J-READING
JOURNAL OF RESEARCH AND DIDACTICS IN GEOGRAPHY
2, 13, December, 2024, pp. 63-79 DOI: 10.4458/7417-04

J - READING
JOURNAL OF RESEARCH AND DIDACTICS IN
GEOGRAPHY
homepage: www.j-reading.org

Learning about humankind's journeys. Some didactic experiences about space travel with primary schools

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Received: December 2023 – Accepted: September 2024

Abstract

In year 2023, the *Gruppo di Lavoro Interdisciplinare per le Sperimentazioni sulla Didattica Innovativa* was established at the European University of Rome. The group is composed primarily of pedagogists and geographers connected to GREAL (Geographic Research and Application Laboratory). In its first project, the group evaluated new methods and modern geotechnologies for teaching pivotal concepts in the historical evolution of human travel and exploration. The project was constructed around two conceptual lines: teaching the fundamentals of orientation, mapping and navigation on the one hand, and of transport-systems and life-support technologies on the other. These lines will serve as a basis for organizing didactic activities about various forms of human travel through different historical periods and different environments, i.e. land, sea, air and space. In this initial phase, the workgroup did not delve deeply into monitoring pedagogic outcomes; it focused instead on the design and practical delivery of a first block of innovative learning experiences for primary schools, concerning space travel and exploration. The laboratories were conducted using traditional geography teaching methodologies, albeit "augmented" through the integration of innovative tools, such as virtual reality and simulations. This paper presents the core concept of the workgroup's didactic purpose in its long-term project and accounts for the initial laboratory activities, proposing reflections on the potential of novel approaches to enhance and fostering geographical learning.

Keywords: Geotechnologies for Didactics, History of Human Travel, Mapping, Simulation, Space Travel, Virtualization

1. Introduction

In November 2022, an interdisciplinary workgroup of pedagogists and geographers at the European University of Rome[1] initiated a research project in geographical didactics. The

[1] It is the *Gruppo di Lavoro Interdisciplinare per le Sperimentazioni sulla Didattica Innovativa* (GLISDI), or *Interdisciplinary Workgroup for Experimentation on Innovative Didactics*. GLISDI is composed by four pedagogy professors, including one specialist in "special didactics", two geography professors, a PhD student, and a support team for practical activities consisting of four to ten Primary Education university students.

aim was to develop new strategies to introduce students from different schools and school-grades to some key-concepts in the evolution of human travel and exploration, across different historical periods. Given the complexity of teaching about different travel systems in different ages and environments, separate blocks of activities are being developed. Their *trait d'union* is the identification of common aspects highlighting continuity from one travel system to the other.

In designing each block, the team builds on a broad theoretical framework that emphasizes laboratory activities and integration of new technologies as effective tools in geographical education (De Miguel González, 2014, pp. 21-38; Kerski, 2015, pp. 183-194; Lavagna et al., 2018, pp. 119-121).

Considering the key research themes in geographical didactics as listed by Giorda (2014, p. 121), the project is particularly focused on the experimentation of new methodologies and educational technologies to convey innovative thematic content.

In this regard, laboratory activities on history of travel and exploration were designed around *collaborative learning* and *learning by doing*. These strategies, as exemplified by various studies, place the students at the centre, making them more actively engaged in their learning process (Tani, 2013; Ascari, 2017, p. 267; Camuffo, 2017, p. 224; Crivelli, 2017, p. 193).

Didactic approaches emphasizing practical experience can be effectively fostered by using geotechnologies, as they can serve as valuable tools for acquiring geographical knowledge and understanding phenomena across different spatial and temporal scales (De Vecchis et al., 2020, p. 261; De Miguel González, 2024, p. 6).

As it is highlighted in the *International Charter on Geographical Education*, teaching geography involves continuously exploring innovative methodologies to support educators at all levels. The integration of technologies becomes increasingly significant, alongside traditional lectures, seminars, and guided tours (De Vecchis, 2021, pp. 52-53). IRGEE[2]'s reflections recognize the use of technologies as "evergreen and emerging issues" requiring ongoing investigation (Chew-Hung and Kidman, 2021).

Geotechnologies can indeed leverage the significant role that emotions play in the learning process, such as wonder and curiosity triggered by experiencing new landscapes (De Vecchis, 2020, p. 170). It is well-known that geographical knowledge benefits from direct observation and experience evoking emotional responses (Giorda, 2014, p. 154). However, when certain locations are difficult or impossible to access, various forms of representation such as photographs, videos, satellite images, digital maps, and – more or less immersive – virtual environments can, at least partially, replace a concrete, on-site experience (Pesaresi, 2012, p. 45; Fea et al., 2013, p. 121; Stojšić et al., 2016, p. 90; Minocha et al., 2018, p. 3; De Vecchis, 2020, p. 217; Bos et al., 2022).

The workgroup reflected on how to apply these theories in teaching the history of travel and exploration. It was crucial to consider the essential link between geographical and historical knowledge, indispensable at all levels of education (MIUR, 2012; De Vecchis, 2020, pp. 40-41; Amatori et al., 2024, p. 275). In the project, it was therefore relevant to show the relationship between the spatial component of travel and its historical evolution. Recognizing the impossibility of encapsulating, in the activities, the entire history of human journeys across the different environments and travel systems, it was chosen to focus on certain key concepts only, as it will be discussed below.

This approach was first tested in a series of "spot-trials", during several public engagement events[3]. Informal feedback during such initial experiences proved promising and encouraged a more structured initiative. The opportunity came during a cooperation with several primary schools in Rome. Between March and April 2023, four laboratory sessions were organized at the European University of Rome. Four schools, ten classes and 225 pupils, in total were involved (Table 1).

[2] International Research in Geographical and Environmental Education.

[3] From 2021 to 2023, activities were presented in different public engagement occasions, like "Geonights" and conferences hosted by the Italian Geographical Society. Fundamentals of sea navigation, air travel, land exploration of remote environments and space travel were story-told mixing traditional presentations with simulations and virtual reality.

Primary school grade	Number of classes	Number of students
Second grade	2	42
Fourth grade	2	61
Fifth grade	6	122
Total	**10**	**225**

Table 1. Number of students for each primary school involved in the activities at the European University of Rome on March 14th, April 14th and 21st, May 19th, 2023 (totals per grade).

The proposal discussed by the workgroup was to host *non-formal learning* activities (according to the definition presented in Tani, 2013, p. 11) to present pupils with themes from both the Geography and Science curricula.

By the end of the fifth grade of primary school pupils acquire, in geography, the concepts of Earth as a planet, its place within the Solar System, and of the Moon as the planet's only natural satellite (Scataglini, 2023; Amatori, 2024). In science, they get familiar with the Solar System and its objects (Sarri, 2022, pp. 18-35). The idea was therefore to build upon these concepts to "narrate" the history of space travel, from early Lunar cartography to the landing of Apollo 11, adding reflections and insights on the future of exploration.

The following paragraph will present conceptual lines; the third one, strategies and methods considered in developing the laboratories; the fourth one will explain some relevant activities. Finally, the paper will reflect on the preliminary results achieved and future perspectives.

2. Conceptual lines

The workgroup planned to create didactical activities on the history of travel and exploration through different environments, i.e. land, sea, air, and space.

The different forms of travel were to be specifically described along two conceptual lines. These are: orientation, mapping, and navigation on the one hand; transport-systems and life-support technologies on the other.

Additional major aspects which characterize travel in geographical terms, e.g. passenger and freight volumes, flows, and logistics in general were not considered in the project.

Regarding the first conceptual line, the group's intention was to prompt students to reflect on the idea that all forms of travel are achieved through the fundamental ability of charting routes. Once the orientation and position of the traveller are known, it then becomes possible to define a route from a departure point to a destination point, regardless of the distance to travel and the transport mode that is considered appropriate for that distance (Borruso et al., 2022, p. 110). In this sense, there is not much conceptual difference between a node on a physical road (e.g. a crossroad, a fork, or a highway exit), a waypoint in a maritime corridor or in an airway. The common requirement is that travellers using the route can recognize their relative position and orientation at any time based on adequate references (Huth, 2013, pp. 19-20). The way such references are acquired, and the freedom-of-movement of the vehicle vary from one travel system to another, but this is not a problem when it comes to presenting school students with this topic. Indeed, once the general concepts are clarified, specific aspects of each travel system can be easily explained, and appropriate examples can be chosen to fit the skills and levels of individual learners. A general element is that positional nodes, connection lines, routes and other information can be represented on *maps*.

Figure 1. A sea navigation map by Albino de Canepa from 1480. Source: Italian Geographical Society.

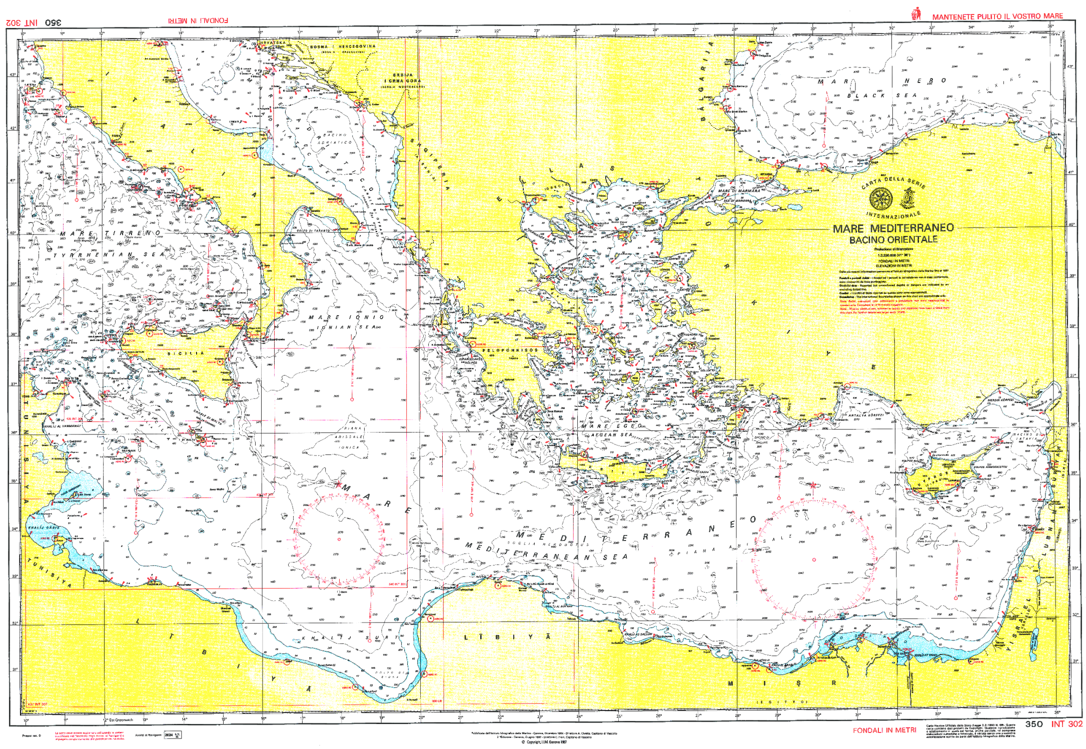

Figure 2. Present-day nautical map of eastern Mediterranean basin, published by the Istituto Idrografico della Marina (1997). Source: private collection.

Maps are optimized for the needs of the specific travel system and in general, for each kind of map, information is organized and presented to take into account scientific and technological progresses.

In other words, while a certain travel system was developing in history, appropriate special cartography was developed in parallel, so that travellers could find, in the maps, all the information they needed to the best of what their time's "standards" could provide.

Nevertheless, general concepts of each travel system remained fairly constant along this evolutionary process. It is therefore possible to present pupils and students with analogies and continuity aspects while, at the same time, highlighting differences brought about by technical progress.

Figure 1 presents an interesting example. A section of a nautical map from the end of the 15th century, drawn by Genoese cartographer Albino de Canepa shows the eastern Mediterranean basin. It features a very precise – for the time – representation of the coastlines. It also includes locations and geographical elements which could be considered, by sailors, as references, due to their visibility from the sea. Geographical features located deeper inland are disregarded because they would be useless for visual navigation. A network of lines is drawn across the sea, and for each line the length and angle provide indications for route planning. Accuracy of these measurements was made possible by the use of the compass. Similar maps spread significantly due to the increasing navigation needs in the Mediterranean Sea during that era (Lavagna and Lucarno, 2007, p. 20). Similarly, an official present-day nautical map (Figure 2) from the Istituto Idrografico della Marina of the same area contains even more accurate information about headings. Coastlines are displayed in detail and prominent features are indicated; as in Albino's map, inland objects are neglected. The present-day map shows depths of the sea by numerical indications and contour lines (isobaths), for two reasons. First, because this information became available in the centuries between the two maps, and second because awareness of the actual sea depth became more relevant in recent times, when large ships with deeper drafts required increased caution in navigating through shallow waters. Yet, one can immediately recognize a clear continuity in conceptualization from the first to the second map, although over 500 years elapsed between them.

Regarding the second conceptual line (*transport-systems and life-support technologies*), the focus was on the significance of technological and technical progress, as well as research, in relation to the expansion of human horizons (Gosch and Stearns, 2008; Huth, 2013).

One, general, example of this trend can be considered with regard to maritime transport: from Antiquity to the beginning of the Modern Era, ships were consistently built in wood and driven by oars and sails; there was, however, a slow but evident progress in technical solutions. From one major innovation to the subsequent one, minor progresses allowed for longer and safer travel. As high-sea seafaring became predominant on coastal one, crews needed to complement traditional land-based visual references and magnetic compass with other means to ascertain their routes. Latitude and longitude were measured by increasingly accurate astronomical and chronometric instruments (Lavagna and Lucarno, 2007, p. 23; Sobel, 2007, pp. 4-6). Hull designs had to be updated to better stand heavier seas and harsher weather.

Yet, even when strong, large and powerful vessels became available to cross oceans or circumnavigate continents, new limits were discovered in providing crews with food of sufficient quality to prevent the insurgence of illnesses associated with lack of vitamins and other necessary substances. Meanwhile, navigation in extreme environments such as the polar or equatorial regions presented travellers with new and potentially hazardous conditions for which traditional equipment and supplies proved inadequate. Limitations to worldwide seafaring, therefore, were to be dealt with at different levels and only when *both* vehicle-related and life-support issues were solved, humankind became technically able to safely sail all seas.

A somewhat similar scenario appears to develop nowadays with regard to long human flights in Earth's orbit, and to the Moon or Mars. The physics of the journey are well established, so that flight planning could be conducted on a routine basis; functionality and control of uncrewed or even crewed spacecraft is fairly well developed from a technological point of view. Life-support and the overall well-being of personnel, however, is yet under study (Cranford and Turner, 2023).

Questions currently addressed by researchers include how to protect the crew's organisms from long exposure to cosmic rays and weightlessness. Furthermore, it appears that issues related to psychological implications of such innovative journeys are still to be fully explored (Cranford and Turner, 2021).

In conclusion, the parallel challenges of making travel possible on the one hand, and making travel survivable and comfortable on the other, are evidently a constant element of human journeys in history (Figures 3-4).

3. Teaching the history of space travel: strategic ideas

In designing laboratory activities for primary school pupils, it would have been unfeasible to summarize the full complexity of mapping/charting and navigation on the one hand, and of transportation technologies and life-support systems on the other, even if applied to space travel only.

The intention was, rather, to find ways to explain such themes by designing activities capable of effectively involving the pupils. In line with the theories of *Teaching Through Geography*, one of the aims was to make transmission of contents more stimulating, but also to help pupils develop important cognitive skills in geography (Leat et al., 2005, p. 330).

Therefore, some of the targets for skill development at the end of primary school according to the *International Charter on Geographical Education* were considered. For example, orientation, which entails the ability to navigate the surrounding environment based on its representation on a map; the ability to understand and interpret maps; the design of travel routes; the extraction of geographical information from various sources, such as maps, satellite images, and photographic technologies; the identification of the main features that characterize a landscape (IGU-UGI, CGE, 2016).

Figure 3. A 18th century British Navy officer administering lemon to heal a sailor suffering from scurvy during a long sea journey. Source: National Library of Medicine. Digital Collection, "James Lind-conqueror of scurvy".

Figure 4. An astronaut exercising on the International Space Station to prevent bone decalcification and muscular atrophy due to prolonged weightlessness condition in space flight. Source: NASA.

Indeed, it was the intention of the workgroup to find effective strategies, based on categories and methods already theorized in the field of geography education, to narrate a relatively new topic such as the history of space exploration.

For these experimental activities we made wide use of traditional supports and tools along with multimedia and innovative didactic geotechnologies. The usefulness of these tools combined in appropriate configurations towards an effective educational storytelling was demonstrated by previous experiences (Marta and Osso, 2015; Macchi Jánica et al., 2018; School AGeI Cesarea Terme collective, 2022).

A first strategic idea is that the key-contents, even if apparently complex, can be proposed with equal effectiveness to different school-grade students, by fine-tuning transmission according to their age. In fact, in geography teaching at different school levels, the same concept is frequently reintroduced, demanding progressively more complex reasoning based on the students' age and previous learning experience (Lavagna et al., 2018, p. 24).

This adaptation is particularly necessary when dealing with the first conceptual line presented in the previous paragraph. An explanation of the basics of how to orient, chart and navigate in space must be associated with the development of mapping skills. Considering the age of our participants, only certain skills could be taken into account within the "Map Reading" domain (symbol/colour detection and decoding; legend comprehension) and "Map Analysis" domain (map scale usage; self-location on map; route understanding and navigation) (Havelková and Hanus, 2019, pp. 363-364). In this regard, in the teaching of "Terrestrial" geography, activities are often initiated to enable students to practice their orientation and map representation skills, by drawing, colouring, and interpreting simple maps (Scataglini, 2022; Figini, 2024).

A second strategic idea is that simulation and virtualization technologies can be used to increase the emotional impact of the learning experience, thus making it more culturally effective. This is particularly true when the places or forms of travel that are to be described would be out of the students' physical reach. Virtualization and simulation, indeed, allow to create vivid representations that "provide strong support for the development of geography teaching and the realization of situational teaching" (Niu et al., 2023, p. 13).

Among those technologies, immersive virtual reality (IVR) can improve motivation in learning. Various studies demonstrate its effectiveness in geography, astronomy, cartography, and spatial orientation. With specific regard to geography teaching, it was successfully used to organize virtual field trips. (Stojšić et al., 2019, pp. 123-124; Bos, 2022, p. 480; Putra et al., 2023, p. 8). The application of these media not only consists in the audio-visual representation of a place, but in its more comprehensive form, it can activate other sensorial channels and enable different levels of interaction (Bos, 2021, p. 5). Nevertheless, it has been shown that even in low-immersivity virtual experiences, in which the user has the only freedom of looking in a desired direction, spatial immersion can be very useful in geography teaching (Stojšić, 2016, p. 90).

Virtual reality (VR) experiences in general boost, nevertheless, the classical power of images to serve as "mediators between places and the knowledge of the subjects that observe" (Giorda and Pettenati, 2018, p. 92). This is particularly true when offering students virtual glances at distant or never-seen-before landscapes. Consequently, the workgroup's activities applied this kind of technology in several cases to narrate some environments in the history of space exploration.

A third strategic idea is that, in a history-of-travel project, students should be involved in activities – fine-tuned for their age – encouraging the hands-on experience of specific elements. These are: the relationship between the traveller's orientation, positioning, and navigation through space; the appropriate visual / instrumental fix of such position and orientation; and their correct charting on a map. The map, in turn, must contain relevant information for the kind of travel. These particular types of activities enable to train students or pupils in the transition between the subjective perspective of being in a certain position at a certain moment, and the ability to identify their current relative position in the area represented on a map (Scaglione and Gallia, 2021, p. 16). It is demonstrated that the spatial skills of primary school children, e.g. spatial orientation and understanding of the relationship between an object and its environment, vary greatly from one student to another. This is a crucial period for a child's spatial development; therefore, laboratory activities are useful both in geography education and for the development of a correct spatial intelligence in everyday life (MIUR, 2012, pp. 46-47; Amatori et al., 2024, p. 208).

4. Activities

During the laboratory sessions organized at the university, students were initially introduced, through a brief lecture, to the key concepts mentioned above.

They were then divided into small groups of four students (occasionally three or five) and guided through the proposed activities, each mediated by one or more facilitators.

A first activity intended to familiarize pupils to symbolization as related to mapping. Specifically, the goal was to show how to render altimetry on a map using a colour palette. Altimetry is generally rendered by a chromatic code in which a colour is associated to a certain height interval to express terrain elevation on a two-dimensional map.

Cartography is widely used as an educational tool and students are accustomed to interacting with it as early as primary school (Scaglione and Gallia, 2021, p. 16). Thus, young pupils were provided with paper maps representing the surface of Mars and were supposed to colour them according to a given chromatic scale.

A common activity in children's labs is colouring maps to reinforce the association between geographical objects and their conventional representation by colour codes (the green of plains, the brown of mountains etc.) (Negri, 2022, p. 84). Hence, by the end of primary school pupils usually comprehend in full the concept of chromatic scales applied to Terrestrial maps.

Through this activity, focus was directed towards generalizing the symbolization concepts. By offering children to colour blank maps representing the surface of other planets, each with a distinct chromatic scale, it became possible to illustrate how the choice of colour expressing altimetric intervals is variously conventional and/or symbolic.

Another activity was implemented to explain the process of constructing a map, using satellite images. In the past decades, remote sensing proved an essential way of acquiring data for the development of maps. Even the most challenging type of human travel from a technical point of view, i.e. the journey to the Moon by the Apollo missions, was prepared by thoroughly representing Lunar features on maps. Data for these maps were acquired – among other devices – by orbiting, unmanned probes called Lunar Orbiters between 1966 and 1967. These vehicles would capture detail images of the Lunar surface on analogue film; the film was internally developed into images which were then electronically digitized by scanning.

Figure 5. Pupils recomposing an image from a Lunar Orbiter mission as a puzzle of linear elements. Source: GREAL.

Scans were then broadcasted via radio to data centres on Earth and the images were then re-composed and printed for mapping analysts to examine (Bowker and Kenrick Hughes, 1971, pp. 1-3). This process was mimicked in a sequence of steps to the benefit of children: the small group was asked to collaboratively recompose an image in the form of a puzzle (Figure 5), just as the data centre on the ground would have recomposed the scanned images radioed from space. Finally, the image was to be pictured as a single file (in our case, via a document camera) and then forwarded to a repository (in our case, to later reach the pupils' school). Puzzles are recognized as a tool to help spatial skills of children (Amatori, 2024, p. 208).

Two low-immersion virtual reality experiences were proposed to narrate to the students the past and future of space exploration, showcasing the extraterrestrial locations that humans have visited and those we plan to explore next. The proposed environments were the Moon and Mars. The chosen immersive setting for the Moon replicates the landing of Apollo 11.[4] The footage begins with the viewers finding themselves inside the lander, with a reconstruction of the spacecraft cockpit around them. Afterwards, they are taken onto the Lunar surface, alongside astronauts Neil Armstrong and Buzz Aldrin. The environment is reconstructed in three dimensions and is visible through static 360° views, while the audio plays fragments from the original recordings. From an educational standpoint, this product allows for a deeper understanding of the history of space exploration. It proved to be very useful to encourage group reflections about technology and life support systems that made the Moon landing possible. Children were invited to notice that astronauts had to wear space suits to survive outside the safety of the pressurised vehicle. Students were then invited to identify Earth as seen from the Lunar environment and to reflect on distances and travel duration.

The virtual representation of the Martian landscape, on the other hand, was made possible through original images acquired by NASA's Perseverance rover and published on YouTubeVR.[5] The 360° panorama was created using photographs captured in 2021. Viewers get the perception of being on the rover and this provides them with a better sense of scale and perspective. The audio, filtered on the rover's background noises, allows for listening to real sounds coming from the surrounding environment.

Since the rover is clearly shown isolated in the Martian landscape, with no astronaut in the surroundings, there was the opportunity of having the facilitator explain pupils that current technology cannot support astronauts' life during a journey to Mars. Therefore, exploration of Mars is currently possible to uncrewed robotic devices only. This makes it also possible to highlight that the current way to observe and "visit" Mars in first-person-view is by remote transmission of images.

Visual representations can thus be a good strategy to introduce students to places and environments they have never *lived* in first person (Neri and Malatesta, 2022, p. 84) and basic 360° immersive videos like these allow for a stronger (albeit limited) experience of an existing though unreachable place for many. Their potential as a teaching tool is increased by the fact that they are often free and accessible (Daniele, 2022, p. 77).

Another virtual reality activity was developed to explain concepts related to "life-support" and human adaptation in travel situations. In this case, however, a highly immersive and interactive VR was employed; it proved even more capable of eliciting emotional responses from students. We used Oculus Quest 2 headsets along with the free "Mission ISS" app, available on Oculus Store.

Pupils were immersed in a virtual environment designed to replicate the International Space Station, also simulating an astronaut's "spacewalk" (Figure 6). Children were reminded about the necessity of wearing a pressurised suit for survival in outer space, as simulated virtually, unlike what happens inside the station.

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[4] The video is made available by Seymur & Lerhn for educational purposes and can be accessed through YouTubeVR as part of their "Education in 360 series". "Moon Landing VR Experience! Join the Apollo 11 mission to the Moon With Education in 360!", https://www.youtube.com/watch?v=aYT5IKxyX4Q.

[5] Perseverance Mars Rover's Mastcam-Z View of 'Van Zyl Overlook' (360 video + audio) https://www.youtube.com/watch?v=5jq9b4FrWCg&t=1s.

They were then asked to explore their surroundings. The remarkably realistic setting generated reactions of astonishment and excitement, especially in the view of the Earth beneath the observer. Interestingly, and differently from what happened with low-immersive experiences, many pupils spontaneously attempted to identify, by indicating them, visible features such as Italy and its islands or the Sun and other stars, without the need for cues from the facilitator. This demonstrates how the *affective-emotional* channel, that can be a key factor in the discovery of an environment at their age (Neri and Malatesta, 2022, p. 84), can be stimulated through such kind of visual input. The virtual "Mission ISS" experience also encouraged a reflection about the relative dimensions of the orbiting station, the Earth itself and the human being: this was made evident by showing pupils that they could move swiftly around the space station but not around the entire planet.

A non-virtual, "hands-on" experience that was implemented aimed to stimulate the orientation of the child. Within a spacious hall of approximately 100 square metres, a pathway marked on the floor by red stripes was set up, featuring a series of obstacle-references leading to a final target. The activity consisted in the guidance of a remotely-controlled explorative rover, with the assigned task to collect rock samples. "Ground crews", each one including two pupils, were provided with a simplified map outlining the planned route (Figure 7).

Children were seated at a control station, with the rover and its intended path out of their view. The rover's real-time images captured via its internal camera and other data were displayed on the control screen. The "crewmembers" took turns in the roles of driver, manoeuvring the rover, and navigator, reading the map and providing instructions to the driver (Figure 8).

Figure 6. Pupils experiencing VR through Oculus Meta Quest 2. Source: GREAL.

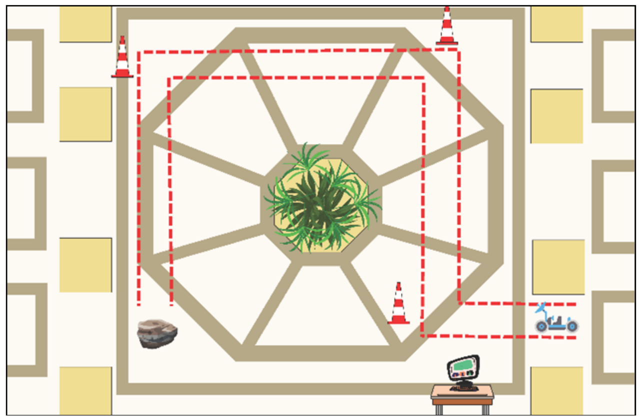

Figure 7. Guiding a small remotely controlled rover from a departure to a destination through a planned route charted on a map. Source: GREAL.

Figure 8. In order to achieve the goal, two pupils, a "driver" and a "navigator" must cooperate to properly steer the rover by only relying on first-person-view camera images and the reference map. Source: GREAL.

Upon reaching the final target, they simulated collecting scientific samples by capturing photographs through the rover's camera. This laboratory activity aimed to aid in the development of child's spatial intelligence, through an interaction both with the environment and its cartographical representation (Messina, 2021, pp. 96-97). Orientation skills are required, as the "crewmembers" navigate the rover through space, by using recognisable reference points on the map. They are also compelled to alter their perspective, as they must rely solely on the rover's camera to perceive the explored space. One initial issue they were therefore tasked with resolving was orienting the map correctly based on this information. Thus, the driver and navigator had to *read* the map before materially attempting the route. Reading a map, in this case, meant interpreting and aligning it so that a specific direction on paper matched the correct relative direction on the ground, to move from point A to point B (Lavagna and Lucarno, 2007, p. 94).

Then, the children received explanations about the functionalities of rovers as exploration tools. The use of mechanical arms for sample collection was illustrated utilizing the Lego Spike Education set (Figure 9). Children were grouped into small teams and then guided through the assembly of a robotic arm capable of grabbing small rocks. After completing the construction, under the supervision of a facilitator, students simulated collecting "rock samples" to be later transferred to the laboratory for analysis. Building blocks are another recognized tool to help children's spatial skills (Amatori, 2024, p. 208).

5. Outcomes

A dedicated space for non-structured interviews to students was organized during one of the didactic days. A limited sample of 58 fifth-grade pupils was asked to freely and orally answering simple questions about the activities they had just participated in.

A total of 1 hour and 17 minutes of recordings captured the students' responses. They were later analysed to derive an initial general survey of which activities had proven to be more emotionally impactful and didactically efficient.

Responses were qualitative and informal in nature, but it was possible for the workgroup to clearly identify the preferred activity type and to aggregate general, recurrent reasons for the expressed preferences. Data revealed that virtual reality and hands-on experiences generated the highest interest (Figure 10).

In addition, a more in-depth analysis of the interviews enabled us to highlight other interesting findings.

More than one student has shown appreciation for the opportunity to move around and participate in activities that were not limited to sitting in a classroom and listening to a lecture. They also underlined how activities of this kind can help understanding new concepts, even "terms that we don't use often"[6], in a simple and practical way.

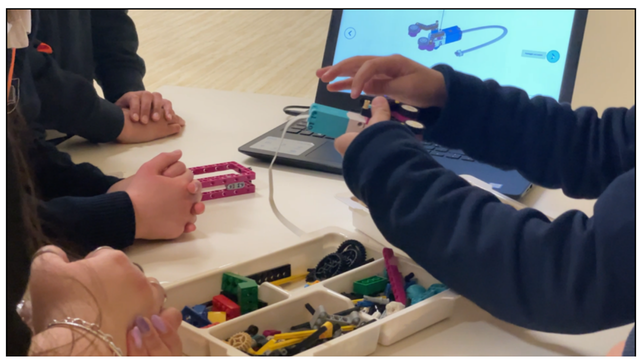

Figure 9. Pupils assembling an electronic robotic arm with Lego Spike Educational Set. Source: IRCIT.

[6] In this paragraph, some excerpts of the interview, translated by the author, are reported.

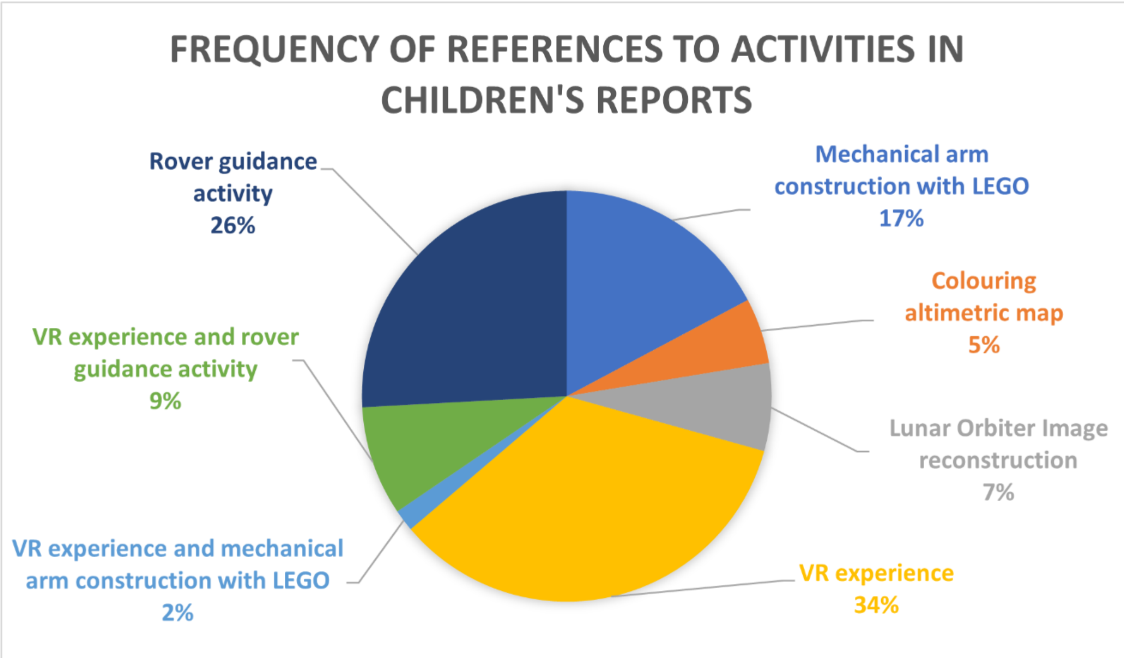

Figure 10. Pie chart showing frequency of references to activities in children's reports about the didactic experience at the European University of Rome on May 19th, 2023 (fourth session). Source: GREAL.

What emerges as particularly interesting from the interview is a widespread sense of responsibility generated by activities that engaged the children first-hand. Many made a point to specify the difference between a videogame and what was perceived as a "real-life situation" in some of the proposed activities. It seems that introducing the laboratories as games based on reality, each with a specific task to complete, was enough to instil a sense of responsibility. Assigning pupils a goal such as creating a map that, if well made, allows for planning a space journey; building a mechanical arm that, if operable, allows for the acquisition of rock samples; driving an exploratory rover with a mission, made everything feeling as if it were "realistic, it was not a videogame". "I felt like […] I was in charge of an excursion on a planet". Many of the children said they felt grown-ups because they were supposed to complete important tasks. Feedback supports the expected conclusion that promoting emotional engagement can enhance knowledge acquisition.

Immersive virtual reality experiences, which were found to be the most attention-grabbing and interesting for students, also given the novelty of the used tool, were described in various terms. Among the descriptions, the most frequent were related to the sphere of "beauty" and "excitement" in seeing places never visited before. Evidently high was the so-called "sense of presence" that these means can generate, by giving the impression of "being" in a reality *other* from the one in which the observer is materially located (Wilkinson et al., 2021). To the question "What do you see?" a pupil wearing the Oculus gave the emblematic answer "I am in space!". She actually answered a question that focused only on the sphere of visual perception, by broadening the response to encompass the entire physical experience. This should promote reflections in teachers regarding the effectiveness of these tools as possible complements or alternatives to *outdoor education*, defined as moving and exploring outside the classroom to actively build knowledge (Di Gioia, 2023, p. 668), especially in cases in which such environment is too complex or even impossible to reach (Bos, 2022, p. 480; Lee, 2023, p. 2).

6. Conclusions

The widely theorized potential of innovative geotechnologies and practical activities as a useful support to geography teaching/learning (De Miguel González, 2014, pp. 21-38; Kerski, 2015, pp. 183-194; Lavagna et al., 2018, pp. 119-121) is further confirmed in our experiences. Pupils' comments allow to grasp individual inputs, remarks, and feelings that show interest, not only in the medium but also in the content that was proposed to them.

In this first series of experimental initiatives our focus was on the design and practical testing of didactic strategies, with main attention on transferring the chosen geographical concepts related to the history of exploration – specifically space exploration – into teaching contents, tools, and methods.

Being this essentially a "prototyping" work, the group did not develop in much depth the monitoring workflow to derive a full-blown analysis of pedagogical effects and variables. This poses a limitation in the initial cycle of activities for the workgroup. Furthermore, each of the ten classes participated in a single dedicated day, allowing every student to experience the full range of proposed activities and to provide the group with valuable feedback and immediate impressions regarding the acquired knowledge. Unfortunately, however, not repeating the encounter with the same class has restricted the workgroup's ability to assess the long-term learning of the presented content. Such research limits are planned to be overcome in further activities.

Nevertheless, as a satisfactory result, our experience validated the assumption that the adoption of modern technologies and didactical methods centered on *learning by doing* and *collaborative learning* can make activities very engaging for students (Tani, 2013; Ascari, 2017, p. 267; Camuffo, 2017, p. 224; Crivelli, 2017, p. 193). It seems possible to use tools, methodologies, and teaching strategies, according to the aforementioned principles, in order to foster students' interest and curiosity. Some of the interviewed pupils declared themselves as being generally not fond of geography; yet, the proposed experiences caught their attention, and made some themes "very understandable". In addition, all responders appreciated the fact that first-hand interaction was a key-element of the activities and made pupils "discover new things not only through books".

Since collaborative learning is highly effective in hands-on applications, it is possible for our group to consider future activities of the same kind also through VR in a metaverse-like context. Up until now, our proposed virtual reality experiences involved students individually, with group discussions afterwards.

It is now possible indeed to consider VR, and by extension the metaverse, as a *place* that integrates or complements the real world. A place where it is possible to experience a "sense of individual presence" nearly comparable to the tangible reality of daily life (Carbone, 2023, pp. 819-820). In our opinion, collaborative activities in VR could possibly increase the students' level of interaction: in a simulated virtual environment they might share more complex situations, bringing the benefits of collaborative learning in otherwise inaccessible geographical contexts.

The sessions have also highlighted the important role of the facilitator in effectively delivering geographical content. The efficacy of each activity stemmed from its alignment with the two previously stated conceptual lines. The facilitator conveyed the content accordingly to each small group of children, fostering their reflection and dialogue on the addressed topics. In future occasions the workgroup plans to involve teachers and educators before the sessions with the classes, so as to activate a positive, better coordinated exchange with facilitators to maximize the effectiveness of their action.

Methods and technologies used in this initial experience are not innovative *per se* as far as design and implementation are concerned, but they can be deemed so regarding the type of application and themes covered.

In future workgroup activities, furthermore, geobrowsers have been identified as additional useful tools. Their potential to provide students with effective visualizations of far off places and to allow "virtual fieldtrips" has been demonstrated (Pesaresi, 2019; Pavia, 2022). Environments on Earth can be explored, by the use of these platforms, according to a multiscalar and comparative approach. It is possible to virtually explore any place on Earth, "zooming" in and out of it, seamlessly transitioning from a "view from above" – giving a sense of objectivity to a "first person view" – providing a feeling of subjectivity.

This ease of transition is made possible, in geobrowsers – as in traditional GIS – by the availability of surface or low-height imagery that can be mosaicked and georeferenced. This enables visualisation in smaller cartographic scale, rendering wider area scenes (Carbone and Casagrande, 2023).

Based on this, it appears clear to us that geobrowsers, including Google Moon and Google Mars, could be particularly useful for storytelling places in the more general framework of the history of travel and exploration. They would in fact allow users to "virtually travel" and thus evocatively experience distant and appealing destinations or otherwise unreachable environments. Exploring Robert F. Scott's McMurdo Antarctic base (1912) in Google Earth (Pavia, 2022, pp. 286-288) or travelling through Lunar craters in Google Moon present two almost equivalent cases of remote places, visitable virtually through equal platforms and equal procedures.

Geobrowsers also allow for an easy construction of simplified maps. As it is now widely acknowledged, a map can be custom-created based on existing webGIS as provided and updated by official sources (Favretto, 2010). The facilitator, along with the students, could then directly *draw* on the platform, adding information such as routes, landmarks, icons. This could enrich an already proposed activity, e.g. the rover-driving exercise. For instance, the route could be collaboratively charted, before navigation, by the students, with guidance and support from the facilitator.

In the future design and implementation of activities, the workgroup has identified several aspects which could be developed based on the past experience. In particular: feedback from pupils should be acquired through structured interviews; feedback should also be acquired from accompanying teachers, possibly through structured interviews and/or questionnaires. In the workgroup's opinion, there should be more than one encounter with each class, in order to assess long-term results of the previous experience and to apply gradual progression in contents to the benefit of the learning process.

The positive results obtained so far and the vast literature on practical activities in geography teaching encourage the workgroup to pursue more developed experiments in the future, and to widen the scope of the contents to include other travel systems in human history.

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