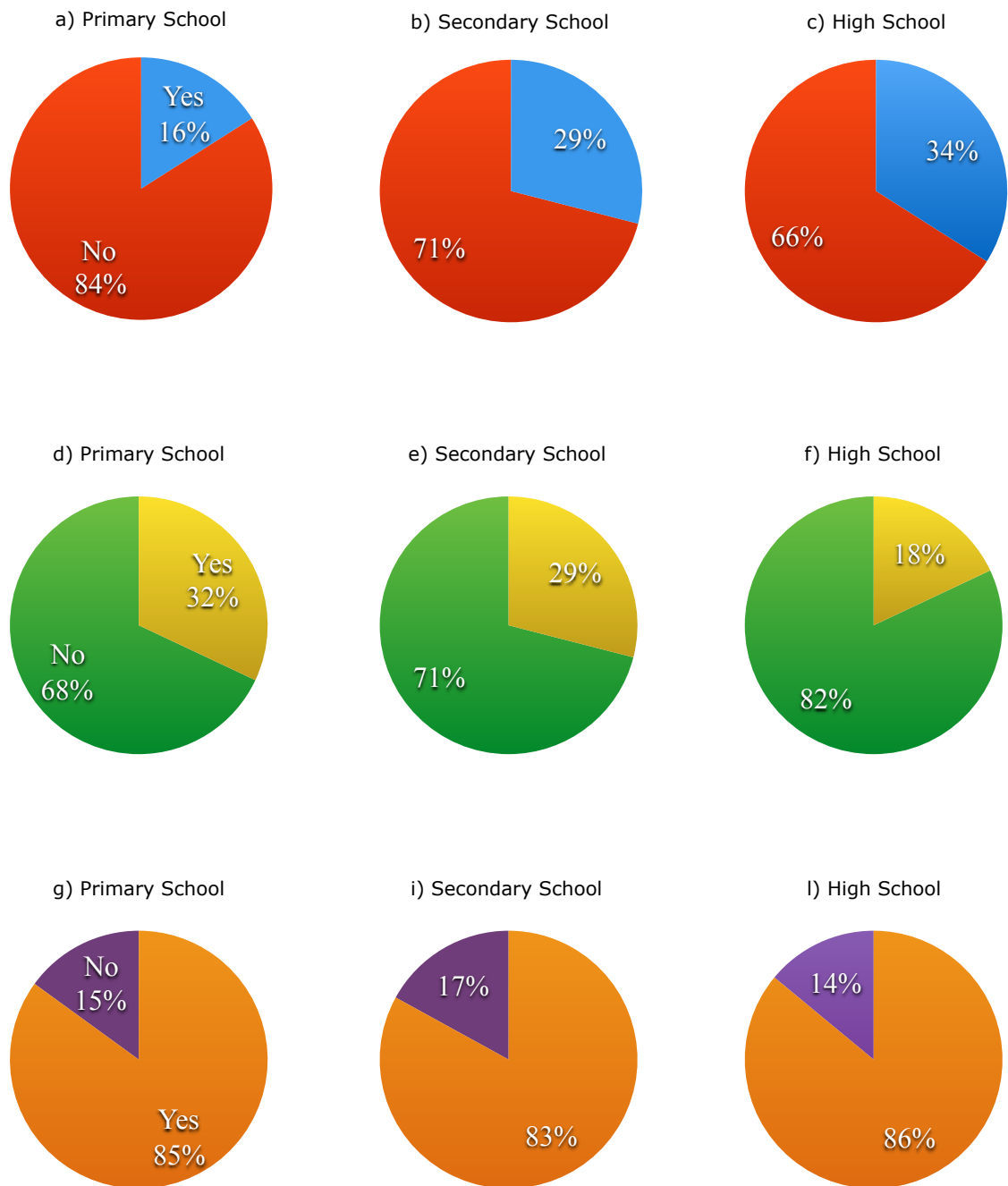


Figure 4.2.1. Teachers' answers (a, d, g: primary schools; b, e, h: secondary schools; c, f, i: high schools) to three significant questions. a, b, c: "Do you feel adequate to the use of new teaching methods?"; d, e, f: "Are you willing to update yourself to effectively use IT tools in teaching?"; g, h, i: "Would you like to have innovative user-friendly teaching materials?".

Data collected in this first research step were used to calibrate the technical-methodological characteristics of the GeoQuest Project, taking the main teaching and educational needs perceived by the teachers into account. Keep in mind that the GeoQuest Project was born as an educational innovation tool, to improve students' learning of Science (Maraffi & Sacerdoti, 2017a), the obtainment of Science and Technology skills (Maraffi & Sacerdoti, 2016a) and to enhance key competences of citizenship (Maraffi et al., 2016b). In fact, to obtain more effective learning results, the teaching materials must be adapted to the needs of the teachers and must be user friendly.

Intermediate step: innovative methodologies mastery

In a second research step regarding the teachers, a sample of 22 teachers (all grades of school, teaching different subjects) voluntarily participated in a refresher course in "Innovative teaching methodologies and digital teaching" was analyzed. In this case, teachers were asked to express a numerical evaluation - on a scale of 1 to 10 - about 10 questions. The results are collected in Table 4.2.2. The results of the second survey show that:

- among the few teachers who would train themselves to innovate their teaching methodologies (Figure 4.2.2), the web and teaching materials are used rather frequently (votes around 7/10). The web in particular is mostly used for translators and vocabularies (8/10). The perception of teachers' pedagogical skills and the mastery of innovative teaching methods is only sufficient (6/10), while the laboratory approach is somewhat higher (6.7/10). The use of technological tools in teaching is insufficient, such as multimedia blackboards (5/10) and tablets (5.7/10), while the mastery of software utilization is definitely insufficient (4.6/10).

Table 4.2.2. Second step teachers' survey: perception of teachers' teaching skills. In yellow "sufficient" results, in orange "insufficient" results, in red "definitely insufficient" results.

Questions	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Ave
Own pedagogical skills satisfaction	8	7	8	5	7	7	5	5	7	5	5	8	6	6	7	6	7	7	8	6	6	8	6.5
Knowledge of modern teaching methods	7	7	9	5	6	7	5	5	7	5	5	7	5	5	5	5	8	8	8	5	5	7	6.2
Use of varied teaching methods	7	7	9	5	6	8	6	6	6	6	6	7	7	7	7	7	7	7	7	7	1	7	6.5
Ease to find educational materials on the web	6	7	7	5	8	7	6	7	7	6	6	8	8	8	8	9	9	9	9	7	4	5	7.1
Use of web educational materials	7	6	7	7	9	8	5	7	7	6	6	9	8	8	8	9	10	10	10	5	4	6	7.4
Use of a Multimedial Blackboard as a projector exclusively	7	6	5	7	5	6	5	2	7	2	2	6	8	7	7	9	1	1	1	4	4	7	5.0
Multimedial Blackboard software mastery	5	6	5	5	7	5	5	5	6	2	2	7	5	5	5	8	1	1	1	5	5	5	4.6
Use of computers for teaching	5	6	9	5	8	6	5	6	6	6	6	8	4	4	8	9	10	10	9	5	5	5	6.6
Use of tablet for teaching	5	6	9	2	7	6	6	2	6	6	2	9	2	3	8	4	10	10	9	5	4	5	5.7
Need to change teaching method	8	7	5	5	6	7	6	6	7	6	6	9	7	7	8	6	7	7	7	6	5	8	6.6
School website usability for institutional purposes	8	8	8	4	6	7	6	6	7	6	5	7	9	9	8	6	8	8	10	7	5	8	7.1
Email usability for institutional purposes	7	8	8	4	8	8	7	7	7	6	6	7	9	9	7	9	10	10	9	6	7	7	7.5
Use of computers to store teaching materials	5	6	7	7	8	6	7	7	8	6	6	9	8	8	8	9	9	9	9	7	7	5	7.3
Use of vocabularies, dictionaries and translators on the internet	7	7	9	7	9	6	7	7	7	7	6	9	10	10	8	9	9	10	10	8	7	6	8.0
Multimedia keynote preference	5	7	7	5	8	5	6	7	6	6	6	9	5	5	6	5	9	10	9	5	4	4	6.3
Use of audio/video media in teaching	7	7	7	5	7	6	6	5	5	7	6	8	5	5	8	9	10	10	10	5	5	7	6.8
Need to maintain a laboratory approach	5	8	9	5	7	5	6	6	6	6	6	9	5	5	7	7	9	9	9	7	5	7	6.7
Social network use	8	8	5	5	7	5	6	7	6	6	6	6	9	9	7	8	10	10	9	8	7	8	7.3
Use of a gaming approach in teaching	7	8	10	5	7	8	6	7	7	7	7	8	5	5	7	9	10	10	9	9	7	7	7.5
Knowledge and skills evaluability	8	7	10	5	6	7	8	6	7	6	6	7	7	7	6	8	8	7	8	8	7	8	7.1

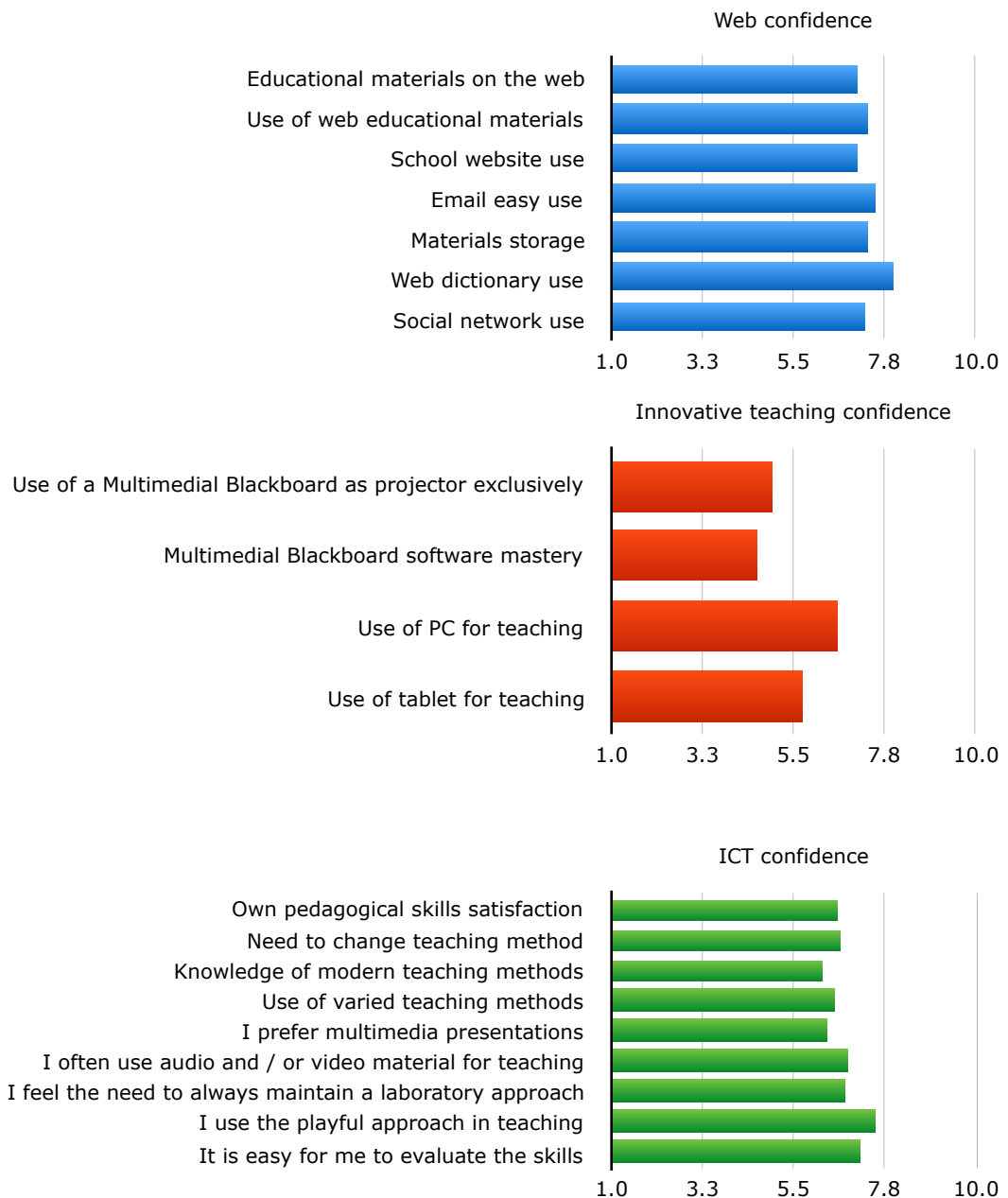


Figure 4.2.2. Web confidence, Innovative teaching confidence and ICT confidence, measured on teachers sample of survey 2.

Final step: teachers' needs

Subsequently, a third phase of investigation with the teachers was carried out. In this case, the survey sample consisted of 439 teachers

Table 4.2.3. Data of fig. 4.2.2	
	Evaluation
Educational materials on the web	7.1
Use of web educational materials	7.4
School website use	7.1
Email easy use	7.5
Materials storage	7.3
Web dictionary use	8.0
Social network use	7.3
Use of a Multimedial Blackboard as projector exclusively	5.0
Multimedial Blackboard software mastery	4.6
Use of PC for teaching	6.6
Use of tablet for teaching	5.7
Own pedagogical skills satisfaction	6.5
Need to change teaching method	6.6
Knowledge of modern teaching methods	6.2
Use of varied teaching methods	6.5
I prefer multimedia presentations	6.3
I often use audio and / or video material for teaching	6.8
I feel the need to always maintain a laboratory approach	6.7
I use the playful approach in teaching	7.5
It is easy for me to evaluate the skills	7.1

participating in the compulsory refresher courses required by the three-year MIUR update plan¹.

Within this sample 154 teachers followed the refresher courses in Didactic Planning of Sciences for Skills, and 285 teachers followed the course of approach to CLIL. Results of the third survey are summarised in Table 4.2.4.

National Plan for teacher training 2016/2019, D.M. 797 of 2016

Table 4.2.4. Third step teachers' survey: interview about innovative teaching implementation.

Questions	Yes	No
Do you feel adequate to the use of new teaching methods?	27.4	72.6
Are you willing to update yourself to effectively use IT tools in teaching?	19.1	80.9
Would you like innovative user-friendly learning materials?	89.3	10.7

We can note that the needs of the teachers less interested in updating and professional improvement are the same as those of the first survey

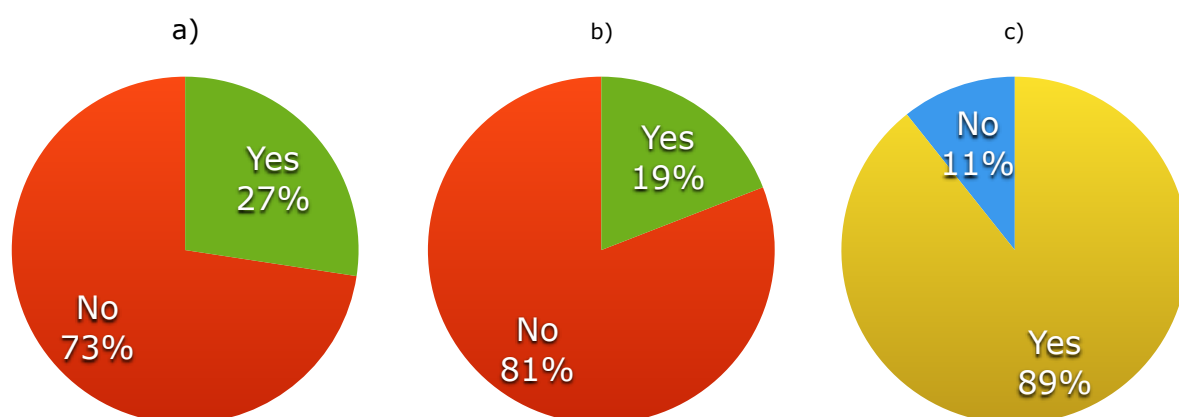


Figure 4.2.3. Adequacy of teachers about new teaching methods (a), will to attend refresher courses (b), innovative teaching materials need (c), measured on teachers' sample of survey 3.

Table 4.2.5. Teachers' needs: to have teaching materials with specific features-1

	Features
1	Structured
2	User-friendly
3	Innovative
4	Interdisciplinary
5	Multilingual
6	Immersive learning environment
7	Skills authentic assessment
8	ICT provided
9	Engagement

(Figure 4.2.3), as the requests of the Ministry of Education, of society, of the whole world, force them to apply teaching methods consistent with a changing world. Summarising, from our surveys, we can highlight these specific teachers' needs (Table 4.2.5):

- to have well-structured, user-friendly teaching materials available. These innovative teaching materials must also allow an interdisciplinary and multilingual approach (CLIL approach) and must develop a learning environment allowing an effective skill assessment.
- to have teaching materials that use ICT (to enhance the digital competence) and that ensure an effective students' engagement.

4.2.1. Implementation of adventure pathways

We have taken into account the specific needs of teachers as we consider essential for them to be able to work in fulfilling conditions, in order to maximize the effectiveness of the teaching action, as reported in Table 4.2.6.

For a detailed description of the GeoQuest Project (disciplines, languages, learning paths, etc..) please refer to the bibliography (Maraffi & Sacerdoti, 2018d; Maraffi & Sacerdoti, 2018e; Sacerdoti et al., 2018). Students need immersive environment to engage themselves and to best "in situation" evaluation; engagement is total thanks storytelling, mystery and suspense. CCRPG creates shared experiences for best cooperative learning. It is user-friendly for teachers and inclusive for student. Table 4.2.7 reports the educational goals and the corresponding strategies adopted in the GeoQuest game in detail.

Table 4.2.6. GeoQuest Project features

Characteristics	CCRPG
Immersion	Narrator's spoken voice, sounds effects, photo, original drawings and music create a totally immersive environment.
Engage	Thanks to storytelling, mystery, and suspense.
Changing environments	Adventure pathways change depending on the players' choices.
Mystery	Each path may have a different ending and fantasy is blended with real world.
Shared experiences	All players follow the game on the same multi-medial whiteboard or other screen.
Cooperative learning	Shared experiences foster cooperative learning.
Lab	Possibility to have lab activities or watch related videos.
Immediate feedback	Game engine indicates immediately whether the answer provided by the player is correct or wrong. In the latter case, the correct answer is indicated.
Interactivity	Players interact with the game through their own smartphones or tablets, using a LAN.
Inter-disciplinarity	Science topics are treated with Humanities.
Multi-language	Adventures pathways are available in any language.
Inclusion	Accessible design creates an inclusive educational environment: different communication codes (video and audio), notebooks
User-friendly	Software is tailored for this CCRPG and it can also be used by non-experienced teachers.

Table 4.2.7. Educational goals and corresponding CCRPG (Computer Classroom Role Playing Game) strategies

Educational Goals		CCRPG Strategies	References
Engaging		Digital storytelling	Maraffi & Scamardella (2016).
		Use of smartphones and tablets	Sacerdoti & Maraffi (2015).
		Sound effects, videos, etc.	Maraffi et al. (2016b).
Immersive learning environment		Photos, videos, drawings, sounds	Maraffi & Sacerdoti (2017b).
Key competences improvement	Communicating in a mother tongue and Communicating in a foreign language	Multilingual	Maraffi & Paris (2017).
	Scientific and technological competence	STEM ¹ topics	Maraffi & Sacerdoti (2016a).
	Digital competence	Digital tool	Maraffi et al. (2017d).
	Learning to learn	Inquiry approach and immediate feedback	
	Social and civic competences	Team working and cooperative learning	
	Sense of initiative and entrepreneurship	Problem solving	
	Cultural awareness and expression	Interdisciplinarity STEAM ² & SSH ³	Maraffi et al. (2016a).
Autentic skills assessment		Interdisciplinarity	Maraffi & Sacerdoti (2016b).
		STEAM ² approach	Maraffi & Sacerdoti (2017a).
		Achievable tasks	Maraffi & Marinelli (2016).
CLIL approach		Multilingual, with virtual mother tongue voices	Maraffi et al. (2017c).
BES		Notebooks, as compensatory tools; audio, video subtitles as dispensative measures	Maraffi & Sacerdoti (2017b).
¹ Science, Technology, Engineering & Math ² Science, Technology, Engineering, Art & Math ³ Social Sciences and Humanities			

The aim of the experimentation is to demonstrate that GeoQuest match the desired characteristics: improving learning and satisfying the teaching needs.

4.3. Experimentation

The total research sample consisted of 40 classes, from primary schools to university, for a total of 914 students. Within this sample, 32 classes (731 students) have experimented with the CCRPG and 8 classes (183 students) had a lesson with traditional methodology: frontal lesson, supported by interactive multimedia whiteboard, photos and videos. Research population's features are summarized in Table 4.3.1, where also the activity proposed is reported. In the table are indicated the classes where there were students with SEN (Special Educational Needs). Each control group has the same characteristics as the experimental group of reference, but has followed a frontal lesson, supported by powerpoint, images and videos.

In Table 4.3.2 the classes submitted to the second step of the experimentation are indicated. These experimental groups have carried out the definitive quantitative experimentation, for a total of 380 students (303 students with CCRPG, 77 students as control group). Icelandic group is a class of Icelandic high school students of 16-19 years old, which participated in an international project focused on GeoQuest Project (Sacerdoti et al., 2018). For a detailed description of the project, see the Annex.

Table 4.3.1. Research population's features

Classes	Students' age	School's kind	CLIL approach	Special Educational Needs	Adventure pathway	Note
4	8-10	Primary		X	SoilQuest	
1	8-10	Primary				Control group
3	11-14	Secondary		X	SoilQuest	
1	11-14	Secondary				Control group
5	13-14	Secondary		X	GQ Phlegraean Fields	
1	13-14	Secondary				Control group
2	16-18	High		X	GQ Phlegraean Fields	
1	16-18	High				Control group
4	14-16	High	X	X	GQ Phlegraean Fields	
6	16-18	High	X	X	GQ Vesuvius	
1	16-19	High	X		GQ Vesuvius	Iceland group
1	14-19	High	X			Control group
2	16-18	High			GQ Vesuvius	
1	16-18	High				Control group
2	17-18	High	X		CrimeQuest	
1	17-18	High	X			Control group
2	14-17	High		X	GQ Hawaii	
1	14-17	High	X			Control group
1	20-22	University			GQ Vesuvius	
40						

Table 4.3.2. Quantitative experimentation sample's features.						
Classes	Age	School's grade	CLIL	SEN	Adventure pathway	Note
6	16-18	High	X	X	GQ Vesuvius	
1	16-19	High	X		GQ Vesuvius	Group from Iceland
1	16-19	High	X			Control group
2	16-18	High			GQ Vesuvius	
1	16-18	High				Control group
2	14-17	High		X	GQ Hawaii	
1	14-17	High				Control group
1	20-22	University			GQ Vesuvius	
15						

A first step of experimentation (questionnaires and experimental data tables, ANNEX A & B) was to make an initial test with the prototype of the game, in order to test, calibrate and validate the experimental protocol, as described in the following:

- a. Calibrate and evaluate the impact and effectiveness of our CCRPG methodology in order to make all the necessary changes to the learning environment: software characteristics, player interactions, game features and enhancements to the stories already completed (processing and improvement step);
- b. Verify applicability in different situations, school types, class types and student ages;
- c. Develop a rigorous experimental protocol to be used in the final phase of the experimentation;
- d. Perform a first qualitative experimentation.

Five different adventure pathways have been realized, related to different students' ages (Table 4.3.3). The experimentation of the GeoQuest Project with the younger students (8-10 and 11-12 years old, with the SoilQuest pathway and with the 13-14 years old students with

the GeoQuest Phlaegraean Fields pathway was evaluated on the basis of authentic evaluation tests.

Table 4.3.3. GeoQuest adventure pathways.			
	Adventure pathway	Students' age	References
1	SoilQuest	8-12	(Maraffi et al., 2016b, 2017b)
2	GeoQuest Hawaii	10-18	(Maraffi & Sacerdoti, 2018b)
3	GeoQuest Phlegraean Fields	13-18	(Maraffi et al., 2015)
4	GeoQuest Vesuvius	17-21	(Maraffi et al., 2016a)
5	CrimeQuest	17-21	(Maraffi et al., 2017c)

4.3.1. GeoQuest Phlaegraean Fields

The most recent school educational experiments accompanied by appropriate media and technological devices are developed along the filrouge of the teaching of the Open Classrooms or of the Flipped Classrooms (Bennett et al., 2013). However, but when it comes to create multidisciplinary modular routes accessible and usable even by the most modern multimedia platforms, research and experimental data are missing. Everything is entrusted to individual interventions, without a frame of theoretical and operational adequate treatment.

The first experimentation was carried out with the GeoQuest adventure set in the Campi Flegrei. Secondary school pupils and high school students have been involved (technical and lyceum school, see paragraph 3.6). The students were given cognitive and satisfaction questionnaires (ANNEX A). Another evaluation of the outcome was made after a month too. In this way we wanted to test the engagement and the effect of the gaming inquiry on learning. At the same time, both teachers and students were asked to suggest changes, in order to improve the proposed methodology. The experimentation was accompanied by the observation in the classroom of the following parameters: attention times, interaction times, active participation through the devices, participation of teachers, problem solving, cooperative learning. The results (ANNEX B) of this first experimentation have been published in Maraffi (2016) and in Maraffi & Sacerdoti (2016b) and reported here.

The appreciation of RPG is high, as the experiments outcomes (Fig. 4.3.1.1).

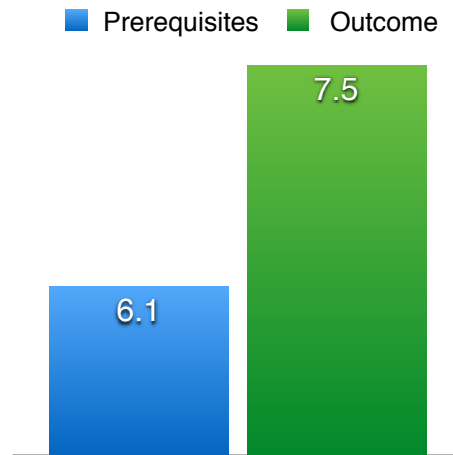


Figure 4.3.1.1. The appreciation of RPG is high, as the experiments outcomes (y value is students' evaluation in a 1-10 scale).

In the outcome we considered the engage and improvement of science, history, foreign language knowledge and skills as a whole. Prerequisites values are computed from the pupils answers on some questions on their initial knowledge about the disciplines involved in the adventure. The outcome is computed by the teacher evaluation on the results and interest on the same topics by the pupils a month after game playing. Compared to the initial prerequisites, the results recorded are very satisfactory. In particular, observing the same samples divided by type of school (Fig. 4.3.1.2), we can see that the obtained results are

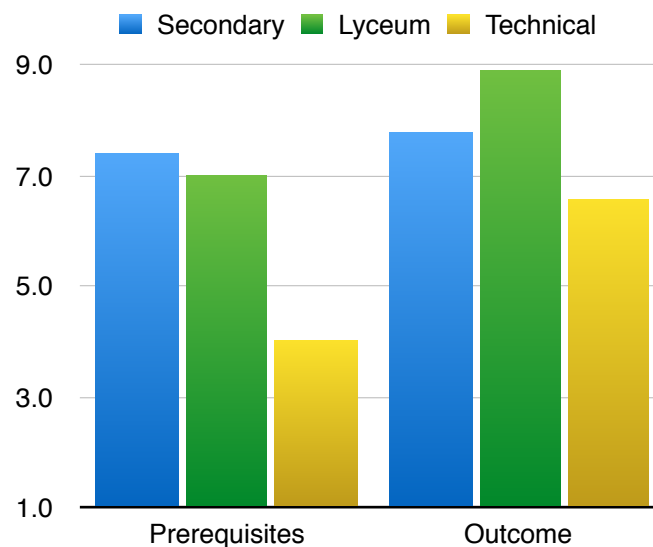


Figure 4.3.1.2. The percentage results are much better where the prerequisites was lower (Technical schools). Y value is students' evaluations in a 1-10 scale.

much better where the prerequisites tests gave lower results (Technical

schools). The results obtained after the experience with the CCRPG are independent of the prerequisites held by the students. Rather Less motivated and interested students, as unfortunately are students from technical schools, have found interest and participation in GeoQuest. The results obtained confirm that they were involved, as a percentage, even more than the high school students.

Table 4.3.4. Data fig. 4.3.1.2		
	Prerequisites	Outcome
	Students' evaluations in a 1-10 scale	
Secondary	7.4	7.76
Lyceum	7	8.9
Technical	4	6.55

4.3.2. GeoQuest Vesuvius

The Vesuvius pathway was used to test, on one hand, the understanding of literary and scientific texts and, on the other hand, the CLIL methodology. The experimentation was then carried out only in high schools (linguistic, scientific, etc..). The characteristics of the experimental sample are reported in tables 4.3.1 and 4.3.2. For an effective evaluation of the comprehension of the texts and of the linguistic learning, identical pre-test and post-test (ANNEX A) were provided to experimental samples, to be done immediately before and immediately after the teaching activity with GeoQuest.

Data processing

The ten questions proposed refer to the main contents conveyed by the didactic activity in order to test both knowledge and skills. Furthermore, post-test surveys were conducted both on students and teachers, about customer satisfaction. The data obtained were submitted to the *Student's t-test* (Figure 4.3.2.1). The first data set was pre-test results, the second was post-test results. The question was: is the difference between pre-test and post-test random? Or is it actually due to the activity carried out with the CCRPG? With Student test is possible to determine if the two sets of data were significantly different from each other. The *t-test* also tells us how significant the differences are; in other

words, it lets us know if those differences could have happened by chance

The diagram illustrates the formula for the calculation of the value of t . The formula is presented as:

$$t = \frac{m_a - m_b}{S \sqrt{\frac{n_a n_b}{n_a + n_b}}}$$

Arrows point from the components of the formula to descriptive boxes:

- A green arrow points from $m_a - m_b$ to a box labeled "difference between the two means".
- A red arrow points from S to a box labeled "mean standard deviation".
- A blue arrow points from the denominator's square root term to a box labeled "dimension factor".

Figure 4.3.2.1. Formula for the calculation of the value of t
(http://www.quadernodiepidemiologia.it/epi/assoc/t_stu.htm)

only or not. Every t -value has a p -value to go with it. A p -value is the probability that the results from your sample data occurred by chance. P -values are from 0% to 100%. They are usually written as a decimal number. For example, a p -value of 5% is 0.05. Low p -values are good; they indicate our data did not occur by chance. For example, a p -value of 0.01 means there is only a 1% probability that the results from an experiment happened by chance. In most cases, a p -value of 0.05 (5%) is accepted to mean the data is valid (Park, 2005). In Table 4.3.2.2 the P -values calculated for the experimental groups are indicated.

it is clear that our experimental data are reliable, as the probability that the obtained results are due to chance is practically nil. This means that post-tests are better because of the effectiveness of the activity with the CCRPG.

In Figure 4.3.2.2 the results of the pre-test and post-test of the last experimentation phase are shown. Figures 4.3.2.2 a-g refers to the class groups that have experimented the CCRPG with the CLIL approach, while figures 4.3.2.2 h, i and 4.3.2.2 l, m show the results of the groups that have experimented with the CCRPG in their mother tongue (Italian). It should be noted that these quantitative results refer to a measure and not to an evaluation: number of exact answers provided.

Table 4.3.2.2. P-values for experimental samples.

Class	Dataset	1	2	t	P-value
Comenio IV I	Media	1.3333	3.6667	5.4377	0.0000083929
	Standard dev.	1.2344	1.1127		
Comenio IV G	Media	2.1818	3.8636	3.9474	0.0002952798
	Standard dev.	1.5318	1.2834		
Mazzini V D	Media	0.2500	3.0625	6.5733	0.0000002843
	Standard dev.	0.5774	1.6112		
Mazzini V A	Media	2.2083	5.0833	7.2091	0.0000000044
	Standard dev.	1.5030	1.2482		
Mazzini V I	Media	2.4800	4.1200	5.2352	0.0000036020
	Standard dev.	0.7141	1.3940		
Mazzini V C	Media	0.9600	6.0400	11.0020	0.0000000000
	Standard dev.	0.7895	2.1695		
Comenio V H	Media	1.9130	4.8261	5.9053	0.000000465
	Standard dev.	1.6491	1.6963		
Comenio V E	Media	1.0526	3.7368	6.7160	0.0000000777
	Standard dev.	1.1773	1.2842		
Kvennaskólinn í Reykjavík	Media	1.5000	4.3333	5.5241	0.0000035797
	Standard dev.	1.2948	1.7489		
Galilei	Media	0.6000	6.1333	13.1235	0.00000000000017
	Standard dev.	1.2984	0.9904		

We compared the number of correct answers provided both immediately before (in yellow) and immediately after (in green) the experience with the CCRPG GeoQuest. The measurement of the learning level reached is indicated on the Y-axis while on the X-axis are the students' identification numbers i.e. those corresponding to the class diary. It is evident in all the class groups that post-test values are clearly higher than pre-test ones.

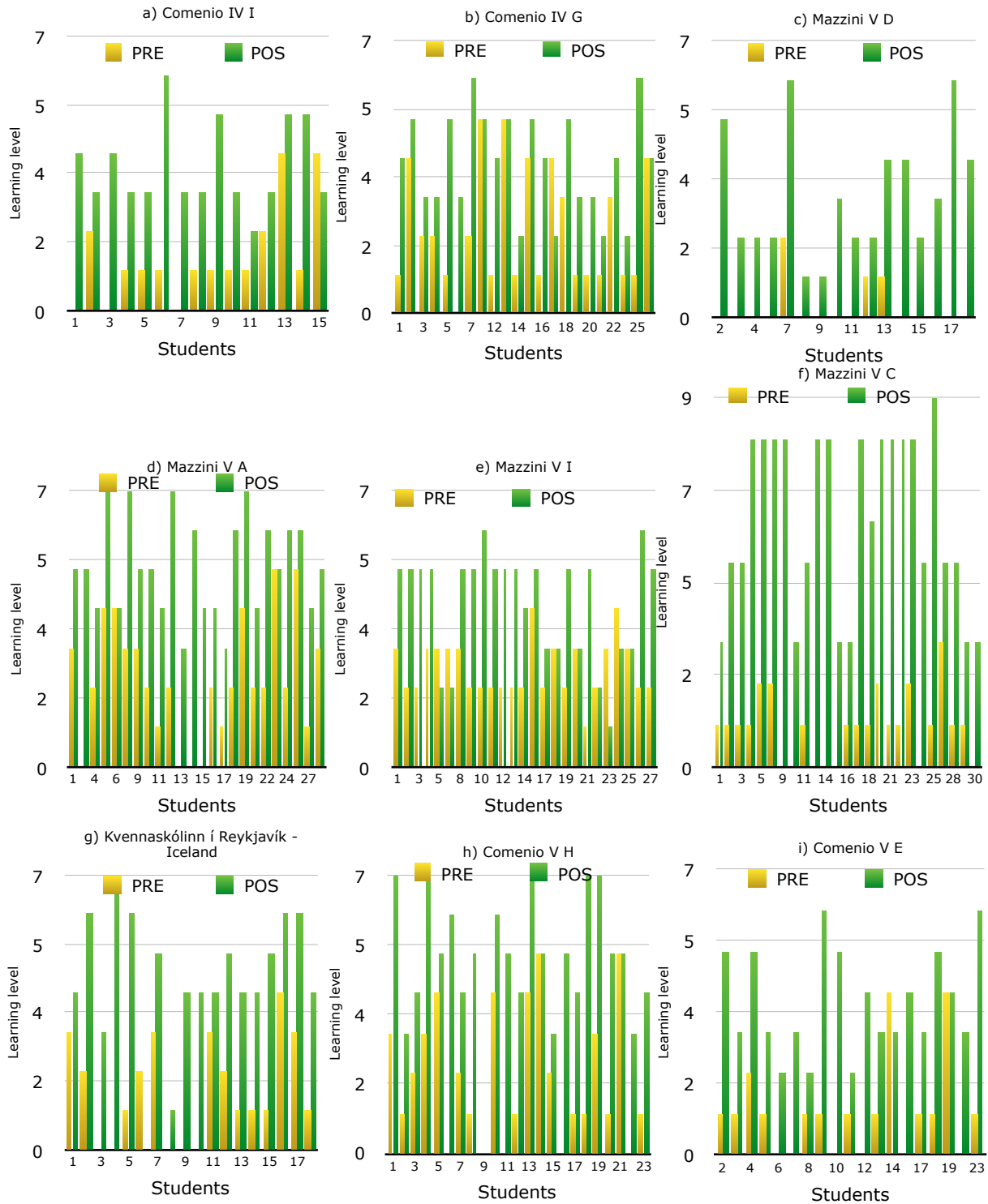


Figure 4.3.2.2. Results of pre-tests and post-tests measured in the last phase of the GeoQuest project experimentation. a-g) GeoQuest Vesuvius with CLIL approach; h, i) GeoQuest Vesuvius.

Table 4.3.2.3a. Data
fig. 4.3.2.2a

	PRE	POS
1	0	4
2	2	3
3	0	4
4	1	3
5	1	3
6	1	6
7	0	3
8	1	3
9	1	5
10	1	3
11	1	2
12	2	3
13	4	5
14	1	5
15	4	3

Table 4.3.2.3b. Data
fig. 4.3.2.2b

	PRE	POS
1	1	4
2	4	5
3	2	3
4	2	3
5	1	5
6	0	3
7	2	6
10	5	5
12	1	4
13	5	5
14	1	2
15	4	5
16	1	4
17	4	2
18	3	5
19	1	3
20	1	3
21	1	2
22	3	4
23	1	2
25	1	6
26	4	4

Table 4.3.2.3c. Data
fig. 4.3.2.2c

	PRE	POS
2	0	5
3	0	2
4	0	2
5	0	2
7	2	6
8	0	1
9	0	1
10	0	3
11	0	2
12	1	2
13	1	4
14	0	4
15	0	2
16	0	3
17	0	6
19	0	4

Table 4.3.2.3d. Data
fig. 4.3.2.2d

	PRE	POS
1	3	5
2	0	5
4	2	4
5	4	7
6	4	4
8	3	7
9	3	5
10	2	5
11	1	4
12	2	7
13	0	3
14	0	6
15	0	4
16	2	4
17	1	3
18	2	6
19	4	7
20	2	4
22	2	6
23	5	5
24	2	6
26	5	6
27	1	4
28	3	5

Table 4.3.2.3e. Data
fig. 4.3.2.2e

	PRE	POS
1	3	5
2	2	5
3	2	5
4	3	5
5	3	2
6	3	2
8	3	5
9	2	5
10	2	6
11	2	5
12	2	5
13	2	5
14	2	4
15	4	5
17	2	3
18	3	3
19	2	5
20	3	3
21	1	5
22	2	2
23	3	1
24	4	3
25	3	3
26	2	6
27	2	5

Table 4.3.2.3f. Data fig.
4.3.2.2f

	PRE	POS
1	1	3
2	1	5
3	1	5
4	1	8
5	2	8
8	2	8
9	0	8
10	0	3
11	1	5
13	0	8
14	0	8
15	0	3
16	1	3
17	1	8
18	1	6
19	2	8
21	1	8
22	1	8
23	2	8
24	0	5
25	1	9
27	3	5
28	1	5
29	1	3
30	0	3

Table 4.3.2.3g. Data fig. 4.3.2.2g

	PRE	POS
1	3	4
2	2	6
3	0	3
4	0	7
5	1	6
6	2	0
7	3	5
8	0	1
9	0	4
10	0	4
11	3	4
12	2	5
13	1	4
14	1	4
15	1	5
16	4	6
17	3	6
18	1	4

Table 4.3.2.3h. Data fig. 4.3.2.2h

	PRE	POS
1	3	7
2	1	3
3	2	4
4	3	7
5	4	5
6	0	6
7	2	4
8	1	5
9	0	0
10	4	6
11	0	5
12	1	4
13	4	7
14	5	5
15	2	3
16	0	5
17	1	4
18	1	7
19	3	7
20	1	5
21	5	5
22	0	3
23	1	4

Table 4.3.2.3i. Data fig. 4.3.2.2i

	PRE	POS
2	1	5
3	1	3
4	2	5
5	1	3
6	0	2
7	0	3
8	1	2
9	1	6
10	0	5
11	1	2
12	0	4
13	1	3
14	4	3
15	0	4
17	1	3
18	1	5
19	4	4
21	0	3
23	1	6

Table 4.3.2.4. Data fig. 4.3.2.3

	PRE	POST	PRE Control group	POST Control group
Percentage of exact answer in a 0-5 scale	1.6	4.3	1.5	2

In Figure 4.3.2.3, the averages of the results are compared to the

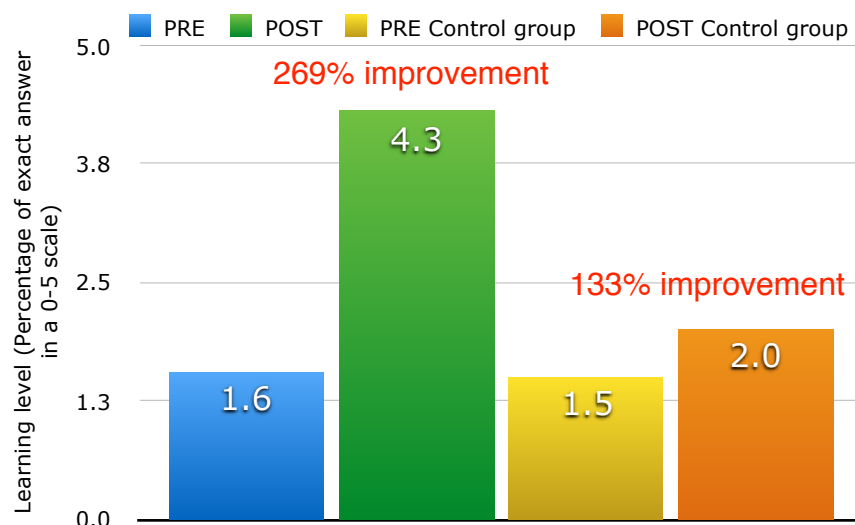


Figure 4.3.2.3. Difference between average values measured in pre-tests and post-tests, compared with control sample's results.

control samples average. Percentage of exact answer was calculated in a 0-5 scale. The figure shows that the number of correct answers provided after the activity with the CCRPG increases by 269%, compared to the increase of 133% recorded after the frontal lesson supported by Power Point. In Figure 4.3.2.4 the data relative to the CLIL approach are compared with those obtained after the experimentation in mother tongue. We can notice that, regarding GeoQuest results, no substantial

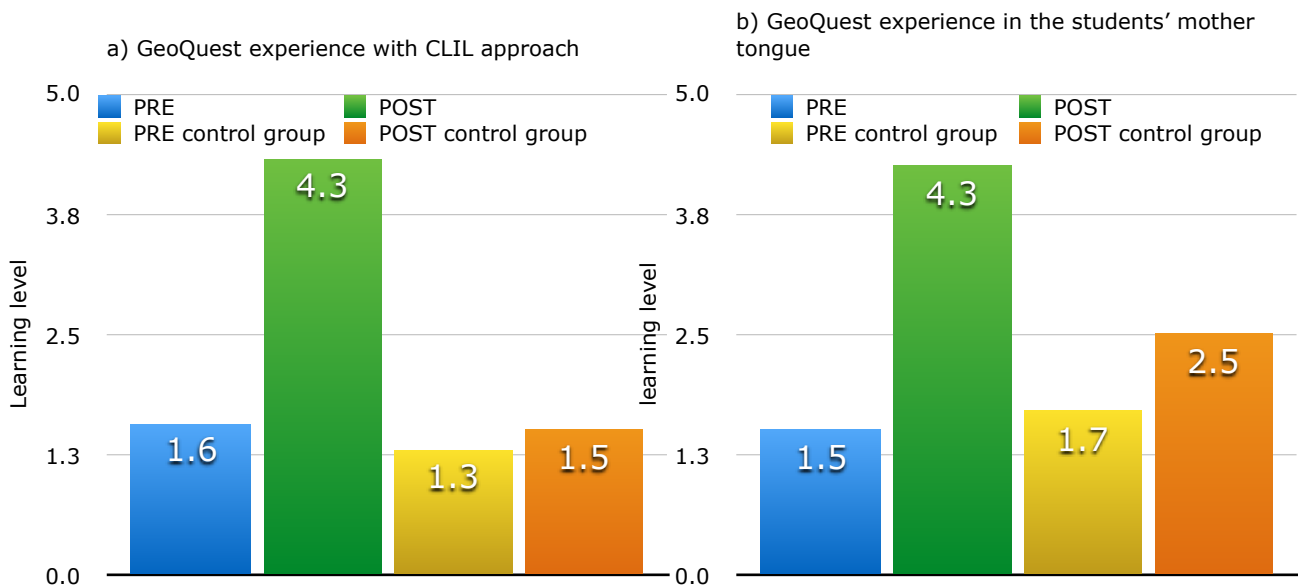


Figure 4.3.2.4. Difference between average values measured in pre-tests and post-tests for GeoQuest experience with CLIL approach (a) and with mother tongue (b).

difference exists between the learning experience carried out in mother tongue and the one carried out in a foreign language (CLIL approach) both in the pre test and post test, proving that the e-learning experience has been positive in both environments. Instead, the results obtained by the control group are slightly better only when the mother tongue is used.

Table 4.3.2.5a. Data fig. 4.3.2.4a			
PRE	POST	PRE Control group	POST Control group
Percentage of exact answer in a 0-5 scale			
1.6	4.3	1.3	1.5

Table 4.3.2.5b. Data fig. 4.3.2.4b			
PRE	POST	PRE Control group	POST Control group
Percentage of exact answer in a 0-5 scale			
1.5	4.3	1.7	2.5

Figure 4.3.2.5 shows the percentage of relative frequency of average of all correct answers provided in pre-tests and post-tests. The histogram

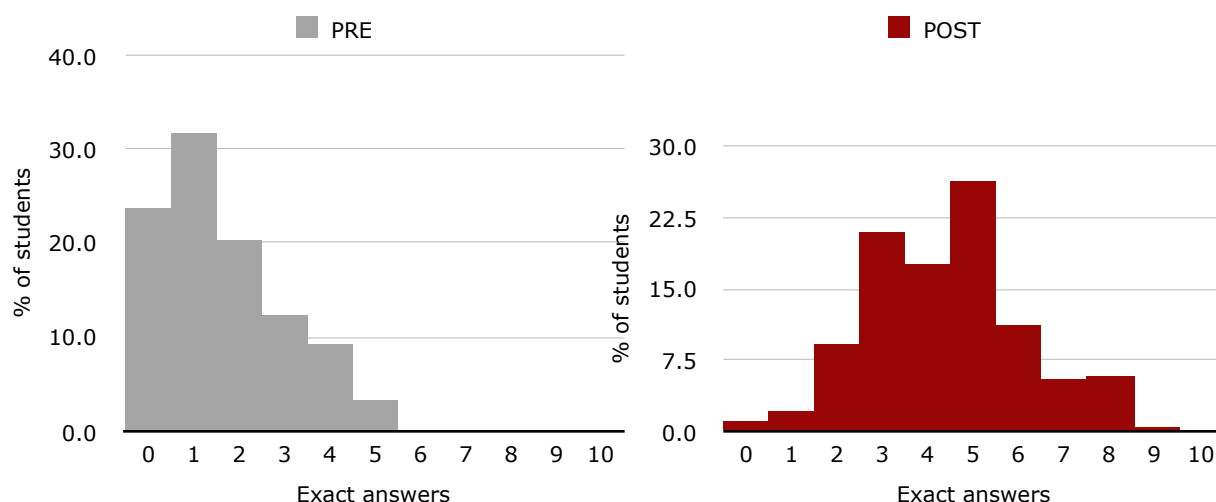


Figure 4.3.2.5. Percentage of relative frequency of correct answers provided in the pre-tests and post-tests.

of the relative frequency percentage of the answers given to the pre-tests shows (Table 4.3.2.7) that, on average, students answered correctly once every 10 times (media=1.6). The majority of students provided only one correct answer or none at all (median=1); the number of correct answers provided by the majority of students is 1 (mode=1). The histogram of the relative frequency percentage of the answers given to the post-tests shows that the students answered 4.4 correct answers out of 10 on average (media=4.4). The majority of students provided up to 4 answers

(median=4); the number of correct answers provided by the majority of students is 5 (mode = 5). Therefore we can state that the teaching activity with the CCRPG positively shifts the performance of the whole class.

Table 4.3.2.6a. Data fig. 4.3.2.5a	
Exact answer	PRE Percentage of relative frequency of correct answers
0.0	23.5
1.0	31.6
2.0	20.3
3.0	12.3
4.0	9.1
5.0	3.2
6.0	0.0
7.0	0.0
8.0	0.0
9.0	0.0
10.0	0.0

Table 4.3.2.6b. Data fig. 4.3.2.5b	
Exact answer	POST Percentage of relative frequency of correct answers
0.0	1.1
1.0	2.1
2.0	9.1
3.0	20.9
4.0	17.6
5.0	26.2
6.0	11.2
7.0	5.3
8.0	5.9
9.0	0.5
10.0	0.0

Table 4.3.2.7. Media, median and mode values for relative frequency of exact answers provided in the pre-tests and post-tests.		
	Pre-tests	Post-tests
Media	1.6	4.4
Median	1	4
Mode	1	5

In Figure 4.3.2.6 the learning outcomes are shown, before and after the CCRPG with CLIL approach. We chose here to consider some questions and answers to show graphically some of the results. In particular, the mineralogy questions data (Figures 4.3.2.6 A, B, C, D) are among the most difficult topics for the students.

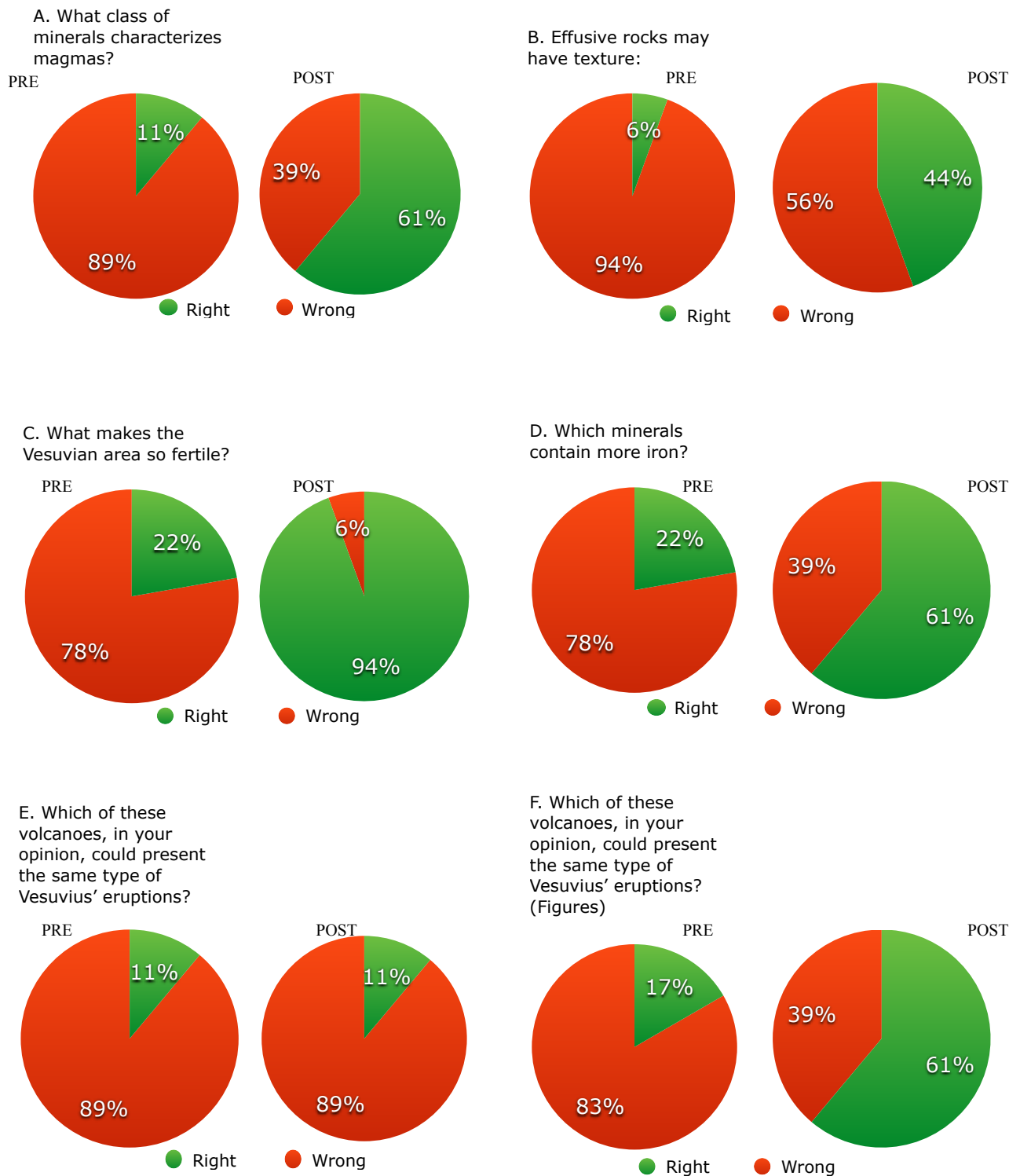


Figure 4.3.2.6. Pie charts showing the results about learning outcomes of Icelandic students, respectively before and after CCRPG. In red the wrong answers, in green the right answers.

Figures 4.3.2.6 E and F refer to the same question: in one case (Fig. 4.3.2.6 E) the question included four choices which were the names of four different volcanoes. In the second case (Fig. 4.3.2.6 F) the four choices were the images of the different volcanoes without their corresponding names. This information is not provided in the game (like the names of the 4 volcanoes proposed in the CCRPG). It is obviously not stored as a concept by students, but they can be reclaimed as competence (the ability to go back from the shape of the volcano to the eruptive style).

Customer satisfaction

Figures 4.3.2.7 points out the students' satisfaction, regarding the overall experience with GeoQuest, the learning environment, the use of

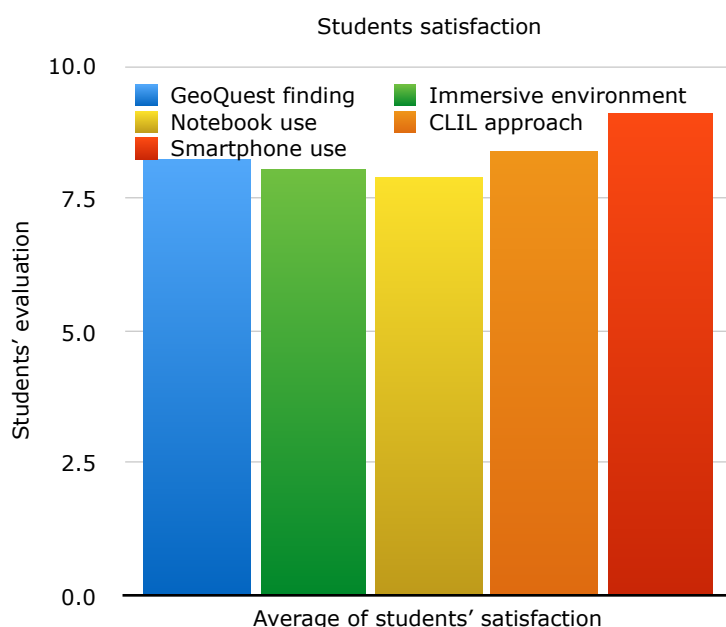


Figure 4.3.2.7. Students' satisfaction.

Table 4.3.2.8. Data fig. 4.3.2.7

	GeoQuest finding	Immersive environment	Notebook use	CLIL approach	Smartphone use
Average of students satisfaction	8.2	8.0	7.9	8.4	9.1

aids (notebooks), the CLIL approach and the use of smartphones. In this case students were asked to express an evaluation from 1 to 10. The evaluations are fully positive (>6). A more detailed analysis (Table

Table 4.3.2.9. Media, median and mode values for students' satisfactions.

Students Satisfaction	GeoQuest finding	Immersive environment	Smartphone use
Media	8.2	8.2	9.1
Median	8	8	10
Mode	8	7	10

4.3.2.9) shows the overall experience with the CCRPG GeoQuest is 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 immersive environment is judged effective by all the students (media = 8; mode = 7); more than half of the students evaluate the use of smartphones with a value higher than 9, the majority giving a rating of 10 (Figure 4.3.2.8).

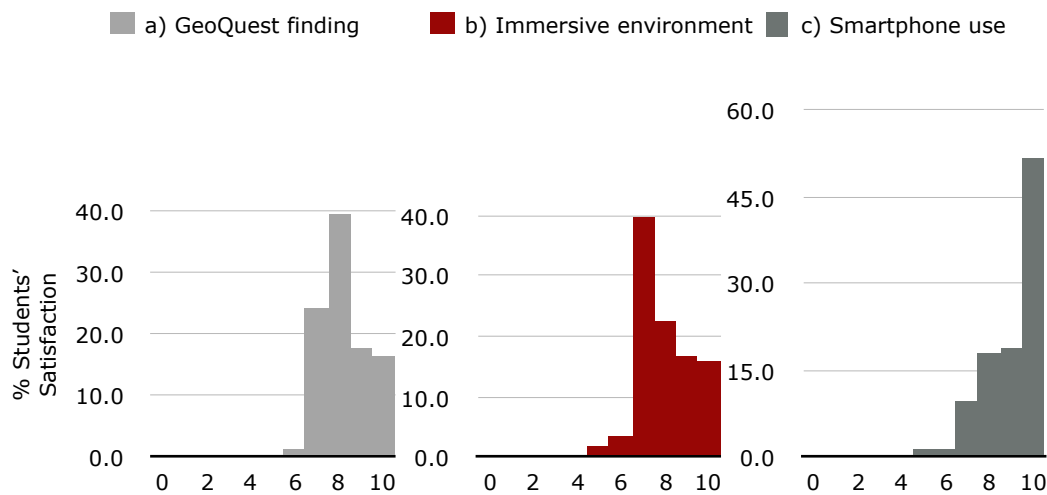


Figure 4.3.2.8. Percentage of relative frequency for students satisfaction.

The experimentation carried out with the class group of the L'Orientale University aimed at having a technical evaluation of the experience with the CCRPG.

In fact, university students had an Applied Linguistics training background in the Education Degree Course. In Figure 4.3.2.9 we can see evaluation average by L'Orientale University's students: all values are higher than 8.5. For a more detailed analysis we put together the evaluations concerning the same topic and we calculated the percentage of the relative frequency of the evaluations.

Table 4.3.2.10. Data fig. 4.3.2.8

	a) GeoQuest finding	b) Immersive environment	c) Smartphone use
0.0	0.0	0.0	0.0
1.0	0.0	0.0	0.0
2.0	0.0	0.0	0.0
3.0	0.0	0.0	0.0
4.0	0.0	0.0	0.0
5.0	0.6	1.8	1.2
6.0	1.2	3.6	1.2
7.0	24.3	39.6	9.5
8.0	39.6	22.5	17.8
9.0	17.8	16.6	18.9
10.,0	16.6	16.0	51.5

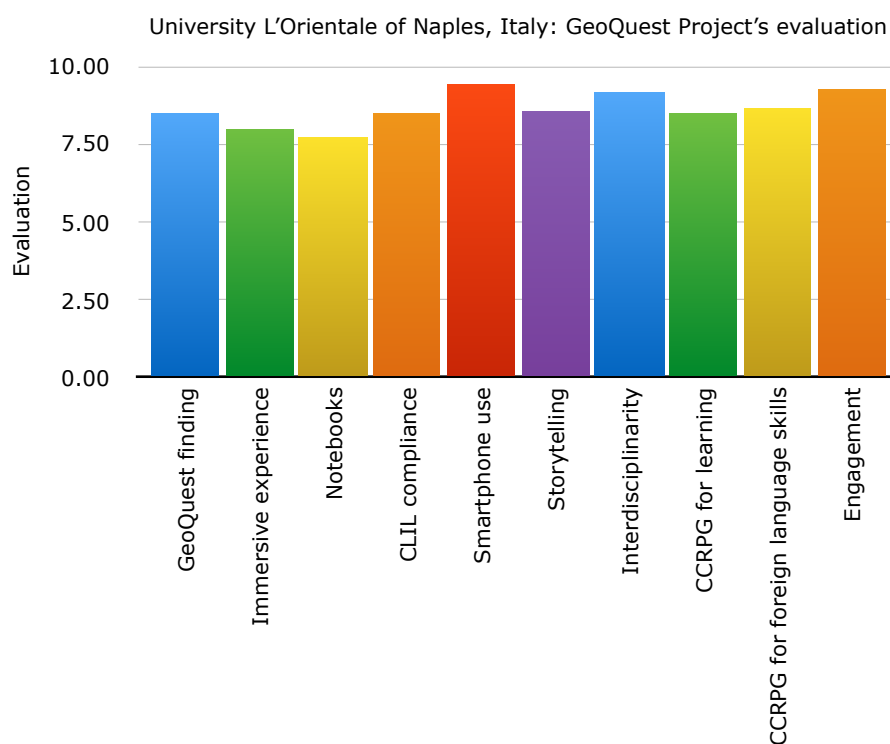


Figure 4.3.2.9. Students satisfaction measured in Education degree course by L'Orientale University of Naples, Italy.

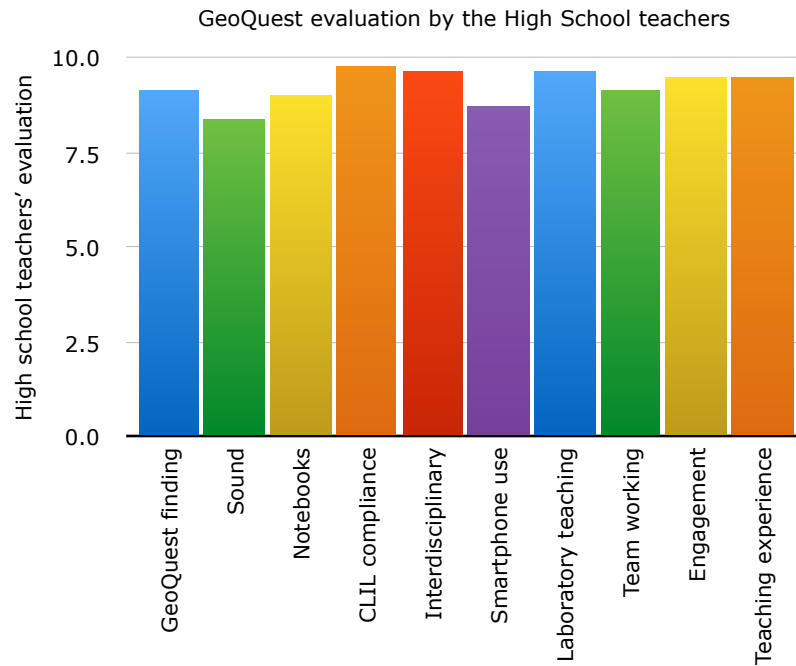


Figure 4.3.2.11. GeoQuest evaluation by the High School teachers.

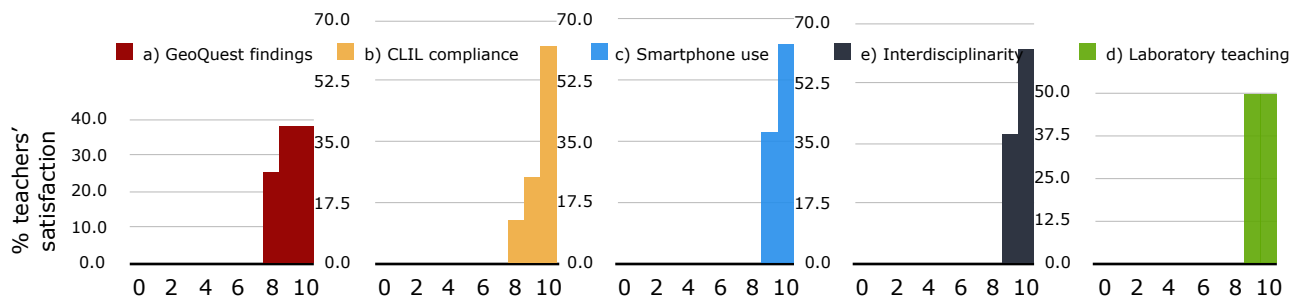


Figure 4.3.2.12. Percentage of relative frequency for the High School teachers satisfaction.

Table 4.3.2.11. Data fig. 4.3.2.9

GeoQuest finding	8.44
Immersive experience	7.92
Notebooks	7.68
CLIL compliance	8.48
Smartphone use	9.36

Storytelling	8.52
Interdisciplinarity	9.16
CCRPG for learning	8.48
CCRPG for foreign language skills	8.64
Engagement	9.2

Table 4.3.2.12 summarises media, median and mode values from evaluation by L'Orientale University undergraduates,

Table 4.3.2.12. Media, median and mode values for students of L'Orientale University.				
Students of L'Orientale University	GeoQuest finding	CLIL compliance	Smartphone use	Interdisciplinary
Media	8.7	9.4	9.6	9.2
Median	9	9	10	10
Mode	9	10	10	10

while in Figure 4.3.2.10 we represented the relative frequency of values in percentage. The technical opinion of the Education university course's students is very flattering: GeoQuest gets an average appreciation of 8.7 (media=8.7); more than half of the students expressed an appreciation higher than 9 (median=9). They considered the interdisciplinary between scientific and humanistic topics brilliant, as well as the smartphone use to interact with the CCRPG (median=10 and mode=10). The most satisfying result, being the specific university course for Education and applied linguistics, is the evaluation of CCRPG GeoQuest for CLIL compliance (median=10; mode=10).

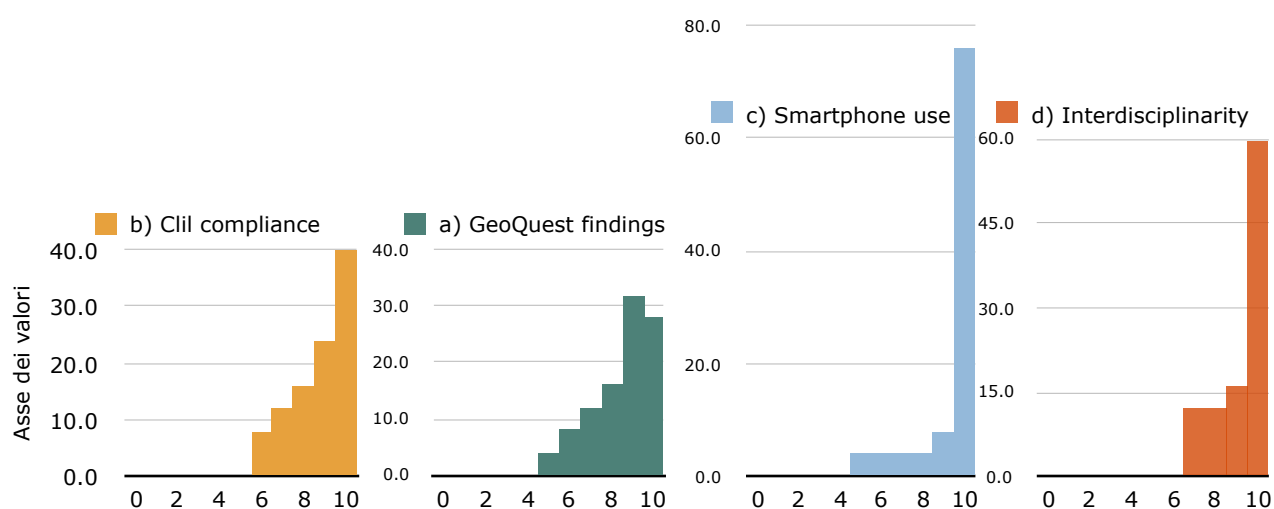


Figure 4.3.2.10. Percentage of relative frequency for students satisfaction, measured in Education degree course by L'Orientale University of Naples, Italy.

Table 4.3.2.13. Data fig. 4.3.2.10

	b) Clil compliance	a) GeoQuest findings	c) Smartphone use	d) Interdisciplinarity
0.0	0.0	0.0	0.0	0.0
1.0	0.0	0.0	0.0	0.0
2.0	0.0	0.0	0.0	0.0
3.0	0.0	0.0	0.0	0.0
4.0	0.0	0.0	0.0	0.0
5.0	0.0	4.0	4.0	0.0
6.0	8.0	8.0	4.0	0.0
7.0	12.0	12.0	4.0	12.0
8.0	16.0	16.0	4.0	12.0
9.0	24.0	32.0	8.0	16.0
10.,0	40.0	28.0	76.0	60.0

Teachers' satisfaction

Teachers were asked to rate some features of GeoQuest as well, on a scale of 1 to 10 (Figure 4.3.2.11), like CLIL compliance, GeoQuest findings, Smartphone use, Interdisciplinarity. All ratings are very high: if we watch the relative frequency (Figure 4.3.2.12), we can see that

GeoQuest teaching experience got an evaluation higher than 9 and more than half evaluations are 10 (median=10 in Table 4.3.2.15). The same teachers' opinion was expressed about interdisciplinary approach, laboratory teaching with the CCRPG and CLIL compliance.

Table 4.3.2.14. Data fig. 4.3.2.12

	a) GeoQuest findings	b) CLIL compliance	c) Smartphone use	e) Interdisciplinarity	d) Laboratory teaching
0.0	0.0	0.0	0.0	0.0	0.0
1.0	0.0	0.0	0.0	0.0	0.0
2.0	0.0	0.0	0.0	0.0	0.0
3.0	0.0	0.0	0.0	0.0	0.0
4.0	0.0	0.0	0.0	0.0	0.0
5.0	0.0	0.0	0.0	0.0	0.0
6.0	0.0	0.0	0.0	0.0	0.0
7.0	0.0	0.0	0.0	0.0	0.0
8.0	25.0	12.5	0.0	0.0	0.0
9.0	37.5	25.0	37.5	37.5	50.0
10.0	37.5	62.5	62.5	62.5	50.0

Table 4.3.2.15. Media, median and mode values for high school teachers satisfactions.

High school teachers	GeoQuest finding	CLIL compliance	Smartphone use	Laboratory teaching	Interdisciplinary
Media	9.1	9.8	8.8	9.6	9.6
Median	10	10	10	10	10
Mode	9.5	10	10	9.5	10

Furthermore, teachers of survey No. 2 had a learning experience with GeoQuest, as test of innovative teaching tool and their evaluations are summarised in Figure 4.3.2.13. The teachers of the second survey are those who have reported insufficient familiarity with ICT (see table 4.2.2)

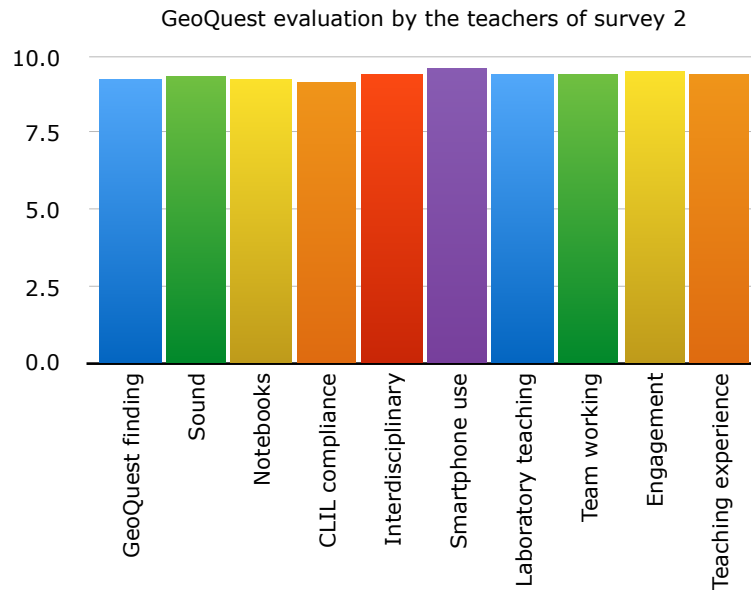


Figure 4.3.2.13. GeoQuest evaluation by the teachers of survey 2.

Table 4.3.2.16. Data fig. 4.3.2.13	
GeoQuest finding	9.2
Sound	9.3
Notebooks	9.3
CLIL compliance	9.1
Interdisciplinary	9.4
Smartphone use	9.6
Laboratory teaching	9.4
Team working	9.4
Engagement	9.5
Teaching experience	9.4

Results are brilliant: see Table 4.3.2.17 and Figure 4.3.2.14.

Table 4.3.2.17. Media, median and mode values for teachers survey 2 satisfactions.

Teachers survey 2	GeoQuest finding	Team working	Smartphone use	Laboratory teaching	Interdisciplinary
Media	9.2	9.4	9.6	9.4	9.4
Median	10	10	10	10	10
Mode	10	10	10	10	10

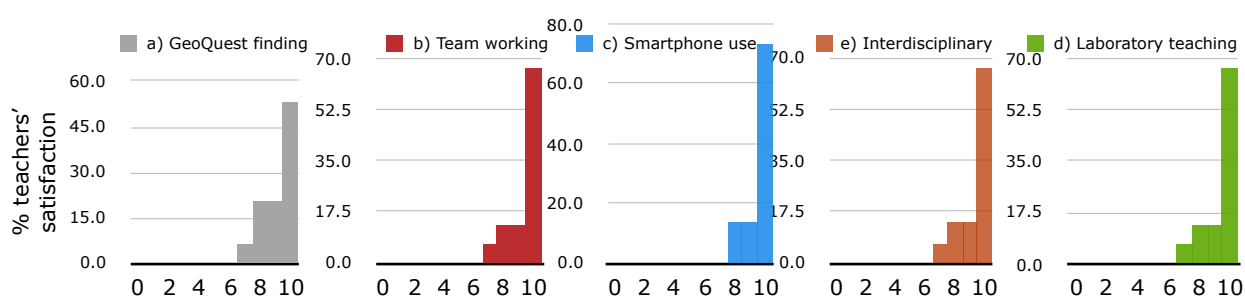


Figure 4.3.2.14. Percentage of relative frequency for satisfaction of teachers of survey 2.

Table 4.3.2.18. Data fig. 4.3.2.14

	a) GeoQuest finding	b) Team working	c) Smartphone use	e) Interdisciplinary	d) Laboratory teaching
0.0	0.0	0.0	0.0	0.0	0.0
1.0	0.0	0.0	0.0	0.0	0.0
2.0	0.0	0.0	0.0	0.0	0.0
3.0	0.0	0.0	0.0	0.0	0.0
4.0	0.0	0.0	0.0	0.0	0.0
5.0	0.0	0.0	0.0	0.0	0.0
6.0	0.0	0.0	0.0	0.0	0.0
7.0	6.7	6.7	0.0	6.7	6.7
8.0	20.0	13.3	13.3	13.3	13.3
9.0	20.0	13.3	13.3	13.3	13.3
10.,0	53.3	66.7	73.3	66.7	66.7

4.3.3. SoilQuest

SoilQuest has been tested on primary school and secondary school students (9-12 years old). Results about SoilQuest's experimentation are shown in Fig. 4.3.3.1, from survey in classroom.

Figure 4.3.3.1. SoilQuest evaluation in a classroom.

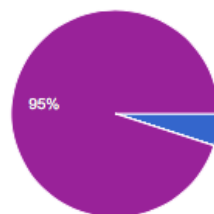
20 risposte

[Vedi tutte le risposte](#)

[Pubblica i dati di analisi](#)

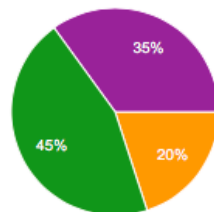
Riepilogo

L'attività mi ha divertito



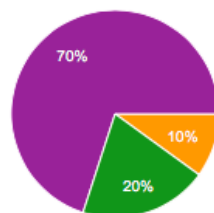
per niente	1	5%
poco	0	0%
abbastanza	0	0%
molto	0	0%
moltissimo	19	95%

Il lavoro di gruppo è stato utile per rispondere alle domande



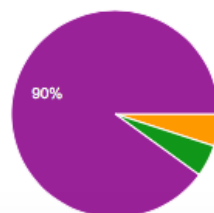
per niente	0	0%
poco	0	0%
abbastanza	4	20%
molto	9	45%
moltissimo	7	35%

Mi è piaciuto affrontare l'argomento Suolo con questo tipo di approccio didattico



per niente	0	0%
poco	0	0%
abbastanza	2	10%
molto	4	20%
moltissimo	14	70%

Vorrei che altri argomenti venissero presentati in questo modo



per niente	0	0%
poco	0	0%
abbastanza	1	5%
molto	1	5%
moltissimo	18	90%

The sample examined claims to have enjoyed a lot SoilQuest (95%), to have found useful the activity with the CCRPG, to have appreciated the Earth Sciences' topic about the soil.

4.3.4. GeoQuest Hawaii

In Fig. 4.3.4.1 there are results from GeoQuest Hawaii experimentation. Questions were the same of GeoQuest Vesuvius test. Y value is the number of exact answer given by students.

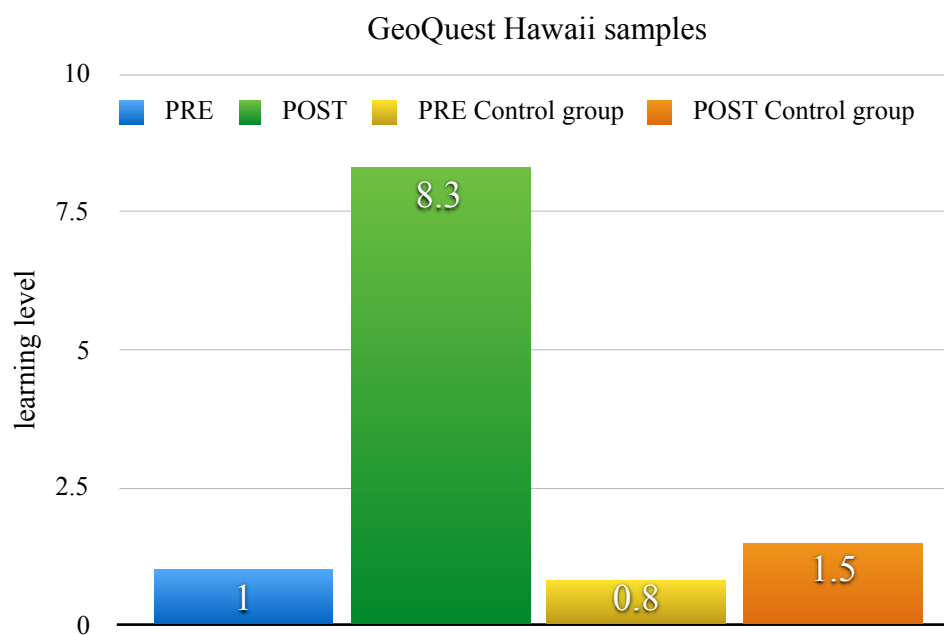


Figure 4.3.4.1. Results of pre-tests and post-tests averages measured in the last phase of the GeoQuest project experimentation for GeoQuest Hawaii.

The experimental sample for GeoQuest Hawaii (Maraffi & Sacerdoti, 2018b) is made up of high school students, who have experienced the CCRPG with the CLIL approach. In GeoQuest Hawaii path, linguistic simplification was tried for the first time. By linguistic simplification we do not mean a mechanical syntactic or lexical impoverishment, operated automatically. Instead, we mean a careful work of linguistic expediency, operated wisely to allow a more immediate and effective use, without altering the due complexity, typical of the spoken language, the idioms, the sentences characteristic of a certain language. In fact, it would not be possible to think of an effective learning if one intervenes by altering the

characteristics of the language, which are not lost, but are more easily enjoyed. As Mahmoud (2014) also asserts, linguistic simplification by caretakers and language teachers needs to be distinguished from the simplification of the learning task by the learners. The learning outcomes measured before and after GeoQuest Hawaii experience, compared to the results of the control group, are brilliant.

5. Chapter V - Discussion

The aim of the present research was to describe the role played by digital games in Earth Science education. The study was focused on demonstrating the effectiveness on acquisition of knowledge, skills, motivation by school students, as well as the perception, views and motivation for their use by science teachers. The data collected and the results found allow to identify some potential advantages and issues related to the use of Computer Classrooms Role-playing Games in Earth Science education.

Previous studies, carried out on Earth Science education are few and limited to the IBSE approach for the study of Geosciences. Boniello (2017) researched the use of virtual world in Geoscience education. In her study she found that students were very engaged in Earth Science topics proposed and the learning environment was effective, as demonstrated by the results of the tests. The study showed that the activity was inclusive for all the students, even those with learning difficulties or lack of attention, also stimulating an effective relationship with the teachers who actively participate the game.

However her experimentation demonstrated a higher interest by the middle school students compared with those from the high school, possibly due to the different age range of the students. The different requirements of the syllabus between the two schools makes more interesting for the teachers in middle schools investigating the possibility to adopt this methodology in their classes. Furthermore, Boniello's research identifies some limitations to the application of the Virtual world to the study of Geoscience: the cultural obstacles, for example the digital divide between teachers and students, or technical obstacles, like the access to technologies by schools, the time required for the experience, the necessary preliminary training of teachers.

Instead, our research shows that the application of the CCRPG does not require digital knowledge, it is user friendly, requires little preparation time. Above all, the CCRPG can also be used without an internet connection and requires only a laptop. On the other hand, the results described above show that there are no differences between primary, secondary and high school in the students' outcomes. From pupils to older

students, the interest shown is high and the results are positive and tangible.

In general, the interest in Earth Science Education in the Italian school is not high (Occhipinti, 2014), therefore studies are devoted to find new educational approaches to improve the interest of the students. Musacchio et al. (2015) suggest an experience based on a hands-on approach, combined with game-related challenges in the field of Geoscience. The feedback of this experience is very positive and it reinforces the reviewed research on using games and hands-on activities in education. GeoQuest project combines gaming and hands-on activities in an immersive and engaging environment, created by digital role-playing game, therefore combining all the elements suitable for an effective learning experience.

Sengupta et al. (2016) extended the theory of disciplinary integration of games for Science education beyond the virtual world of games. Science teachers' experiences, attitudes, perceptions, concerns and support needs, related to the use of educational computer games were investigated in the study by An et al. (2016). This study highlighted that the major barriers to integrating educational computer games into the classroom included lack of computers, lack of time, time needed for preparation for school and national high-stakes testing, and lack of knowledge about science games. Therefore, there are no previous studies on Earth Science education with digital games to take as reference or to use as comparison.

5.1. Analytical Discussion

Experimental observation evidences show that CCRPG seems to be the most effective game based learning typology to improve student learning. Digital storytelling enhances student engagement, in agreement with Akkerman et al. (2009) which found that *storifying* history using mobile games had a positive effect on student engagement. Figure 3.7.2.3 (Maraffi & Paris, 2017) showed that the attention rate for the frontal lesson and the one related to the multi-media lesson are similar, supporting the possible effectiveness of a digital approach to learning. The

multi-media activities (PPT supported) allow only a degree of attention slightly larger compare (Fig.3.7.2.3) and to the traditional transmissive lesson. This may be the contribution of the multi-media tool, which increases the perception. The student's perception increases but, however, the attention duration is equally short and the drop out is the same. Instead, the CCRPG allows a significantly greater attention, with a persistent attention during the whole activity.

The analysis of the results referring to the single classes (Fig. 4.3.2.2) shows that the knowledge of the topics treated in the games, possessed by the students before experimenting with the CCRPG, was extremely poor, if not null (Fig. 4.3.2.2c). We must bear in mind that these are classes for which the topics covered in the CCRPG are part of the curriculum program, that is, they should study them. Furthermore, six out of the nine classes examined are senior classes, for which the game topics are compulsory for the final exam (figs. 4.3.2.2 c, d, e, f, h, i, l). We can have a more detailed overall idea effectiveness of the CCRPG if we analyse in details the relative frequencies of the correct answers, expressed as a percentage (Fig. 4.3.2.5). In Figures 4.3.2.5a the values of mean, median and mode are very close to each other: students' knowledge and skills in Earth Science, as they emerge from the pre-tests, are extremely disappointing, despite national school reforms, environmental issues awareness or the prospect of the final exam. The histogram of Figures 4.3.2.5a has a positive skewness: the distribution of the values is shifted downwards. Although there are students more or less predisposed to study in the individual class groups, or differently interested, usually little or nothing is done in the field of Earth Science. The histogram of Figures 4.3.2.5b presents a mode of 5, i.e. in the post-tests following the CCRPG there is a 400% improvement. The results are poorly dispersed (media = 4.4; median = 4; mode = 5); the distribution is quite symmetrical, with a tail of higher results, compared to the lower ones (slight negative skewness) demonstrating the efficacy of the CCRPG approach. As already mentioned, such satisfying results cannot be due to chance, as demonstrated by the *Student t-test* values obtained. The excellent learning result obtained with the CCRPG GeoQuest is even more evident thanks to the comparison with the control sample (figure 4.3.2.3). The CCRPG sample and the control sample started at the same level: the improvement in learning levels measured after the CCRPG is 269%, while the control sample after the traditional lesson checks an improvement of

133%. Since the traditional lesson carried out for the control sample had the help of multimedia and powerpoint tools, we can conclude that it is not the multimedia tool itself to give a more profitable learning environment, but the CCRPG engaging and interactivity approach.

5.1.1. CLIL approach

The learning improvement obtained with CCRPG GeoQuest is the same (more than 268%), both using the CLIL approach (Figure 4.3.2.4a) and using the mother tongue CCRPG (Figure 4.3.2.4b). The control sample outcomes still remain lower than the experimental classes, but the outcomes of the CLIL approach are worse (133% improvement, Fig. 4.3.2.4a) than the mother tongue ones (147% improvement, Fig. 4.3.2.4b). Therefore the CLIL approach reduces the results of disciplinary learning, if conveyed by lessons supported by multimedia tools; instead with the CCRPG you can obtain the learning (fluent understanding) of the foreign language without decreasing the learning of the contents and the competences proper of the various subjects.

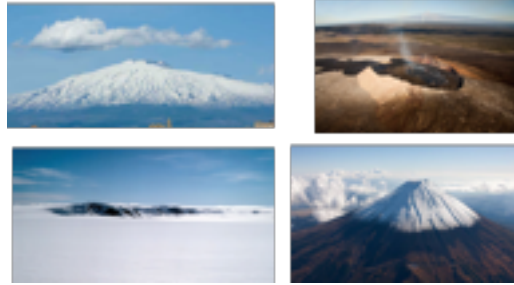
5.1.2. Discussion about Icelandic experience's findings

The Figure 4.3.2.6 shows that even the most difficult topics can be successfully learned through the CCRPG. A separate consideration must be done for Figure 4.3.2.6 E and F. In GeoQuest pathways no information is provided to answer these questions:

Which of these volcanoes, according to you, might have the same type of Vesuvius eruptions?

- ☐ •Kilauea, Hawaii Islands
- ☐ •Monte Fuji, Japan
- ☐ •Etna, Italy
- ☐ •Grimsvötn, Iceland

Which of these volcanoes, according to you, might have the same type of Vesuvius eruptions?



Yet in the post-test of Fig. 4.3.2.6 F there is an improvement in the responses of 286.7%. Why? Because in the first case questions requested only to answer names and therefore require knowledge of the names themselves: if they are not provided, they can not be invented. Instead, in the second case the images require concepts that, although not provided, can be recovered thanks to the skills acquired with the CCRPG activity. From the figure 5.1.2.1 we can see that, unlike the Italian students, Icelandic ones have the practice of subjects of mineralogy, of volcanology and of geology in general. This because they follow curricular courses in both Science and Geology. Yet the number of correct answers in the pre-test is low (Table 5.1.2.2; Figs. 5.1.2.3 and 5.1.2.4). After the activity with the CCRPG GeoQuest the correct answers are many more. This proves the effectiveness of the CCRPG methodology in learning.



Table 5.1.2.1. Data fig. 5.1.2.1

	YES	NO
Did you know Mineralogy before this teaching activity?	14	4
Did you know Mineralogy before this teaching activity?	9	9
Did you know Mineralogy before this teaching activity?	16	2
Did you know Mineralogy before this teaching activity?	16	2
Did you know Mineralogy before this teaching activity?	11	7
Did you know Mineralogy before this teaching activity?	10	8
Did you know Mineralogy before this teaching activity?	6	12
Did you know Mineralogy before this teaching activity?	16	2
Did you know Mineralogy before this teaching activity?	18	0
Did you know Mineralogy before this teaching activity?	12	6

Table 5.1.2.2. Questions of Pre-test and Post-test given to Icelandic students.

No	Questions
1	Which class of minerals characterizes the magma?
2	What kind of eruption destroyed Pompeii?
3	Who described the 79 a.C. eruption in a famous letter?
4	Which activity often anticipates volcanic eruptions?
5	The effusive rocks can have texture:
6	What activity can follow volcanic eruptions?
7	What makes fertile the Vesuvian area?
8	Which minerals contain more iron?
9	Which of these volcanoes, according to you, might have the same type of Vesuvius eruptions?
10	Which of these volcanoes, according to you, might have the same type of Vesuvius eruptions? (with photos)

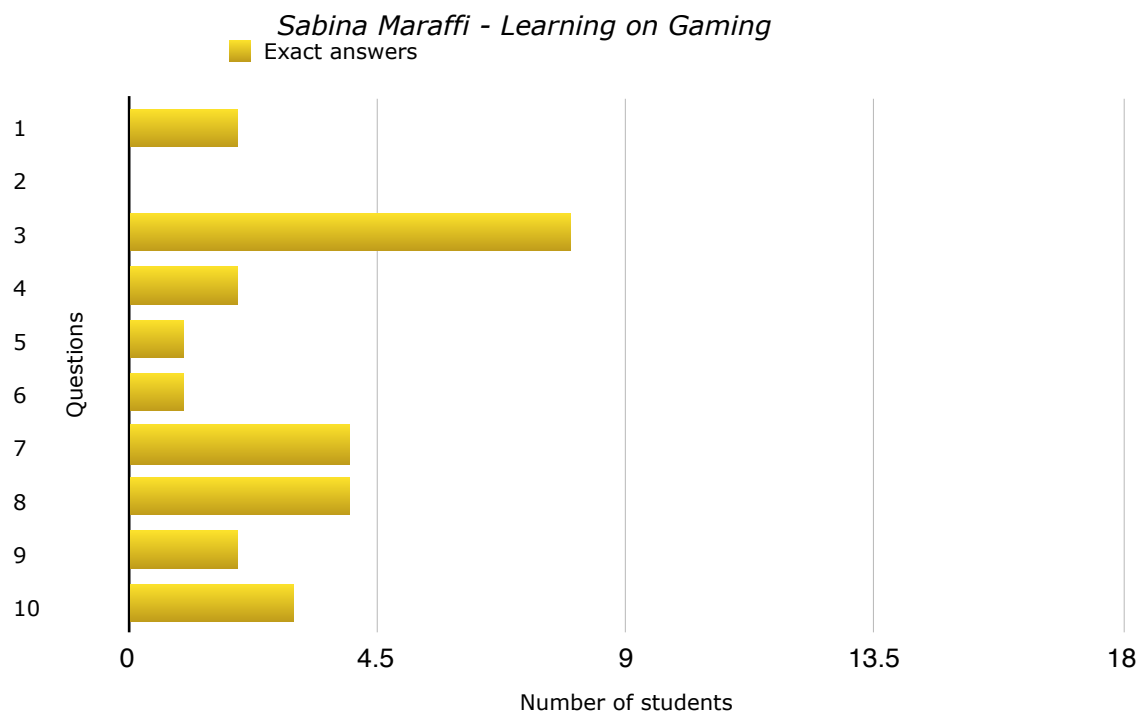


Figure 5.1.2.3. Kvennaskólinn í Reykjavík - Iceland. PRE-TEST. Number of students who provided the correct answer for each question. The question numbers refer to Table 5.1.

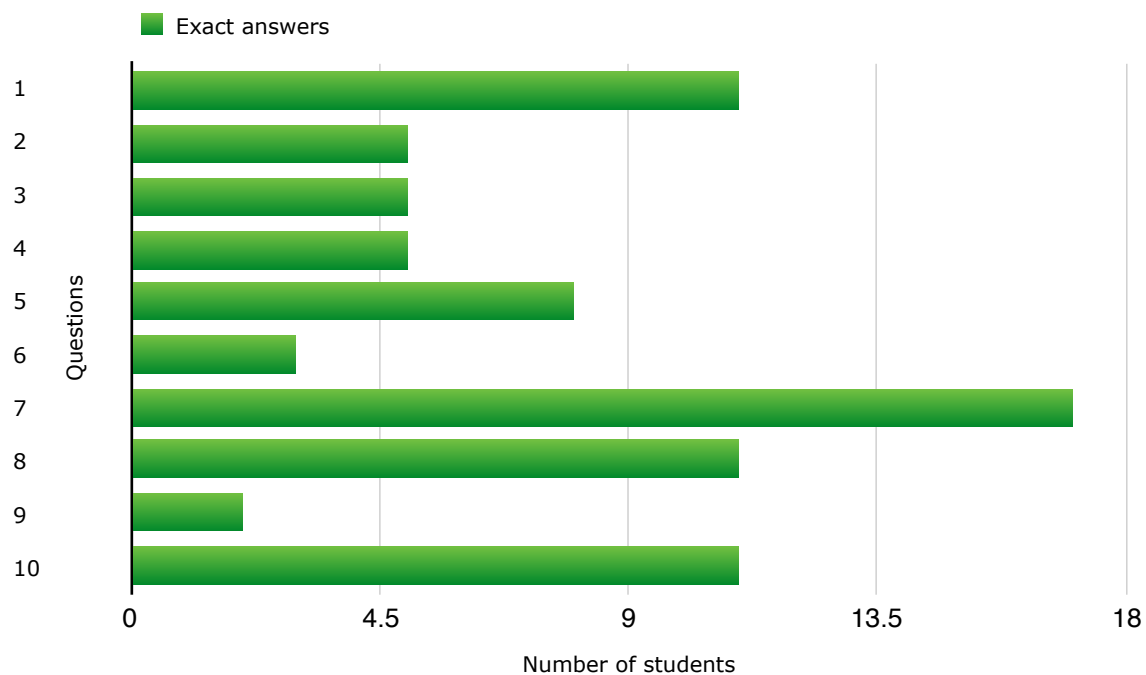


Figure 5.1.3.4. Kvennaskólinn í Reykjavík - Iceland. POST-TEST. Number of students who provided the correct answer for each question. The question numbers refer to Table 5.1.

5.1.3. Students' and teachers' satisfaction

In the following the frequency charts for the topics considered most important are shown. The evaluations requested to the students have all had excellent results. The use of the notebook and the CLIL approach are *teaching* matters more than *learning* matters; therefore, we focused students satisfaction on the learning experience with the CCRPG. It should be noted that student judgments are not dispersed, but homogeneously concentrated in the area of excellence. It is obvious that the use of technological tools constitutes an engagement for the students and in fact the appreciation is highest (median = 10; mode = 10).

To the university students of Linguistics in Education a more technical evaluation, typical of their specific research studies, was requested, based on ten questions, as shown in figure 4.3.13. All evaluations are highly positive, so we have chosen to develop the relative frequency charts for 4 topics, which are the same on which the analysis of evaluations by the other groups has been focused. Brilliant results here again, concentrated in the area of excellence (figure 4.3.14). The evaluation of the results and the comments of these students show that, on the one hand, even for university students, the experience with the CCRPG is effective, on the other hand that future teachers express an appreciation supported by innovative teaching and methodological skills.

Finally the teachers' results are summarized. High school teachers (Figures 4.3.15 and 4.3.16) have experimented CCRPG GeoQuest with their students and the teachers of survey No. 2 (Figures 4.3.17 and 4.3.18) have personally experienced the CCRPG, evaluating its teaching and learning characteristics. The analysis of the data (Tables 4.3.15 and 4.3.17) shows that teachers give an excellent evaluation to the teaching experience with GeoQuest, evaluating positively the interdisciplinary approach, the CLIL compliance, the team working and laboratory teaching with CCRPG, the use of ICT. These results are particularly important because the professional judgment of the teachers can provide information that can contribute to the improvement of the CCRPG. Also, their positive evaluation support the idea that such approach could be used successful in many schools since it could meet the interest of both students and teachers.

5.1.4. Students with Special Educational Needs

In chapter 4 (table 4.3.1) the classes in which pupils with Special Educational Needs were present are indicated. These students did the teaching activity with GeoQuest together with the whole class, taking advantage of the compensatory tools mentioned in chapter 3, and were subjected to the same pre-tests and post-tests of their classmates. The results were perfectly in line with the rest of the class, so much so that they are not distinguishable from the results of the other students (see chapter 4). This shows that the CCRPG is effective for personalized learning too. On the other hand, the interactive characteristics of the activity with GeoQuest revealed a greater involvement of all the students, without distinction, involving even the students less prone to Science.

5.1.5. Spin-off for Pupils and Younger students: the Apps

The teaching experience carried out in the volcanic area of Campania region in Italy, where Mt.Somma-Vesuvius and Phlaegrean Fields are located, and the PhD carried out in an area with high seismic hazard prompted to apply the Learning on Gaming methodology for the development of an App to improve Earth Science knowledge, environmental awareness and safety education (Fig. 5.1.5.1).



Figure 5.1.5.1. Saving Yourself versions for volcanic and seismic hazards.

Saving Yourself is an App on iOS to learn the correct behaviours to keep in an emergency caused by natural phenomena. The App is intended to provide, in the most immediate and practicable way, what to do in case of volcanic eruptions or earthquakes. The App consists in adventures thought and built for different students' ages. The App can be used at school to optimize education safety measures, but can also be useful to refresh what it has been studied before regarding Earth sciences topics

related to volcanoes and earthquakes. The methodology used are storytelling, gaming (Fig. 5.1.5.2), use of Information and Communication Technologies, innovative teaching. For the youngest students (age 8-11)



Figure 5.1.5.2. Methodology is storytelling, gaming, use of information and communication technologies, innovative teaching.

storytelling can be used to guide kids through the comics to learn the basics of geology and the best practices of civil protection related to volcanic and seismic hazard and the foundation of risk prevention. All the Saving yourself apps are enriched with original designs, suitable for the youngest, and appealing for all ages. Another engage element is the presence of a game with multiple levels, with different prizes to win: a green belt, a red belt (Fig. 5.1.5.3), a blue belt, a safety star and so on.



Figure 5.1.5.3. Another engage element is multiple game levels, with different prizes: a green belt, a red belt, a blue belt, a safety star.

At the end of the game, each player can do a test to check what kind of "emergency expert" he/she has become.

Another important strength of the activity is the immediate feedback obtained during the game (Fig. 5.1.5.4): a wrong answer is indicated in red, while the correct answer appears in green. Then some explanation on the right answer is available. Through the App and the game, a wealth of valuable information on Geosciences is provided; for example, the rise of the gas inside the magma, or terms such as vulnerability, hazard and risk.

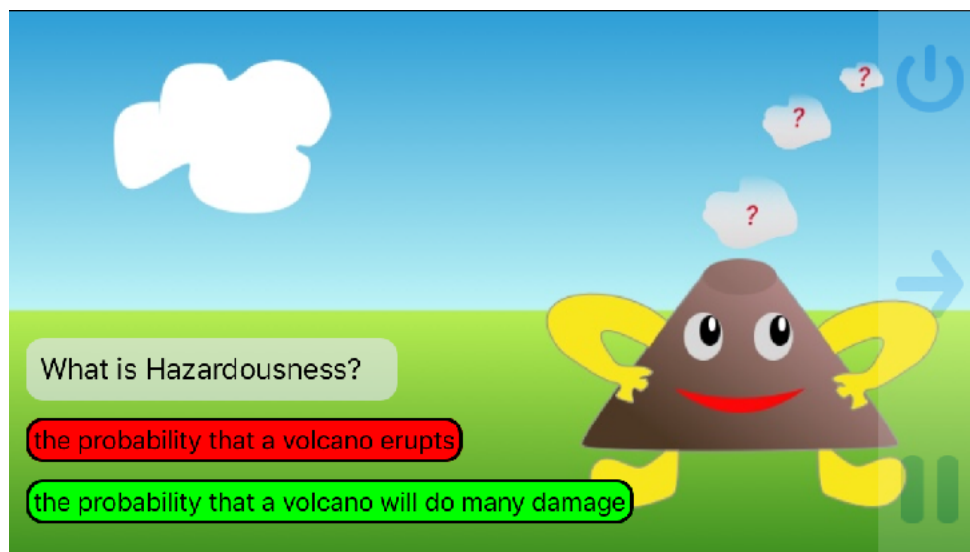


Figure 5.1.5.4. Immediate feedback: wrong answer is indicated in red, while the correct answer appears in green.

With GIFs (Graphics Interchange Format, a bitmap image format that supports animations), the Earth mechanisms are clarified (Fig. 5.1.5.5), so it is easier to defeat the frequent misunderstandings regarding the Earth interior, the plates movements, the convection cells, the formation of ocean ridges. Regarding the civil protection, the App, and in particular the earthquake version, aims to make the students aware of the actions and the precautions to take during and after an emergency and to give informations useful to act effectively and avoid panic.

Saving Yourself was presented at the Fall Meeting of the American Geophysical Union (AGU, 2017) (Maraffi & Sacerdoti, 2017c) but it has not subjected yet to experimentation. It is reported here for complete report of the variety of activities created in the frame of the PhD research.

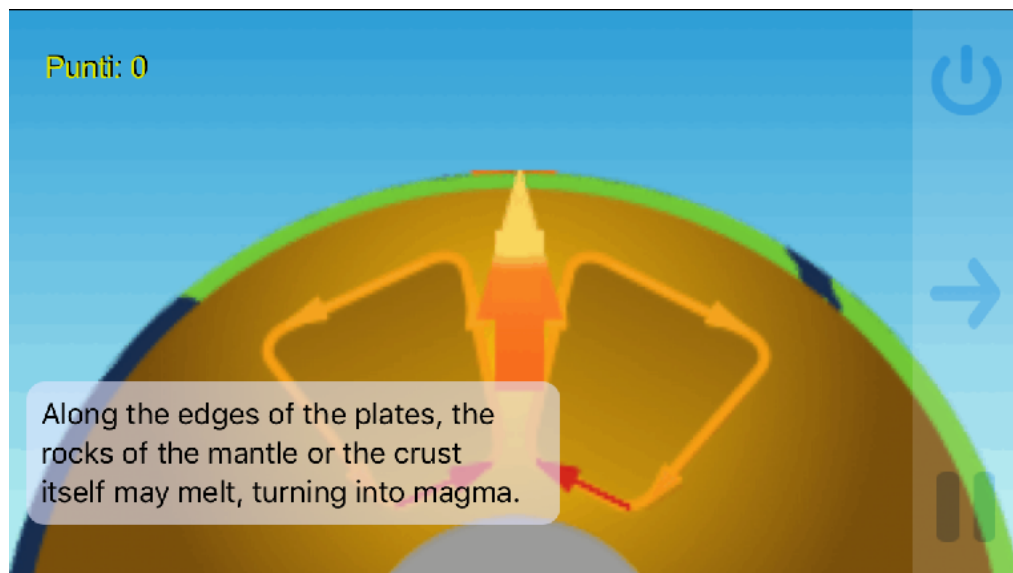


Figure 5.1.5.5. With GIFs is possible to easily illustrate the most important mechanisms inside the Earth.

6. Chapter VI - Conclusions

The aim of this research project was to improve the learning of Earth Science, stimulating the curiosity and participation of students with innovative teaching methods. At the same time the idea was to provide Science teachers with an easy-to-use teaching technology, useful to induce the most reluctant teachers to address Earth Science topics, through stimulating and interdisciplinary teaching materials. Moreover, an important goal to achieve was to favor the complete integration of the class group with a personalized didactics, which could provided also the inclusion of students with Special Educational Needs. With a view to comply also to the European Recommendations about Education, a new teaching technology was planned, that could allow, among those already mentioned, the acquisition of key competences of citizenship, with particular consideration to the learning of foreign languages and the knowledge about other countries and cultures.

For this reason it has been proposed the application to Earth Science of the Learning on Gaming (LoG) and the development of a new Digital Game Based Learning (DGBL) approach. The aim is to create new educational games, using a learning environment with game mechanisms useful to enhance engagement and acquisition of skills and improve education outcomes. The research of this PhD has been focussed on the development and experimental verification of virtual games under the denomination of CCRPG (Computer Classrooms role Playing Games) and GeoQuest project, devoted to science education with an interdisciplinary approach.

The experimentation allowed to evaluate and prove that the GeoQuest Project can contribute positively to science education, guaranteeing an effective acquisition of the key competences and the disciplinary ones requested by the modern Science and Technology. This has been demonstrated by the results obtained by the tests which show an improvement in learning levels obtained with the CCRPG of 269%, while the control sample using the traditional lesson shows only an improvement of 133%. (Figs. 4.3.2.5; 4.3.2.3). The results obtained by experimenting the use of gaming for the science education also demonstrated that it is possible to reconcile the needs of teachers to have user-friendly teaching materials, that do not require major adaptation, to

the needs of students to have effective training. The data obtained on a large number of students of different ages and school types allowed to show the potentials and advantages of this type of educational activity, which overcome the results obtained by a simple virtual game, testifying that the new approach used in GeoQuest is effective in fostering the acquisition of knowledge.

The GeoQuest Project has been also considered by the teachers a good educational tool, as it is able to stimulate students' interest and keep their attention high during the entire duration of the teaching activity (Fig. 5.1) favouring their engagement in the learning process. This result was evidenced by the answers to the questionnaire administered to a large number of teachers participating to the experimentation with their classes (par 5.1). The analysis of the data (Tables 4.3.14 and 4.3.15) shows that teachers give an excellent evaluation to the teaching experience with GeoQuest and to the interdisciplinary approach, to the CLIL compliance, to the team working and laboratory teaching with CCRPG, to the use of ICT.

6.1. Research questions and outcomes

In particular, the experimentation allowed to answer the research questions formulated at the beginning of the project, which were identified as in the following questions.

6.1.1. Could digital games foster acquisition of Science skills?

In chapter 4 (Figures 4.3.2.3 and 4.3.2.4) it has been shown that the difference between the pre-test and the post-test is considerable, ie the improvement of sciences knowledge is satisfactory. In Fig. 4.3.2.6E and 4.3.2.6F it is clear that the difference between pre-test and post-test is minimal if the knowledge is investigated (names of volcanoes for example). On the other hand, if the skills are investigated, the difference between pre-test and post-test is remarkable (images of the volcanoes, through which it is possible to connect the form to the eruptive style).

6.1.2. Could computer games be a vehicle for "in-situation" learning?

In chapter 3 we have seen that computer games, by reproducing a complex and interdisciplinary reality, create a learning environment in which the student is "in situation". Students must not elaborate an abstraction from the information received, since the CCRPG reproduces ever-changing realities. Many technical and professional skills, but also transversal and decisive - such as those related to the ability to manage situations that are always new and unexpected, problem solving, divergent and creative thinking - are acquired directly "in situation", through direct experience. The individual does not learn through lessons that transmit a defined quantity of abstract knowledge that will then be assimilated and applied in other contexts, but "learn by doing" (learning-by-doing). The concept of "situated learning" (Piangiamore et al., 2016) develops normally as a result of involvement in specific activities, in specific contexts, in the relationship with other people. According to this theory, learning is not configured as an individual practice and free from the dynamics and the context of belonging but, on the contrary, through social and participative activities like in the CCCRPG, not only merely cognitive (transfer of knowledge) and individual.

6.1.3. Could role-playing games support personalized learning?

GeoQuest make use of compensatory tools , like narrative contest, memory retention, coherent feedback, alarms and important cues (such as hotspot, media controls, sound cues, guide, noise, abstraction, alert, switch, mouse-over, scaffolding, and game tips to help the player perform accurately), visual modality. They are all considered to be effective in enabling persons with developmental disabilities to enhance understanding and remember information (as described in paragraph 3.7.2), allowing to obtain the full inclusion of students with Special Educational Needs, as reported also in paragraph 5.1.4. Therefore, GeoQuest could represent a valid educational tool, also because it can be changed or built up from the beginning to take into account students'

difficulties or request by the teachers, for example to facilitate the inclusion of hearing or visually impaired students or could adapt to a personalized teaching for students with specific times and learning methods.

6.1.4. Could game-based learning motivate teachers and renew their teaching styles or habits?

The analysis of the data results regarding the teachers (par. 4.3.2, Tables 4.3.2.14) shows that they gave excellent evaluations to the teaching experience carried out with GeoQuest, appreciating the interdisciplinary approach, the CLIL compliance, the team working and laboratory teaching possibility with CCRPG, the practical use of ICT. This positive appreciation is an indication that the teachers are open to new educational approaches when they recognized its effectiveness in all the educational aspects. The difficulties of a new approach can be easily overcome with a brief training and the availability of ready-to-use materials. Moreover, they much appreciated the possibilities to build their "own stories" and involve the students in the creative process.

6.1.5. Could the GeoQuest Project play a role in improving the learning of Earth Science?

Overall, the results illustrated in chapter 4 and discussed in chapter 5, show that the topics of Earth Science, dealt through the use of CCRPG in an interdisciplinary way, demonstrated to have achieved excellent outcomes in terms of learning and interest, helped also by stimulating the curiosity of students via the demonstration of the interconnected links among Science. Therefore CCRPG could be a way to introduce more Earth Science in the teaching of the Sciences, as demonstrated by the SoilQuest (for middle school students) or CrimeQuest games (for high school students).

6.2. Final remarks

The GeoQuest Project effectively matches the needs identified by students and teachers (see Chapters 4 and 5), i.e an effective learning with an easy-to-use teaching technology. The experimentation has been carried out in two phases to allow to calibrate and better improve the GeoQuest project obtaining a rigorous and reliable evaluation of the results, as supported by the large experimental sample.

We also confirm that the Learning on Gaming, proposed through the CCRPG GeoQuest, can improve an integrated development of basic skills and European key competences and foster Earth Science disciplines (Chapter 4) as well as being a teaching tool that perfectly complies with the demands of modern society (Chapter 1).

Above all, the project answers the research questions in teaching and learning processes in Science Education: to create an educational tool that ensures students build knowledge of the disciplines founding cores in an interdisciplinary key, which allows students to acquire technical and technological skills, mastery of foreign languages, flexibility, creativity and entrepreneurship. At the same time, the CCRPG GeoQuest favours the teachers' teamwork and the students' cooperative learning, favorites teachers to apply the innovative teaching approaches needed today, in a user-friendly and satisfying way. Until today, teaching products appreciated by the students were judged by the teachers either ineffective or too challenging. Teaching products pleasing to the teachers, on the other hand, proved either ineffective for the students or too obsolete. The Computer Classroom Role Playing Game GeoQuest, instead, ensures much higher learning outcomes than those obtained with other teaching tools, as observed by the teachers (chapter 4), thus favouring the acquisition of scientific, interdisciplinary and digital skills. The evaluation of students' performances is also made simple and this is particularly appreciated by the teachers, who also appreciated the flexibility which allows integrating laboratory teaching, CLIL approach, application of the Inquiry methodology, students engagement and authentic assessment of the skills.

GeoQuest also meets the liking of students, both for being a game, close therefore to their interests, and for using modern technology. On the

other side, the results of the experimentation show that the CCRPG brings a significantly higher concentration, compared to other teaching methods, with a persistency of the students' attention level during the whole game (chapter 5). We have demonstrated, comparing classes with different teaching methods, that it is not the multimedia tool itself to give a more successful learning environment, but it is the CCRPG which produces a high level of engaging and interactivity, stimulating the attention of the students and the retention of the informations gained.

Contrary to the majority of the educational games, the CCRPG tool sharing allows other teachers to implement the game or create new adventure paths, working together with their students or other teachers, favouring also contacts and exchange among schools in Italy and abroad. The creation of new adventure pathways activates positively in the students digital and technological skills. Furthermore, the practice of storytelling improves students' learning and the search for the various building blocks to use for the game stimulates the acquisition and management of the different channels of communication and learning (images, videos, audio, etc..).

6.3. Limitations and Solutions

During the various phases of experimentation some weaknesses of the CCRPG emerged, which can be here summarize, along with the possible solutions:

1. Dealing with the younger students (8-10 years old), the mechanism of the game could in some cases distract from the educational objectives, as they let themselves be taken by the dynamics of the scores instead of the content.
2. Time management is not always functional to teaching, as some paths are longer than others or just too long for the school time available.
3. The syntax used in the oral and written expression is very rich and sometimes complex for using with digital tools and with the short time

characteristics of gaming and storytelling: for example, some phrases that appeared on one screenshot were too long to read or contained too complex terms.

4. The syntax in foreign languages (for example English) was sometimes too complex for the students, both Italian and non- Italian, even in countries where English is considered a second mother tongue.

To solve these weakness, in the course of the research project some adjustments were carried out:

👤 Weakness n. 1. Make the CCRPG more flexible, so as to regulate the mechanisms of the game according to the age of the students. For example, now it is possible to choose whether to differentiate the roles of the players or not; whether to have them proceed alone or guided by the teacher; whether to watch videos of hands-on activities or make the same activities in the class during the game.

👤 Weakness n. 2. Now at any time the adventure path can be interrupted and resumed later, or it is possible to "skip" parts of the pathway, according to the objectives chosen or the time available.

👤 Weakness n. 3 and 4. As a consequence of the project, a collaboration started on linguistic simplification in storytelling and gaming, collaborating with Prof. Johanna Monti, from the University L'Orientale of Naples, Italy, Department of Linguistic, Literary and Comparative Studies. A PhD student (Dr. Annalisa Raffone) is carrying out a Research Project (PhD "Innovative to Industrial Characterization" XXXII cycle, within the PhD in Literary, Linguistic and Comparative Studies at the University of Naples "L'Orientale") on Linguistic Simplification in the Storytelling applied to Gaming, specifically for GeoQuest Project ("Development and effects that the use of Digital Storytelling, understood as a new art of narration, brings in the teaching of foreign languages and cultures"). There is already a first result: the GeoQuest Hawaii adventure pathway was created according to the canons of linguistic simplification applied by Dr. Raffone (collaboration foreseen in the frame of her PhD project with the author of this thesis and with the company *e-voluzione srl*, the EvoQuest software patent holder).

6.4. Future developments

Since the beginning of the first experimentation and also as a result of the disclosure of this research work, the requests to try the game in many schools have multiplied. The five already existing pathways will soon be joined by others already requested. Some schools, in different Italian regions, have placed GeoQuest at the base of school projects to support learning or development of scientific and digital skills (Projects with Ministry of Education funds). GeoQuest was chosen as a Joint Project between European countries by the executive board of Science on Stage Europe (<https://www.science-on-stage.eu>), which deals with the spread and sharing of innovative methodologies to teach Science. Science on Stage funded the exchange between Italy and Iceland for the diffusion of the CCRPG methodology. The final presentation of the results will be carried out in Portugal.

Finally, the positive experience with GeoQuest Project attracted a series of related projects (Maraffi & Sacerdoti, 2018d, 2018e). A new App has been developed for education to show the students the behaviors to keep during emergencies, diversified by students' age and subject. The first App , regarding earthquakes has been presented at the 2017 American Geophysical Union meeting in New Orleans (USA) and attracted a lot of attention by the educators. Also there was a request to apply the CCRPG to tourism, with the creation of adventure paths that could allow the fruition of the Italian and foreign natural and cultural heritage sites, which will be object of a new project.

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7.1. Sitography

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8. Appendix

A. Questionnaires

B. Joint Project GeoQuest Project for Science on Stage Europe

C. CLIL Project with GeoQuest, ITS "L. Galvani" Giugliano in Campania - Naples, Italy.

D. Brochures of GeoQuest adventure pathways and spin-off.

ANNEX A: Questionnaires

I. Students test for first step of experimentation (calibration).

Scuola: ☐ Infanzia ☐ Primaria ☐ I grado ☐ Liceo ☐ Ist. tecnico ☐ Ist. profess.
 Classe: ☐ 1° ☐ 2° ☐ 3° ☐ 4° ☐ 5° ☐ Classe aperta
 Disciplina docenti coinvolti:

Hai sperimentato una metodologia didattica basata sul gioco.

In particolare il gioco proposto è un **gioco interattivo**, cioè consente agli studenti di interagire con il gioco stesso e di costruire il percorso di gioco in base alle proprie scelte.

L'attività proposta è anche un **Gioco di Ruolo**, denominata **RPG** (dall'inglese *Role Playing Game*), in quanto ogni studente può immedesimarsi in un ruolo preciso e portare avanti la propria strategia in funzione del ruolo assegnatogli.

Ti chiediamo ora di rispondere ad alcune domande per aiutarci a proseguire il nostro lavoro: il questionario è anonimo, NON VALUTA la tua performance nel gioco né la tua bravura. Serve a conoscere le impressioni reali degli studenti per ottenere un miglioramento generale della didattica e della vita scolastica di ogni allievo.

	Attribuisci, nella seguente tabella, un voto da 1 a 10 (1=valore più negativo; 10=valore più positivo)	Voto
1	Quanto hai avvertito la differenza tra il metodo di lavoro scolastico tradizionale e il metodo di lavoro con il gioco interattivo? (1=poca differenza, 10=molta differenza)	
2	Quanto credi possa influire il supporto fornito da un gioco di ruolo per aumentare la tua motivazione in classe? (1=poco, 10=molto)	
3	Credi che l'utilizzo di giochi didattici (come il RPG) possa essere utile ad aiutare lo studente a capire e quindi ragionare su concetti esposti? (1=poco, 10=molto)	
4	Credi possa influire l'utilizzo del Gioco per il livello di attenzione in classe? (1=poco, 10=molto)	
5	Valuta il tuo livello di attenzione durante il percorso del RPG, in rapporto all'attenzione che hai normalmente durante una lezione tradizionale (1=minore, 10=maggiore)	
6	Trovi che la metodologia di insegnamento che utilizza il gioco interattivo abbia fatto sì che si sia creato in classe un ambiente adatto allo scopo didattico? (1=minore, 10=maggiore)	
7	Ritieni che gli argomenti più difficili risulterebbero più semplici se presentati attraverso un gioco didattico interattivo?	
8	Ritieni possibile che l'uso dei giochi didattici possa migliorare il tuo successo scolastico?	
9	Se dovessi mettere in ordine le tue materie scolastiche in base alla motivazione che creano in te, in quale posizione si troverebbero le scienze della terra? (1= ultimo posto, 10= primo posto)	
10	Pensi che l'ordine sarebbe lo stesso se tutti i docenti usassero i giochi didattici interattivi?	

Collega ognuna delle seguenti caratteristiche con la metodologia didattica corrispondente (una X)	Lezione tradizionale	Lezione con Presentazione Power Point	Gioco Didattico
Semplice da seguire			
Difficile da seguire			
Stancante			
Varia			
Monotona			
Facilita l'apprendimento di argomenti complessi			
Facilita la partecipazione			
Piena di spunti			
Piatta			
Coinvolgente			

	Attribuisci un voto da 1 a 10 (1=pessimo; 2=negativo; 3=scarso; 4=insufficiente; 5=da migliorare sensibilmente; 6=poches cose da migliorare; 7=accettabile; 8=efficace; 9=ottimo;10=eccellente)	Voto
1	Ambiente di gioco	
2	Presenza della voce narrante (<i>master di gioco</i>)	
3	Suoni (passi, bisbigli, cadute, terremoto, ecc.)	
4	Possibilità di consultare il Power Point su minerali e rocce	
5	Possibilità di consultare il link di geologia	
6	Presenza, insieme agli argomenti di Scienze, di racconti mitologici e/o storici	
7	Possibilità di rispondere con il proprio smartphone	
8	Possibilità di giocare con lo smartphone anche se la rete internet della scuola non funziona	
9	Possibilità di lavorare insieme ai compagni	
10	Possibilità di giocare anche se non si conosce l'argomento di gioco	

Conclusione

Nel complesso il tuo giudizio sull'esperienza del gioco didattico interattivo è:

- ☐ da riprovare con altre avventure
☐ da riprovare con altre materie
☐ da non riprovare

II. Teachers test for first step of experimentation (calibration).

Scuola: ☐ Infanzia ☐ Primaria ☐ I grado ☐ Liceo ☐ Ist.tecnico ☐ Ist.profess.

Classe: ☐ 1° ☐ 2° ☐ 3° ☐ 4° ☐ 5° ☐ Classe

aperta

Disciplina docenti

coinvolti:

Hai sperimentato una metodologia didattica basata sul gioco.

In particolare il gioco proposto è un **gioco interattivo**, cioè consente agli studenti di interagire con il gioco stesso e di costruire il percorso di gioco in base alle proprie scelte.

L'attività proposta è anche un **Gioco di Ruolo**, denominata **RPG** (dall'inglese *Role Playing Game*), in quanto ogni studente può immedesimarsi in un ruolo preciso e portare avanti la propria strategia in funzione del ruolo assegnatogli.

Ti chiediamo ora di rispondere ad alcune domande per aiutarci a proseguire il nostro lavoro: il questionario è anonimo, NON VALUTA la performance nel gioco né la preparazione degli studenti. Serve a conoscere le vostre impressioni reali per ottenere un miglioramento generale della didattica e della espressione professionale di ogni docente.

	Attribuisci un voto da 1 a 10 (1=pessimo; 2=negativo; 3=scarso; 4=insufficiente; 5=da migliorare sensibilmente; 6=pochissime cose da migliorare; 7=accettabile; 8=efficace; 9=ottimo; 10=eccellente)	Voto
1	Ambiente di gioco	
2	Presenza della voce narrante (<i>master di gioco</i>)	
3	Suoni (passi, bisbigli, cadute, terremoto, ecc.)	
4	Possibilità di consultare il Power Point su minerali e rocce	
5	Possibilità di scegliere la lingua	
6	Presenza, insieme agli argomenti di Scienze, di racconti mitologici e/o	
7	Possibilità di rispondere con il proprio smartphone	
8	Possibilità di giocare con lo smartphone anche se la rete internet della scuola non funziona	
9	Possibilità di lavorare insieme ai compagni	
10	Possibilità di giocare anche se non si conosce l'argomento di gioco	

Nel complesso il tuo giudizio sull'esperienza del gioco didattico interattivo è:

- ☐ da riprovare con altre avventure
☐ da riprovare con altre materie
☐ da non riprovare

III. Teachers test for GeoQuest experience outcome.

Scuola: ☐ Infanzia ☐ Primaria ☐ I grado ☐ Liceo ☐ Ist. tecnico ☐ Ist. prof.

Classe: ☐ 1° ☐ 2° ☐ 3° ☐ 4° ☐ 5° ☐ Cl. aperta

Disciplina docenti coinvolti:

Hai sperimentato la metodologia didattica del *gioco di ruolo interattivo GeoQuest*.

Ti chiediamo ora di rispondere ad alcune domande per aiutarci a proseguire il nostro lavoro: abbiamo bisogno di conoscere la **ricaduta didattica** dell'esperienza che abbiamo condotto insieme. Poiché non intendiamo in alcun modo entrare nell'autonomia didattica del singolo docente, ti chiediamo di scegliere la tipologia di osservazione che ritieni più opportuna (verifica scritta, verifica orale, brain storming, ecc.) e di operare un monitoraggio complessivo sul gruppo classe. Ti consigliamo di effettuare l'osservazione entro i 15 giorni successivi alla sperimentazione del gioco. Ti saremmo grati se volessi rispondere alle domande poste di seguito e inviare il questionario via mail al seguente indirizzo: sabina.maraffi@unicam.it

	Attribuisci un voto da 1 a 10 (1=pessimo; 2=negativo; 3=scarso; 4=insufficiente; 5=da migliorare sensibilmente; 6=poches cose da migliorare; 7=accettabile; 8=efficace; 9=ottimo; 10=eccellente)	Voto
1	Durante l'esperienza gli studenti erano partecipi	
2	In seguito hanno mostrato curiosità verso gli argomenti affrontati nel	
3	In seguito hanno mostrato curiosità verso la metodologia del <i>Gioco di</i>	
4	Conoscenza degli argomenti di Scienze della Terra precedente	
5	Conoscenza degli argomenti di Scienze della Terra successiva	
6	Gli studenti hanno migliorato le proprie <i>conoscenze</i> in mineralogia	
7	Gli studenti hanno migliorato le proprie <i>conoscenze</i> in geologia	
8	Gli studenti hanno migliorato le proprie <i>conoscenze</i> in storia	
9	Gli studenti hanno migliorato le proprie <i>competenze</i> in scienze	
10	Valutazione della ricaduta didattica rispetto alla lezione tradizionale	

Alla luce dei risultati ottenuti, il tuo giudizio sull'esperienza del gioco didattico interattivo è:

- ☐ da riprovare con altre avventure
☐ da riprovare con altre materie
☐ da non riprovare

IV.Students test for SoilQuest experimentation.

QUESTIONARIO DI GRADIMENTO di SoilQuest Alunni

Sezione 1. Informazioni generali

Scuola e classe di appartenenza

.....

Genere Età

.....

Scegli il grado da 1 a 5 corrispondente a ciò che pensi 1=per niente, 2=poco, 3=abbastanza, 4=molto, 5=moltissimo

L'attività mi ha divertito

	1	2	3	4	5	
Per niente	☐	☐	☐	☐	☐	Moltissimo

Il lavoro di gruppo è stato utile per rispondere alle domande

	1	2	3	4	5	
Per niente	☐	☐	☐	☐	☐	Moltissimo

Mi è piaciuto affrontare l'argomento Suolo con questo tipo di approccio didattico

	1	2	3	4	5	
Per niente	☐	☐	☐	☐	☐	Moltissimo

Vorrei che altri argomenti venissero presentati in questo modo

	1	2	3	4	5	
Per niente	☐	☐	☐	☐	☐	Moltissimo

Il videogioco mi ha entusiasmato

	1	2	3	4	5	
Per niente	☐	☐	☐	☐	☐	Moltissimo

Sezione 2. Informazioni disciplinari

Gli ingredienti del suolo sono:

- I rifiuti trasformati dall'uomo
- Ghiaia, cemento, asfalto e acqua
- Minerali, aria, acqua e materiale organico

Per la formazione di 10 cm di suolo fertile sono necessari:

20 giorni 20 mesi 2000 giorni 2000 anni 2 milioni di anni

Cementare un terreno o asfaltarlo

- Mantiene il suolo fertile e coltivabile
- Impermeabilizza il terreno
- Non fa danni per l'ambiente

La capacità di trattenere acqua di un suolo dipende:

- Dalla quantità di Humus
- Dal colore del suolo
- Dalla presenza di una copertura di plastica

L'agricoltura biologica

- Evita lo sfruttamento del suolo e ne mantiene la fertilità
- Non utilizza la rotazione colturale
- Non utilizza mezzi meccanici

Nel sottosuolo la biodiversità animale dipende:

- Dal tipo di suolo
- Dalla quantità di sassi presenti in un terreno
- Dal tipo di coltivazione e dalla quantità di Humus

Il suolo "che cosa fa?": (più risposte corrette)

- Origina l'arcobaleno
- E' fonte di cibo e vita
- Filtra ed immagazzina acqua potabile
- Forma le rocce
- Assicura il riciclo dei nutrienti

Il suolo è una risorsa rinnovabile

- SI
- NO

V. Teachers test for SoilQuest experimentation.

Sezione 1. Informazioni generali

Scuola e classe di appartenenza Genere Età

.....

Disciplina insegnata.....

L'attività è stata svolta con:

☐ gioco di ruolo

☐ lezione ed esperimenti pratici

Sezione 2. Osservazione del docente durante l'attività

Scelga il grado da 1 a 5 corrispondente a ciò che pensa

1=per niente d'accordo, 2=poco d'accordo, 3=d'accordo, 4=molto d'accordo, 5=del tutto d'accordo

L'attività ha coinvolto positivamente gli alunni

	1	2	3	4	5	
Per niente d'accordo			☐	☐	☐	Del
tutto d'accordo				☐	☐	

L'attività ha coinvolto anche gli alunni che solitamente non partecipano alle lezioni

	1	2	3	4	5	
Per niente d'accordo			☐	☐	☐	Del tutto
				☐	☐	d'accordo

Il lavoro di gruppo è stato utile per rispondere alle domande del gioco

	1	2	3	4	5	
Per niente d'accordo			☐	☐	☐	Del
tutto d'accordo				☐	☐	

E' utile affrontare l'argomento "Suolo" con questo approccio

	1	2	3	4	5	
Per niente d'accordo			☐	☐	☐	Del
tutto d'accordo				☐	☐	

Vorrei che altri argomenti venissero presentati con questo approccio

	1	2	3	4	5	
Per niente d'accordo			☐	☐	☐	Del
tutto d'accordo				☐	☐	

VI.Pre-test for GeoQuest Vesuvius with CLIL approach.

Kvennaskólinn í Reykjavík	Please, give one answer Right answer is only one for each question.
Name of student	

- | | |
|--|--|
| <ol style="list-style-type: none"> 1. Which class of minerals characterizes the magma?
 ☐ Oxides
 ☐ Silicates
 ☐ Carbonates
 ☐ Sulphates 2. What kind of eruption destroyed Pompeii?
 ☐ Effusive
 ☐ Explosive
 ☐ Hydromagmatic
 ☐ Magmatic 3. Who described the 79 a.C. eruption in a famous letter?
 ☐ Tacito
 ☐ Goethe
 ☐ Plinio the younger
 ☐ Plinio the older 4. Which activity often anticipates volcanic eruptions?
 ☐ High intensity earthquakes
 ☐ Low intensity earthquakes
 ☐ Tsunamis
 ☐ Rain 5. The effusive rocks can have texture:
 ☐ Holocrystalline
 ☐ Porphyric
 ☐ Granitic
 ☐ Schistose 6. What activity can follow volcanic eruptions?
 ☐ Explosive
 ☐ Ortomagmatic
 ☐ Seismic
 ☐ Hydrothermal | <ol style="list-style-type: none"> 7. What makes fertile the Vesuvian area?
 ☐ Mud
 ☐ Lava
 ☐ Ash
 ☐ Limestone 8. Which minerals contain more iron?
 ☐ Quartz
 ☐ Leucite
 ☐ Pyroxene
 ☐ Gypsum 9. Which of these volcanoes, according to you, might have the same type of Vesuvius eruptions?
 ☐ Kilauea, Hawaii Islands
 ☐ Monte Fuji, Japan
 ☐ Etna, Italy
 ☐ Grimsvötn, Iceland 10. Which of these volcanoes, according to you, might have the same type of Vesuvius eruptions? |
|--|--|



VII.Pre-test for GeoQuest Vesuvius with CLIL approach.

Kvennaskólinn í Reykjavík	Please, give one answer Right answer is only one for each question.
Name of student	

- | | |
|---|--|
| <p>1. Which class of minerals characterizes the magma?</p> <p>☐ Oxides</p> <p>☐ Silicates</p> <p>☐ Carbonates</p> <p>☐ Sulphates</p> <p>2. What kind of eruption destroyed Pompeii?</p> <p>☐ Effusive</p> <p>☐ Explosive</p> <p>☐ Hydromagmatic</p> <p>☐ Magmatic</p> <p>3. Who described the 79 a.C. eruption in a famous letter?</p> <p>☐ Tacito</p> <p>☐ Goethe</p> <p>☐ Plinio the younger</p> | <p>☐ Plinio the older</p> <p>4. Which activity often anticipates volcanic eruptions?</p> <p>☐ High intensity earthquakes</p> <p>☐ Low intensity earthquakes</p> <p>☐ Tsunamis</p> <p>☐ Rain</p> <p>5. The effusive rocks can have texture:</p> <p>☐ Holocrystalline</p> <p>☐ Porphyric</p> <p>☐ Granitic</p> <p>☐ Schistose</p> <p>6. What activity can follow volcanic eruptions?</p> <p>☐ Explosive</p> <p>☐ Ortomagmatic</p> <p>☐ Seismic</p> |
|---|--|

ANNEX B: Joint Project for Science on Stage

I. Presentation

ICELAND, ITALY, GREECE



GeoQuest Project

Project Proposal

Prepared for: Science on Stage Teacher Exchange

Prepared by: Proff. Asdís Ingólfssdóttir, Sabina Maraffi, Astrinos Tsoutsoudakis

20 July 2017

JOINT PROJECTS

Date: November, 1, 2017 - July, 31, 2018

Teachers:

- Asdís Ingólfssdóttir, _____
- Sabina Maraffi, School of Science and Technology, Geology Division, University of Camerino, Italy
- Astrinos Tsoutsoudakis, _____

Meeting location: 1. Reykjavík (Iceland), 2. Heraklion (Greece), 3. Naples (Italy),

Topic: *Learning on Gaming in STEAM (Science, Technology, Engineering, Mathematics, combined with Arts) Education:* GeoQuest Project, teaching Earth Sciences, Environmental Sciences, Chemistry in an interdisciplinary way with History and Social studies

1. Teaching Sciences with Learning on Gaming, Storytelling, Hands-on activities.
2. Teaching Earth Science with Learning on Gaming, Volcanology, Hands-on activities.
3. Teaching Sciences with Learning on Gaming; presentation of Project work, in collaboration with “Città della Scienza” of Naples, Italy.

Scope

1. **Encourage exchanges of knowledge within Europe**, studying three types of volcanoes through the history, myths, customs and traditions of local populations in order to build and strengthen **European Citizenship**.
2. **Introduce innovative approaches** that put the student and their needs in the center and enhance the learning styles and the spirit of initiative to effectively and engaging the development of **basic skills**.

Solution

GeoQuest Project is a Computer Class Role Playing Game (CCRPG), based on a new technology, designed for deeper learning of Science, Technology, Engineering, Mathematics, combined with Arts (STEAM) and Social Sciences & Humanities (SSH). It could improve the innovation and creative capacities of learners and support the new role of teacher as a coach of the learners, using a new interfaces (the students use their own tablet or smartphone to interact with the game): it's naturally a mixed reality learning environment, giving to the students the feel “to be IN the adventure environment”.

Concept and Methodology

The idea is to develop a software platform to create user-defined role-playing adventures. We have identified the lack in the market of a product that allows a single user (that acts as a master), to create a graphical role-play adventure that can be shared with and played by his/her friends. Actually there is no existing platform that allows this, and that can be a powerful potential business opportunity.

Another key point in favor of this kind of technology is that it can be utilized by customers without any programming knowledge, thus amplifying enormously the number of potential users.

Italian team has designed and realized an alpha version of the software engine in order to evaluate the estimated effort to develop a marketable product, but further study is necessary.

We have also realized, as an example, four adventures with our engine that have been tested with groups of students with very good results.

The prototypal engine allows the participation of the players in the adventure by using their smartphone or tablets with a simple browser.

The prototypal system is designed to be played in a living room all together to achieve the full involvement in the game, and because it is actually designed to be played in LAN, but the final product can also allow the participation of online players in the same game, without a physical presence in the same room.

Our experience on our prototypal engine is on educational games for schools, and our results have been published during international conferences.

Educational Activity Objectives

The game meant as a teaching tool is a situations-learning mode that requires the student to mobilise its resources to find solutions that require skills rather than simple knowledge.

The use of an educational game can achieve several significant results:

- students are asked to recover their previous knowledge;
- encouragement of the use of complex cognitive processes (reasoning, transfer, critical thinking, creative thinking);
- learning into meaningful and real contexts;
- stimulation of students' interest;
- enhancement of students' abilities.
- facilitation of learning, since the material created is usable both in the laboratory, either in place of the laboratory, and downstream of the development of a learning unit (as a conclusion and verification), or upstream (as a stimulus).
- development of new games and new teaching methods in general.
- increase in the teaching of the last generation ICT.
- teaching support, through the use of materials that meet all of the latest instances of standards and methodologies (as delineated in Europe 2020: A European strategy for smart, sustainable and inclusive growth)
- teaching support with Content and Language Integrated Learning (CLIL), with the ability to have all the materials in any languages.
- spreading a truly interdisciplinary training culture, exceeding the dichotomy science / humanities.
- personalised teaching support, also in case of Special Educational Needs.

Basic Skills Improvement

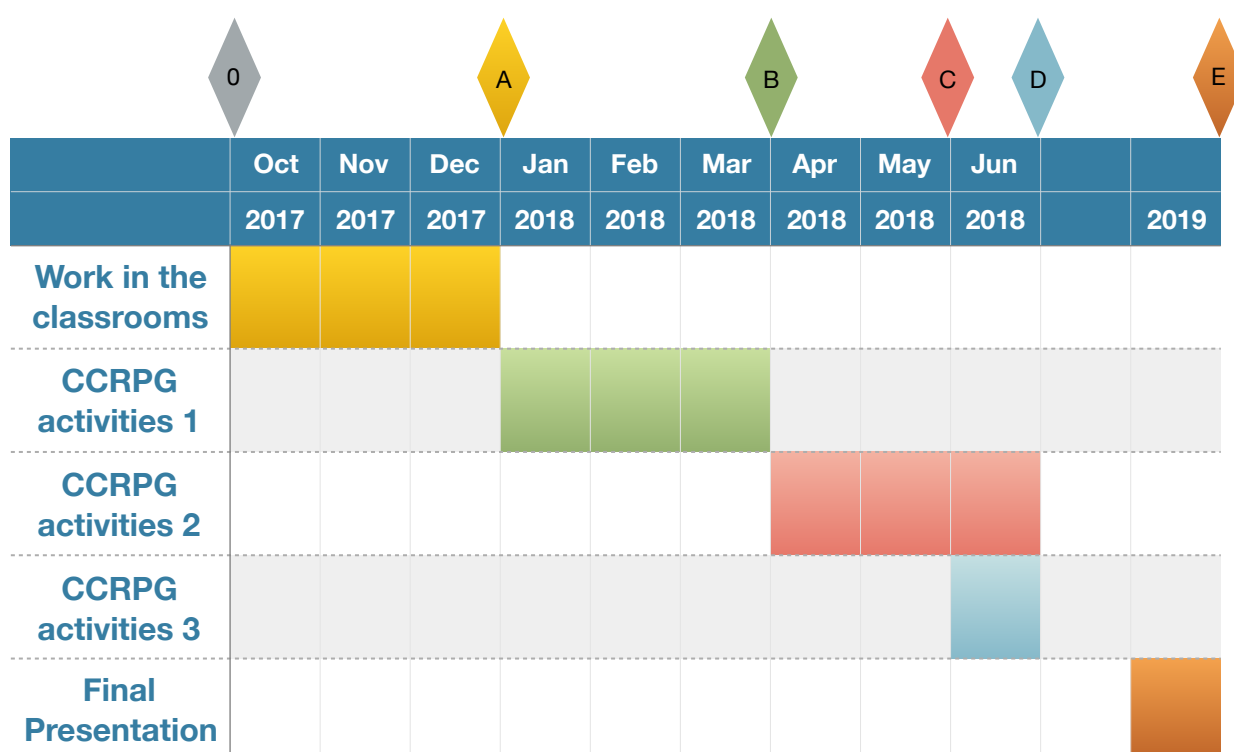
The CCRPG "GeoQuest" could improves both integrated development of basic skills and European key competences:

- Communication in one's mother tongue: through storytelling
- Communication in foreign languages: multi-language game matches CLIL approach
- Skills in maths and science: scientific topics
- Digital skills: use of computers to play the game and tablets, smartphones for interaction
- Learning to learn: inquiry, problem solving
- Social and civic responsibility: group activities, collaborative learning, peer tutoring
- Initiative and entrepreneurship: organisation of inquiry resolution paths as a group
- Cultural awareness: multidisciplinary pathways aimed at overcoming the dichotomy between Science and cultural expressions (Humanities).

The game features can be a vehicle for “situated learning” and support a personalised learning (different communication codes and different modality to convey complex topics).

Project Structure

Steps	Activities	Who	Where	When
Kick-off	* Training to teachers on how the game works, how to prepare stories, materials collections, etc.	* all participants	SKYPE	Oct 2017
Work in the classrooms	* Teachers prepare a draft story to guide students activities * Storytelling: students of each country elaborate a story and collect materials (images, photo, traditions, myth, etc.) * Game languages: mother language (Greek and Icelandic) and English	* selected classroom	Greece and Iceland	Oct-Nov 2017
Technical Preparation	* Materials checks (image resolution, video quality, etc.) * Game realization * Game Translations from English to Italian	* Sabina Maraffi * e-voluzione (software design company)	Italy	Nov 2017 (Icelandic) Jan 2018 (Greek)
Teacher evaluation	* Game testing with Icelandic teachers	* Italy and Iceland	Skype	Dec 2017
CCRPG activities 1	* Icelandic classrooms experiment Vesuvius adventure and Icelandic adventure * Test with students which participate to story preparation and new classes	* Italy and Iceland	Iceland	Dec 2017
Teacher evaluation	* Game testing with Greek teachers	* Italy and Greece	Skype	Feb 2017
CCRPG activities 2	* Greek classrooms experiment Vesuvius adventure and Greek adventure * Test with students which participate to story preparation and new classes	* Italy and Greece	Greece	Mar 2018
Refinement Activities	* Refinements based on the test outcomes	* all participants	Skype, mail, etc.	Dec 2017- Jun 2018
CCRPG activities 3	* Italian classrooms experiment Icelandic and and Greek adventures	* all participants	Italy	June 2018
Final Presentation	* Final Presentation at Città della Scienza to discuss on the outcomes, to prepare future projects together and to prepare the Science on Stage participation	* all participants	Italy	June 2018



Milestones

- 0 Kick-off meeting (Teleconference)
- A Meeting in Iceland
- B Meeting in Greece
- C Meeting in Italy
- D Results Presentation at "Città della Scienza" (Naples, Italy)
- E Final Presentation at Science on Stage Festival

II. Report of first step of Joint project in Iceland for teachers exchange (Science on Stage Europe).

Sabina Maraffi
Ásdís Ingólfssdóttir
Joint Project GeoQuest
7 dicembre 2017

Teachers Exchange Report



Preliminary steps

Kick-off - Training to teachers on how the game works, how to prepare stories, materials collections, etc.

Work in the classrooms - Teachers prepared a draft story to guide students activities. Students of each country elaborated a story and collected materials (images, photo, traditions, myth, etc.).

Planning Exchange Details - Àsdís, Sabina and Astrinos have agreed on the necessary prerequisites for the GeoQuest Project's teaching activities, timing of meeting, duration of the activities.

Àsdís-Sabina Exchange - Àsdís identified a class with which to perform the activity. She also involved colleagues, in particular Haraldur Gunnarsson, a professor of Earth Sciences, to attend both the teaching experience with Sabina and to prepare a future GeoQuest adventure on Iceland, to be done by Icelandic students.

Teachers Exchange

During the visit, among other things, Sabina:

- Receive an introduction about the Icelandic school system and Kvennaskólinn of Reykjavík.
- Do a Meeting with Àsdís Ingólfsdóttir.
- Visit the school and some classrooms.
- Gave lessons of geology with the GeoQuest project to classes in 2nd year of study.
- Do a Meeting with Haraldur Gunnarsson, teacher of geology.
- Visit a class, first year students in chemistry.
- Field trips in Iceland to experience the Icelandic geology/geography and nature.

GeoQuest Experiences

The Icelandic students have experienced the GeoQuest Project, based on a Computer Class Role Playing Game. This Game consist of several interdisciplinary Science adventures, to improve STEM Education and foster Science learning. The pathway's topic chosen for Icelandic students was GeoQuest Vesuvius, to strengthen the exchange through

Students and teachers play together with GeoQuest Vesuvius

Icelandic students have played the Vesuvius pathway of GeoQuest, to live an "Italian adventure" in an immersive teaching environment.



the knowledge of the natural, historical and cultural features of the participating countries.

The aim of exchange was:

1. Encourage exchanges of knowledge within Europe, studying three types of volcanoes through the history, myths, customs and traditions of local populations in order to build and strengthen European Citizenship.
2. Introduce innovative approaches that put the student and their needs in the center and enhance the learning styles and the spirit of initiative to effectively and engaging the development of basic skills.
3. Foster English language as vehicular language.

Players interact with Science Game through their own smartphones

GeoQuest Project combines Innovative Teaching, ICT, Sciences, Technologies, in a STEM approach.



Exchange between Iceland (host) and Italy (hosted) had two different kind of activities:

- A. *Experimenting of GeoQuest Vesuvius* with Icelandic students: the students seemed involved and motivated throughout the activity, notwithstanding the particular adventure lasts 90 minutes and the Icelandic students are used to do activities of up to 40 minutes. Sabina gave students a test check immediately before and immediately after the activity, whose results will be analysed and shared as soon as possible.
- B. *Implementation of new game paths* with Icelandic teachers: we had a training meeting to share instructions on the specific engine software used to prepare the adventure games, to use and build new Game adventure. To this aim, Sabina and e-voluzione s.r.l. (Software Developer Company and Copyright owner) gave to Icelandic teachers:
 1. A Storytelling presentations on how to write an effective adventure story
 2. A EvoQuest user manual presentation

Italian and Icelandic teachers work together to share GeoQuest experiences.

The Kvennaskólinn í Reykjavík hosted Italian teacher for learning with GeoQuest and to share GeoQuest Project teaching technology.



3. A ZIP file with an example with all Folder organisation for building the teasing game.
4. Technical and organisational support throughout the future development of the new path.

Future Steps

1. Icelandic students, together with their teachers, will develop a new GeoQuest pathway about Iceland (geology, nature, saga and culture). It will be ideal to improve their STEM knowledges and skills (through Science path, using of software, etc.).
2. Àsdís Ingòlfsdóttir will go to Italian school with Sabina (we hope!) to experiment the new GeoQuest Iceland Game with Italian students and to share with Italian teachers first step Joint Project results.
3. Implementation of GeoQuest teaching activities with other teachers, is possible also with other countries (i.e. Greece with Astrinos).
4. Sharing final results and best practices in a final meeting

Sabina Maraffi



The screenshot shows the Science on Stage Europe website. The header features the logo with stars and the text 'SCIENCE ON STAGE EUROPE' and 'THE EUROPEAN PLATFORM FOR SCIENCE TEACHERS'. A navigation bar includes links for Home, Countries, Activities, Festivals, Teaching Materials, Press, About Us, and Blog. The main content area displays a blog post with a star icon and the title 'From Italy to Iceland: Teacher Exchange on GeoQuest'. The post text describes a teacher exchange between Sabina Maraffi and Ásdís Ingólfssdóttir, their participation in the Science on Stage festival 2017, and their collaborative project 'Who killed Maya Foster? A CLIL CrimeQuest'. It details their plan to develop a new project combining computer games in STEM classes with research on geology and geography. The post is dated 04.01.2018 and includes a list of tags: teacher exchange (7), science on stage italy (3), science on stage iceland (1), science on stage festival 2017 (24), italy (5), ict (18), iceland (1), geology (2), geography (6), and computer game (1). Social media sharing icons for Twitter, Facebook, Google+, and Email are also present.

SCIENCE ON STAGE EUROPE
THE EUROPEAN PLATFORM FOR SCIENCE TEACHERS

Blog

From Italy to Iceland: Teacher Exchange on GeoQuest

04.01.2018

Tagged with:

- teacher exchange (7)
- science on stage italy (3)
- science on stage iceland (1)
- science on stage festival 2017 (24)
- italy (5)
- ict (18)
- iceland (1)
- geology (2)
- geography (6)
- computer game (1)

Recommend:

Twitter Facebook Google+ Email

Last summer Sabina Maraffi and Ásdís Ingólfssdóttir met as teacher delegates of Science on Stage Italy and Science on Stage Iceland at the European Science on Stage festival 2017 in Debrecen, Hungary. Sabina presented the project 'Who killed Maya Foster? A CLIL CrimeQuest, interactive computer class Role Playing Game'. Now she and Ásdís came up with the idea to do a teacher exchange and develop a new project together which combines the idea of Sabina to use computer games in STEM classes and to do research on geology and geography.

For developing the GeoQuest project Sabina went to see Ásdís in Iceland where she learned about the Icelandic school system, visited Ásdís school and did field trips to experience the Icelandic geology, geography and nature. Sabina also met with Haraldur Gunnarsson, a teacher and professor of Earth Sciences who is joining the project too. On site Sabina gave geology lessons with the GeoQuest project to second year students. Therefore she chose several interdisciplinary science adventures about the Vesuv for the Icelandic students, so they would not only improve their STEM skills but also gain knowledge about nature, history and culture of her own home country Italy. Furthermore, Sabina shared the game with other Icelandic teachers.

As a next step Ásdís will visit Sabina in Italy. But before she is going to develop a GeoQuest game with her students on Iceland's geology and geography for challenging the Italian students.

Report of the Joint Project on the Science on Stage Europe website.

The GeoQuest Joint Project is currently in the process of being finalized and will be officially presented during the Science on Stage Europe Festival which will be held in Cascais in 2019.

III. Report of second step of Joint project in Italy for teachers exchange (Science on Stage Europe).

Ásdís Ingólfssdóttir

Sabina Maraffi

Joint Project GeoQuest

29 marzo 2018

Teachers Exchange Report



Preparation phase

Asdis and Sabina worked together to storytelling of adventure game pathway about Iceland. Sabina identified a class with which to perform the activity. She also involved colleagues, in particular Alessandra Scamardella, professor of Literature, and Patrizio Avino, professor of Earth Sciences, to attend together the teaching experience with Asdis.

Second Teachers Exchange

Italian and Icelandic teachers work together to share GeoQuest experiences.

The Italian Liceo hosted Icelandic teacher for learning with GeoQuest and to share GeoQuest Project teaching technology.



During the visit, among other things, Asdis:

- Receive an introduction about the Italian school system.
- Do a Meeting with Sabina Maraffi.
- Visit the school and some classrooms.
- Gave lessons of geology with the GeoQuest Project to classes in 3rd year of study.
- Do a Meeting with Alessandra Scamardella, teacher of literature, and Patrizio Avino, Science teacher.
- Visit School laboratory of chemistry, laboratory of biology, laboratory of informatics.
- Visit School Planetarium and had a teacher demonstration with Prof. Avino.

GeoQuest Iceland Experience

The Italian students have experienced the GeoQuest Project, based on a Computer Class Role Playing Game. This Game consist of several interdisciplinary Science adventures, to improve STEM Education and foster Science learning. The pathway's topic chosen for Italian students was GeoQuest Iceland, to strengthen the exchange through the knowledge of the natural, historical and cultural features of the participating countries.

The aim of exchange was:

1. Encourage exchanges of knowledge within Europe, studying three types of volcanoes through the history, myths, customs and traditions of local populations in order to build and strengthen European Citizenship.

2. Introduce innovative approaches that put the student and their needs in the center and enhance the learning styles and the spirit of initiative to effectively and engaging the development of basic skills.
3. Foster English language as vehicular language.

Exchange between Italy (host) and Iceland (guest) had two different kind of activities:

- A. *Experimenting of GeoQuest Iceland* with Italian students: the students were involved and motivated throughout the activity.

Students and teachers play together with GeoQuest Iceland

Italian students have played the Iceland pathway of GeoQuest, to live an "Icelandic adventure" in an immersive teaching environment.



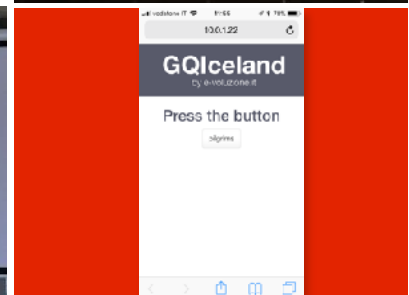
- B. *Implementation of new game paths* with Italian teachers: we had a training meeting to share instructions on the specific engine software used to prepare the adventure games, to use and build new Game adventures.

Future Steps

1. Icelandic students, together with their teachers, will played with GeoQuest pathways about Iceland and Italy (geology, nature, saga and culture). It will be ideal to improve their STEM knowledges and skills (through Science path, using of software, etc.).
2. Italian teachers and Icelandic teachers will make their students to realize an adventure pathway based on astronomy, with the ancient mythology of the two cultures, and interdisciplinary links with physics, chemistry, mathematics, literature, art history, technology.
3. Implementation of GeoQuest teaching activities with other teachers, is possible also with other countries (i.e. Greece with Astrinos).
4. Sharing final results and best practices in a final meeting.

Players interact with Science Game through their own smartphones

GeoQuest Project combines Innovative Teaching, ICT, Sciences, Technologies, in a STEM approach.



COUNTRIES
ACTIVITIES
FESTIVALS
TEACHING MATERIALS
PRESS
ABOUT US
BLOG

Blog

Part two: Teacher Exchange on GeoQuest

27.03.2018

Tagged with:

- teacher exchange (9)
- science on stage italy (5)
- science on stage iceland (2)
- science on stage festival 2017 (31)
- follow up activity (5)

Recommend:

This January Sabina Maraffi, teacher delegate from Science on Stage Italy, went to see Ásdís Ingólfssdóttir, teacher delegate from Science on Stage Iceland. Both teachers met at the European festival 2017 in Debrecen, Hungary, where they decided to do a teacher exchange and develop a new project together which combines the idea of Sabina to use computer games in STEM classes and to do research on geology and geography.

For further developing the GeoQuest project Ásdís now travelled to Italy where she visited Sabina at the Liceo Galileo Galilei in Naples. This time the Italian students experienced the GeoQuest project, based on a Computer Class Role Playing Game, that Sabina Maraffi presented at Debrecen. The game consists of several interdisciplinary science adventures, to improve STEM education and foster science learning. The pathway's topic chosen for Italian students was GeoQuest Iceland, to strengthen the exchange through the knowledge of the natural, historical and cultural features of the participating countries.

ANNEX C:CLIL Project with GeoQuest, ITS "L. Galvani"

I. Scheda progettazione no 1

Progettazione di **lezioni** CLIL” **Content Language Integrated Learning**”
interdisciplinari in più classi con sperimentazione RPG interattivo

Scuola: ITS “L. Galvani” Giugliano in Campania - NA

Classe/i: 2 O, 1M, 1B (flipped) e 3B (flipped)

Insegnante/i: (LS: English) Pierro Anna – Rossana De Martino (Science: Pennacchio Antonio – Schettino M. Rosaria) (Humanistic: Giuseppina Vallefucio) -

Titolo della lezione: Just do it: “Geo Quest”

Unità di apprendimento: uda 2 per la 2 O

Disciplina/e coinvolta/e: Assi Linguistico e Scientifico

Lingua/e: Inglese, Italiano

destinatari	Classi del biennio comune e 1 terza classe	
contenuti disciplinari	Elementi basici di Geoscienze, elementi di chimica, conoscenza del territorio: Storia e mitologia greca e latina, conoscenze pregresse di Letteratura Italiana (ambiente di gioco: Campi Flegrei, collegamento con l’Inferno di Dante) – Lingua veicolare: Inglese	
modello operativo	docenti	☐ insegnamento gestito dal docente di disciplina x insegnamento gestito dal docente di lingua ☐ scambio docenti x insegnamento in co-presenza x altro _esperto esterno Dott. Prof. Sabina Maraffi School of Science and Technology, UNICAM
	alternanza L1 – L2/LS	☐ no x sì – in quale forma _durante lo svolgimento dell’ Interactive Class Role Play Game, le voci narranti nella sola lettura della parte relativa alle descrizioni tratte dall’Inferno della Divina Commedia – sottotitoli e mc test in British English

attività	Experimental class Interactive Role Play Game.
che cosa fa l'insegnante	Per tutti Introduce l'esperto e l'attività, spiega la finalità della sperimentazione (motivazione – apprendimento attraverso il gioco, “malgrado la Lingua”) e segue le fasi della scelta dei ruoli e dei gruppi. Durante la fase del collegamento e lo svolgimento del gioco supporta gli allievi, restando poi in contatto visivo, in voluto “a parte”. Rassicura gli allievi che esitano (bassa autostima) Prende appunti.
che cosa fanno gli studenti	Tutti-Inizialmente scettici sulle proprie capacità, richiedono spiegazioni ed intervento della docente di lingua. Seguono poi le istruzioni per collegarsi con la lan wireless per il gioco con i propri devices. Scelgono in maniera ordinata il ruolo ed il gruppo di appartenenza. Durante lo svolgimento del gioco seguono attentamente ed eseguono le azioni necessarie, man mano entrando nell'attività senza necessità di mediazione linguistica. Sono presenti alunni DA e BES con DSA, perfettamente a loro agio nell'esecuzione dell'attività. A fine attività compilano un questionario di gradimento e valutazione dell'esperienza.
Obiettivi disciplinari, linguistici, trasversali (relazionali/ cognitivi/abilità di studio)	Obiettivi formativi linguistici/ trasversali: Comprendere (key concepts e key words) con facilità praticamente tutto ciò che serve al task mentre si ascolta e legge veicolato in LS (superamento della barriera, motivazione). Saper ricavare velocemente le informazioni provenienti da diverse fonti sia parlate che scritte, ristrutturando gli argomenti in funzione di un obiettivo. Individuare le sfumature di significato in situazioni complesse per rispondere al compito richiesto. Saper collegare le conoscenze pregresse ed in atto in funzione della realizzazione del target. Saper ricavare dagli errori l'input positivo alla modifica ed all'aggiustamento per il percorso, ricavandone comunque informazione e soddisfazione nella soluzione del problema. Collaborare e partecipare per la risoluzione di un task complesso con naturalezza. Capire e rispettare le regole ed i ruoli, saper gestire tempi e consegne.
modalità di lavoro	Situazione, padronanza, soggetti: Problem Posing-Problem solving- Docente facilitatore, animatore Allievi in esperienza diretta (scoperta) Attività di ricerca e laboratorio (sperimentazione) Continuità ricercata con l'esperienza, congruenza psicologica con gli interessi degli allievi Pregnanza affettiva ed emotiva del lavoro di classe e benessere relazionale Valutazione dei processi (coinvolgimento, condivisione, significatività soggettiva dell'attività) Valorizzazione degli itinerari del cambiamento.
tempi	2h a gruppi di due classi – aula magna. 2 h per classe nelle aule I tempi sono considerati onnicomprensivi di collegamento e successiva conversazione sull'esperienza in LS e compilazione del questionario di gradimento
materiali, sussidi	LIM come proiettore dell'ambiente gioco, collegata al PC, rete autonoma, smartphones/ tablets. I materiali di consultazione sono disponibili all'interno dell'ambiente stesso di gioco in qualsiasi momento, sia in formato testo che multimediale (link esterni ed interni alla rete)

ANNEX D: Brochures of adventure pathways and spin-off.

E-VOLUZIONE S.R.L.

UNIVERSITY OF CAMERINO

GeoQuest Project

Computer Class Role Playing Game



Learning on Gaming

Our "Learning on Gaming" is a different approach: you learn "while" you play. The game hides the didactic inside an adventure game.

Computer Class Game; INTERACTIVE, using SMARTPHONES and TABLETS; not require internet connection; MULTI-DISCIPLINARY, combining Sciences, Literature, Art, Physics, Astronomy, History, Myth and more; MULTILINGUAL, compatible with CLIL methodology; INCLUSIVE, presenting compensatory instruments; Education realised with the latest ICT.

1

MULTI-LANGUAGE

(CLIL compliance)

2

INTERDISCIPLINARITY

between sciences and humanities

3

INCLUSIVE

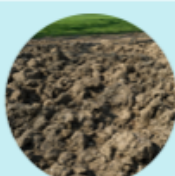
Our Game has compensative measures for Special educational Needs



GeoQuest Vesuvius
Earth Sciences, Literature, Greek and Latin texts, Arts, Myth.



GeoQuest Phlaeagraean Fields
Volcanology, Mineralogy, Literature, History, Arts, Myth.



SoilQuest
Earth Sciences, Environmental Education, Hands-on Activities.

To get further information

Some bibliographical contributions of the authors

Sacerdoti F.M. & Maraffi S., "EVO-RPGE an Interactive Role Playing engine" ICEILT - The International Congress on Education, Innovation and Learning Technologies, Granada, 2015. ISBN: 978-84-944311-3-5. Edited by: ScienceKNOW Conferences C.B. September 2015, p.148.

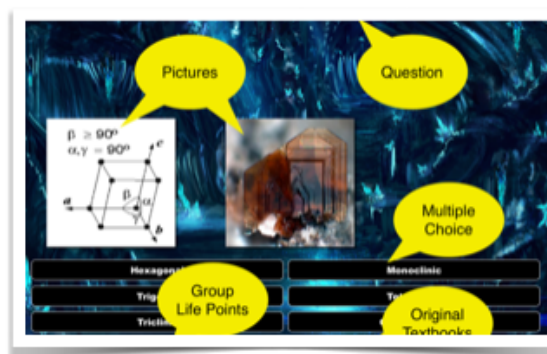
Maraffi S., Sacerdoti F.M., Scamardella A., "GeoQuest VESUVIUS a Class Role Playing Game", 2016 Hawaii University International Conferences on Science, Technology & Engineering, Arts, Mathematics and Education (STEAM), Honolulu, Hawaii, USA, 10 - 12 June 2016. ISSN 21629188 CD ROM, ISSN 2162917X ONLINE.

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Maraffi S., Paris E., Sacerdoti F.M. & Scamardella A., 2016. Geoquest, a Computer Class Role Playing Game. Oral presentation, 2nd European Mineralogical Conference - Rimini (Italy), September 11-15, 2016. EMC2016 Book of Abstracts: "Minerals, rocks and fluids: alphabets and words of planet Earth", pag.733.

Maraffi S. & Sacerdoti F.M., GeoQuest a computer classroom Role Playing Engine to teach earth science in an interdisciplinary way. 9th annual International Conference of Education, Research and Innovation. - Seville, 14th, 15th and 16th of November, 2016.

Maraffi S., Pennesi D., Acqua A., Stacchiotti L. & Paris E., 2016. "SoilQuest: an IBSE approach with Computer Class Role Playing Game", International Journal Of Research And Innovations In Earth Science. 3.5 (2016): 88-91. http://ijries.org/administrator/components/com_jresearch/files/publications/IJRIES_127_FINAL.pdf



Technics Characteristics

- ◆ Speaking voice in about 30 different languages;
- ◆ Sounds effects, Musics, Videos;
- ◆ Possibility to choose a role in the game, for best feedback results;
- ◆ Game system records students answers and proceeds according to majority criterion;
- ◆ the interaction between players and the central computer is via their smartphones, tablets, or laptops.

EVOQUEST ENGINE

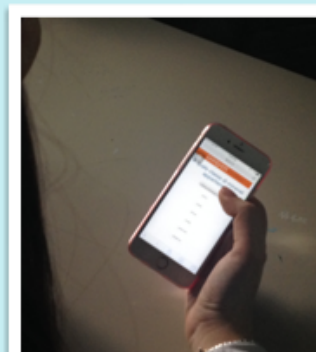
The adventures are realised with EvoQuest, an innovative software which realise a Role-Play Engine (EvoRPGE) to be held in the classroom. The software interface is visible to the entire group of students through use of Projector or WIB and the interaction between players and software is with their own smartphones, tablets, or laptops.

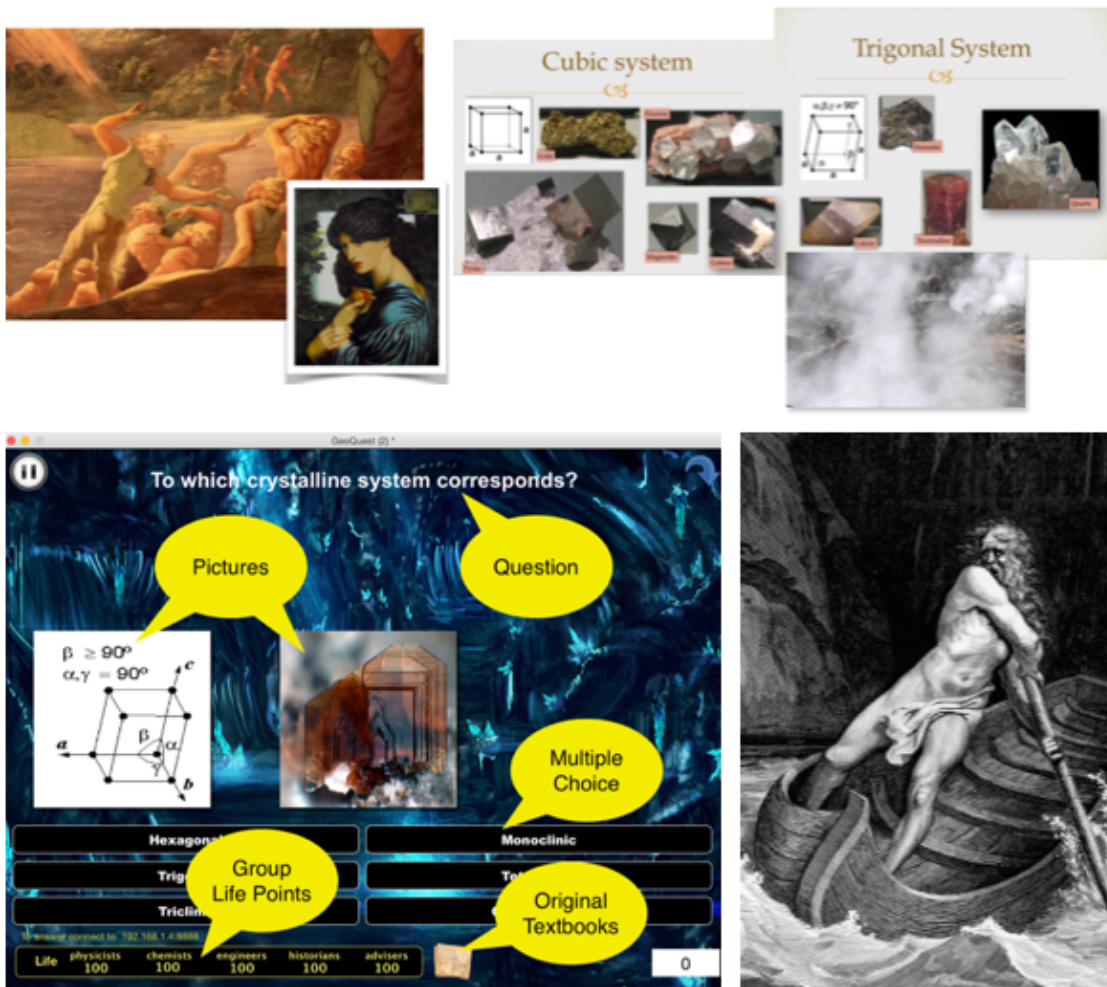
e-voluzione s.r.l.

www.evoquest.eu

francesco@sacerdoti.net

+393355824909





The collage features several elements: a classical painting of figures in a landscape, a portrait of a woman, a diagram of a cubic crystal system with a unit cell and various mineral samples, a diagram of a trigonal crystal system with a unit cell and mineral samples, a screenshot of the GeoQuest game interface showing a question about crystalline systems with multiple choice options (Hexagonal, Trigonal, Triclinic, Monoclinic, Tetragonal) and a 'Group Life Points' bar, and a classical painting of a man in a boat.

GeoQuest

Phlaegraean Fields



Computer Class Role Playing Game

Computer Class Game; INTERACTIVE, using SMARTPHONES and TABLETS; not require internet connection; MULTI-DISCIPLINARY, combining Sciences, Literature, Art, Physics, Astronomy, History, Myth and more; MULTILINGUAL, compatible with CLIL methodology; INCLUSIVE, presenting compensatory instruments; Education realised with the latest ICT.

www.evoquest.eu

www.maraffi.net

GeoQuest Phlaeagraean Fields: a Computer Class Role Playing Game

The proposed teaching experience has been successfully tested as part of a research project of PhD in “**Teaching and Learning Processes in Earth Sciences**”, at *School of Science and Technology*, University of Camerino, using an innovative new educational technology, *Learning on Gaming*.

Technical characteristics:

- ★ Speaking voice
- ★ Music and sounds effects
- ★ Video
- ★ Visual effects
- ★ Internet connection independent
- ★ Multi language
- ★ CLIL compliance
- ★ Special Educational Needs compatible
- ★ Hands-on activities
- ★ Skills assessments

Interdisciplinary objectives:

- ❖ Learn to decode oral and written informations;
- ❖ Learn to decode and to take different disciplinary information from literary texts;
- ❖ Consolidating basic knowledges and skills in Humanities and Sciences.

Key Competences:

- ❖ Learning to learn;
- ❖ Communication in the mother tongue;
- ❖ Communication in foreign languages;
- ❖ Basic competences in science and technology;
- ❖ Digital competence;
- ❖ Social and civic competences;
- ❖ Sense of initiative and entrepreneurship;
- ❖ Cultural awareness and expression.

Activity duration:

- ◆ 120-150 minutes.

Equipments:

- LIM or other projector;
- PC
- Students smartphones or tablets, or personal computers.

More information:

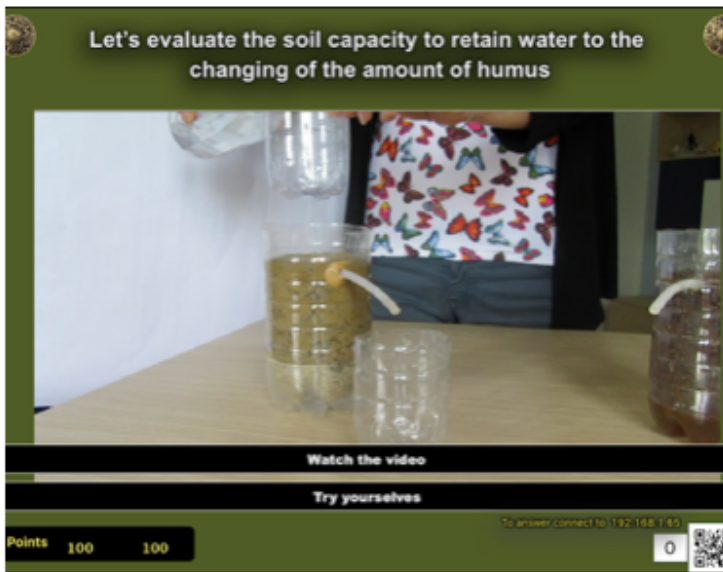
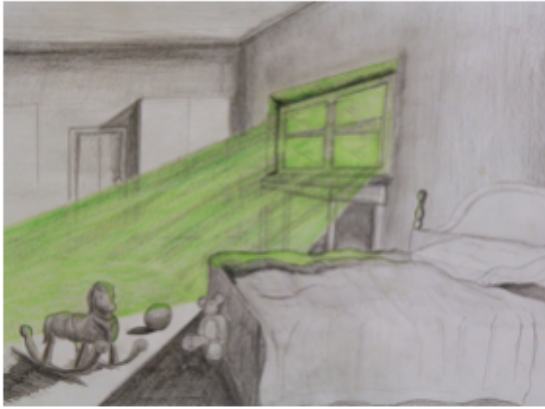
Prof.ssa Sabina Maraffi

sabina.maraffi@unicam.it

+393476974232

Demo:

www.evoquest.eu



SoilQuest



Computer Class Role Playing Game

Computer Class Game; INTERACTIVE, using SMARTPHONES and TABLETS; not require internet connection; MULTI-DISCIPLINARY, combining Sciences, Literature, Art, Physics, Astronomy, History, Myth and more; MULTILINGUAL, compatible with CLIL methodology; INCLUSIVE, presenting compensatory instruments; Education realised with the latest ICT.

www.evoquest.eu

www.maraffi.net

SoilQuest: a Computer Class Role Playing Game

The proposed teaching experience has been successfully tested as part of a research project of PhD in **“Teaching and Learning Processes in Earth Sciences”**, at *School of Science and Technology*, University of Camerino, using an innovative new educational technology, *Learning on Gaming*.

Technical characteristics:

- ★ Speaking voice
- ★ Music and sounds effects
- ★ Video
- ★ Visual effects
- ★ Internet connection independent
- ★ Multilanguage
- ★ CLIL compliance
- ★ Special Educational Needs compatible
- ★ Hands-on activities
- ★ Skills assessments

Interdisciplinary objectives:

- ❖ Learn to decode oral and written informations;
- ❖ Learn to decode and to take different disciplinary information from literary texts.

Key Competences:

- ❖ Learning to learn;
- ❖ Communication in the mother tongue;
- ❖ Communication in foreign languages;
- ❖ Basic competences in science and technology;
- ❖ Digital competence;
- ❖ Social and civic competences;
- ❖ Sense of initiative and entrepreneurship;
- ❖ Cultural awareness and expression.

Activity duration:

- ◆ 60 minutes.

Equipments:

- LIM or other projector;
- PC
- Students smartphones or tablets, or personal computers.

More information:

Prof.ssa Sabina Maraffi

sabina.maraffi@unicam.it

+393476974232

Demo:

www.evoquest.eu



GeoQuest Vesuvius



Computer Class Role Playing Game

Computer Class Game; INTERACTIVE, using SMARTPHONES and TABLETS; not require internet connection; MULTI-DISCIPLINARY, combining Sciences, Literature, Art, Physics, Astronomy, History, Myth and more; MULTILINGUAL, compatible with CLIL methodology; INCLUSIVE, presenting compensatory instruments; Education realised with the latest ICT.

www.evoquest.eu

www.maraffi.net

GeoQuest Vesuvius: a Computer Class Role Playing Game

The proposed teaching experience has been successfully tested as part of a research project of PhD in “**Teaching and Learning Processes in Earth Sciences**”, at *School of Science and Technology*, University of Camerino, using an innovative new educational technology, *Learning on Gaming*.

Technical characteristics:

- ★ Speaking voice
- ★ Music and sounds effects
- ★ Video
- ★ Visual effects
- ★ Internet connection independent
- ★ Multilanguage
- ★ CLIL compliance
- ★ Special Educational Needs compatible
- ★ Hands-on activities
- ★ Skills assessments

Interdisciplinary objectives:

- ❖ Learn to decode oral and written informations;
- ❖ Learn to decode and to take different disciplinary information from literary texts;
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Key Competences:

- ❖ Learning to learn;
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- ❖ Communication in foreign languages;
- ❖ Basic competences in science and technology;
- ❖ Digital competence;
- ❖ Social and civic competences;
- ❖ Sense of initiative and entrepreneurship;
- ❖ Cultural awareness and expression.

Activity duration:

- ◆ 120-150 minutes.

Equipments:

- LIM or other projector;
- PC
- Students smartphones or tablets, or personal computers.

More information:

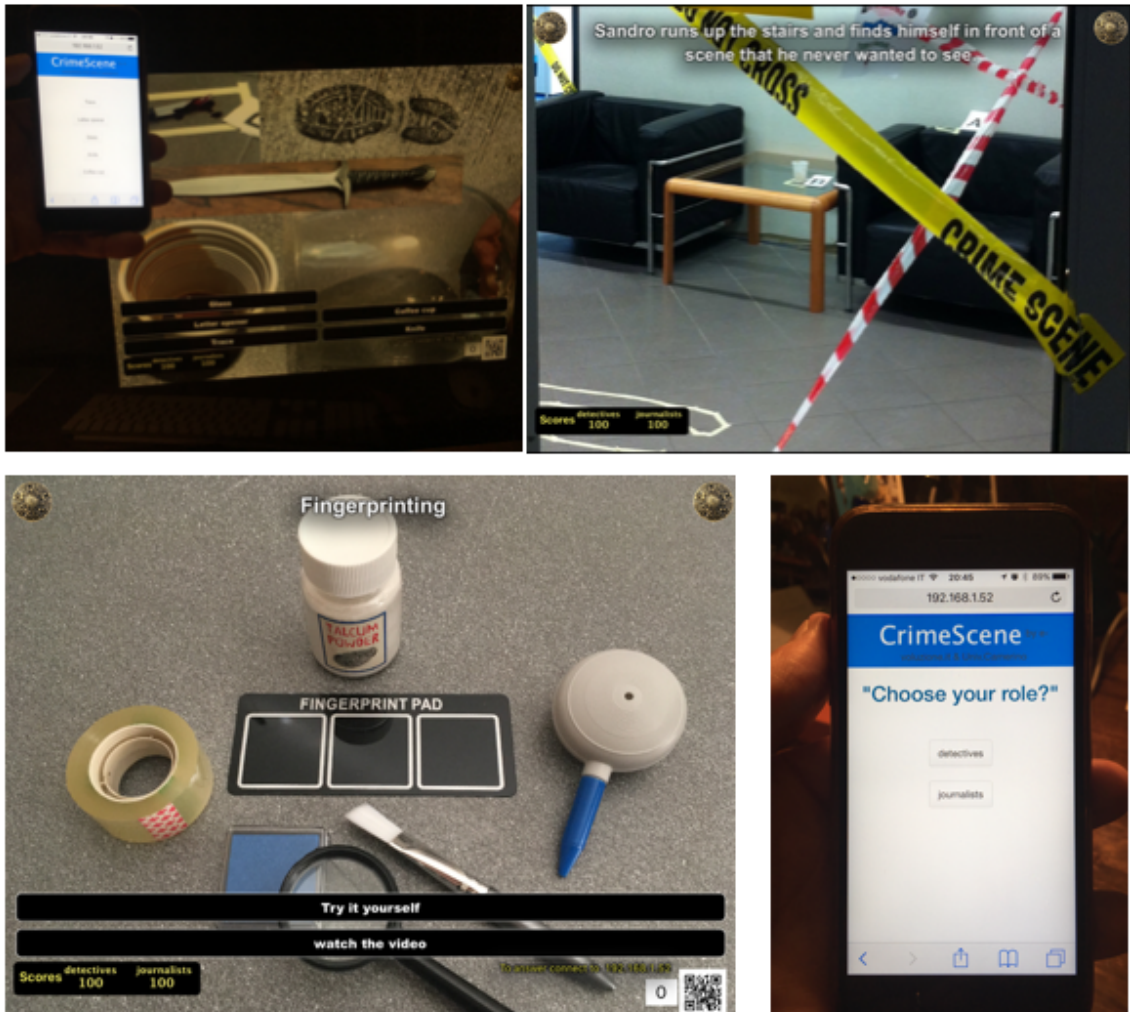
Prof.ssa Sabina Maraffi

sabina.maraffi@unicam.it

+393476974232

Demo:

www.evoquest.eu



CrimeQuest



Computer Class Role Playing Game

- INTERACTIVE, using SMARTPHONES and TABLETS; not require internet connection;
- MULTI-DISCIPLINARY,
- MULTILINGUAL, compatible with CLIL methodology;
- INCLUSIVE, accessible design creates an inclusive Educational Environment.

www.evoquest.eu

www.maraffi.net

Saving yourself!

Correct Behaviors in Emergency



An App for Educators, Teachers, Students, Self-Made People ...

To understand earthquakes and volcanoes and the strategies to reduce the risks associated with these phenomena.

This App intends to provide the best and most convenient behaviour on emergency, with particular reference to volcanic emergency and seismic emergency.

It can be used at school to optimise security education measures, and it's also a game useful to rethink on what has been studied.

1

ALL AGES

Versions for kindergarten, primary and secondary school

2

MULTILANGUAGES

App is available in Italian and English

3

NEEDFUL

Paths on the most current geological emergencies



Volcanos Emergency

To know the danger and the risk associated with an eruption.



Earthquakes Emergency

To adopt correct behaviors in case of earthquake.



Hydrogeological Emergency

To obtain awareness of alert levels and cautionary measures.