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# Towards other worlds

## Practicing exogeography in primary schools

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**Abstract.** In 2023, an experimental research study was conducted at the European University of Rome in primary school education, focusing on an innovative area of study called "exogeography". This field is based on the concept that humanity may, over time, develop new perspectives for settlement and activity beyond Earth. These perspectives can be observed and explained using the epistemological and methodological tools of traditional geography, provided they are adapted to new contexts. The experiment involved a total of over 200 children aged between 6 and 11. A multidisciplinary pathway was set up at the university, featuring virtualization and simulation technologies, construction workshops, and interactive teaching. This contribution summarizes the first results achieved to benefit both primary school students and teachers.

**Key words.** Exogeography: VR: Simulation: Primary Education

## 1. Introduction

In 2023, the GREAL Laboratory at the European University of Rome developed an extracurricular activity to teach primary school pupils some fundamentals of exogeography and history of space travel, the former being the "declination towards space" of traditional Geography (D'Ascenzo 2010; Casagrande 2021)

This particular activity stemmed from a wider reflection, in our workgroup, about how to introduce students and pupils from different school types and levels to some milestones in the history of human journeys. Such reflection involves travel as a manifestation of potential human presence and actions in general, wherever the location and whatever the implementation may be.

Before developing the exogeography project presented here, our team had the opportunity to explore the use of various activities to narrate these aspects of the history of travel to high school and university students. In these cases, some "one-off sessions" (i.e. not part of structured programmes) were designed to test the methodological and technical implementation we were attempting to apply. The activities were founded on the idea that incorporating technologies such as virtual environments, combined with hands-on experiences like simulations and practical tasks, could enhance learning effectiveness.

The idea of using virtual reality as a tool for content delivery stems from the proven ability of immersive devices, such as headsets, to generate a strong sense of presence, especially if compared to 2D environments (Clemente et al. 2024; Theodorou et al. 2023). This heightened sense of presence has been shown to enhance engagement and cognitive retention, making VR an ideal medium for educational purposes. By creating more interactive and immersive learning environments we wanted to let students experience subjects in a more tangible and engaging way, increasing motivation and deeper understanding of the proposed geographic themes (Bos et al. 2022; Stojšić et al. 2016). Hands-on activities are invaluable in education at all age levels, as they engage students in experiential learning, enabling them to grasp abstract concepts through direct interaction. In the context of the history of travel, exercises – such as navigating and mapping – help bridge the gap between theory and practice. These activities may then promote spatial awareness and critical thinking, encouraging the transition from a ”subjective” understanding of one's position in space to an ”objective” representation of such position on a map (Messina et al. 2021).

## 2. Previous activities

Practical examples of activities designed to convey brief insights into the history of travel were tested on several occasions, particularly during various seminars and scientific meetings held at the Italian Geographical Society in 2022 and 2023. These sessions were intended to illustrate some aspects of human exploration and travel, by combining verbal explanations with interactive and immersive experiences. Our targets were mainly high school and university students.

One notable example was an activity that focused on the history of maritime travel. Following an aural overview of significant aspects of sea voyages, students experienced a Virtual Reality (VR) tour of the training ship Amerigo Vespucci. [1] Using Oculus Meta Quest 2 headsets, they were transported into a 360° video tour offering a glimpse into areas of the ship, both above and below deck, and providing an engaging "visual peek" of maritime exploration history.

Another activity was put in place to highlight the challenges of reaching remote and uninhabited locations. Students experienced Arctic landscapes through a five-minute VR visualization.[2] This experience showcased four real scenarios captured using a 360° camera during the Polarquest 2021 expedition, providing a unique opportunity to explore the distant environment of the Arctic with natural sounds recorded on-site, offering a vivid portrait of a frontier of human exploration. Another engaging exercise was presented related to aerial navigation. Students participated in a simulated flight operation. In this case, participants were introduced to a typical, though simplified, workflow of planning and conducting a low-altitude navigation on a military jet reconnaissance plane of the 1960s-1980s. The first step was to plan the route on a map, by establishing heading and distances from a departure point (a racetrack at the northern edge of Treviso) to a destination point (San Marco Square in Venice). The second step was to do calculations on a whiteboard, in order to define expected flight-times at different speeds (300 to 500 knots). The students were then shown a large aerial, nadiral picture of the arrival area in Venice and were invited to observe visual references for their final approach for the intended low-level photography. In turning to the simulation part, the ”pilots” - with only the view from their cockpit (Fig. 1) - were required to fly the plane from specific visual reference points on the scenery towards a destination target by flying the appropriate calculated headings (175°-180° initially, then 130°) and expecting to see within a certain time interval

[1] ”Visione a 360°della nave Amerigo Vespucci” (by Paolo Micai), https://www.youtube.com/watch?v=uMVSzoS3x6U Last accessed November 30th, 2023

[2] VR Experience-Polarquest 2021, https://www.youtube.com/watch?v=vIn832dzezA Last accessed November 30th, 2023

**Fig. 1.** Student simulating the flight from Treviso to Venice. Source: GREAL

a railway bridge first and, after the alignment turn, San Marco's bell tower.

## 3. Exogeography laboratories

Building on these initial experiences, we have turned our focus to the future frontiers of human exploration. We acknowledged that such activities, showing different forms of representations, can enhance the understanding of remote and inaccessible environments (Pesaresi et al. 2012; Fea et al. 2013; Stojšić et al. 2016; Minocha et al. 2018; De Vecchis et al. 2020; Bos et al. 2022) but also shed light on the dynamics and challenges inherent in exploratory journeys beyond human frontiers.

Accessing increasingly remote environments depends on the ability of acquiring a high degree of knowledge about their nature and characteristics. For this reason, being able to travel, for instance, to Mars, entails the previous acquisition of deep understanding of its environment. The more humankind expands, the more this expansion requires the use of remote-sensing and uncrewed exploration, which in fact is part of the knowledge acquisition process. Exploring Mars might actually become a direct human experience when astronauts will step on the red planet; but it is already a well-developed field of science, as automatic orbiters, landers and rovers have been visiting it since several decades. Sending an automated rover to Mars, having it sample the surface and observe the local environments remains, in all aspects, a classical story of human travel based on orientation, mapping, and routing. Moreover, maintaining the proper functioning of onboard systems - or, in other words, ensuring the "health" of the robotic device - in non-Earth-like environments requires an understanding of unique conditions and the ability to address potential challenges with suitable technical solutions.

Important tests for our teaching project took place on four separate occasions in 2023, when our university hosted informal educational presentations on exogeography for children from four primary schools in Rome. We welcomed at the European University of Rome, a total of 225 pupils (mostly fifth grade), from 10 classes. In this overall framework, human travel to space was to be explained in terms of spatial settings, navigation, mapping of different environments, evolution in transportation systems and life-support systems. Our workgroup included university professors (geographers and pedagogists), PhD students, graduate and undergraduate students; when possible, teachers accompanying pupils were also involved.

Contents were chosen so to clarify the main concepts. Presentation methods and activities were developed relying, as much as possible, on innovative technologies and hands-on work. In comparison to a presentation for adults, dealing with children implied some simplification, although much attention was paid in not "dumbing-down" complex concepts.[3]

Let us briefly summarize the most successful activities tested.

### *3.1. Mapping altimetry*

It was appropriate to show the continuity between the cartography used to represent Earth's surface and cartography used for mapping other celestial bodies (e.g. Mars or the Moon)

[3] The workshop activities were featured in an episode on the YouTube channel "Silvia'I&' Kids", which shows the experience through the perspective of one of the students who participated. https://www.youtube.com/watch?v=N41U7qgchMU Last accessed 22th January, 2025.

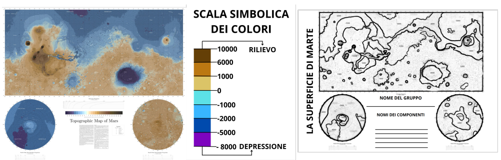


**Fig. 2.** A topographic map of Mars (left). Source: NASA. The map to be coloured according to a chromatic scale based on altimetry (centre/right). Source: GREAL.

by highlighting that some representation concepts are equivalent.

Primary school children are accustomed to interacting with maps (Scaglione & Gallia 2021) and they acquire the concept of altimetry and its expression by the use of a colour palette. A typical "terrestrial" standard is to use green for flatlands, yellow for hills, brown and grey/white for mountains. Our goal was to generalize symbolization by showing that the chromatic scale is conventional and other colours can be used to express the same concept. Pupils were presented a Mars planisphere and were invited to colour its sections according to altimetric intervals as shown in the legend (Fig. 2).

### 3.2. Broadcasting images from space

Planetary maps are developed from remotely sensed images. The reconnaissance vehicle would typically acquire images of the target object and send them to receiving stations on Earth for processing and analysis. One of our activities with school-children aimed at presenting them to a historical lunar reconnaissance process. The uncrewed Lunar Orbiter probes, in the 1960s, used to orbit the Moon capturing photographs on film; images were developed inside the probe in flight, scanned and then broadcasted via radio. A receiving station on the ground would get the signals and compose a copy of the original image, for analysts and cartographers to prepare maps (Bowker & Hughes 1971). This process was mimicked, in the form of a game, by asking children to recompose the linear puzzle of the image, then to scan it as a unique representation, adding metadata (i.e. their names and class) and then sending it to a repository (to be later forwarded to their school via mail as an "archive" of the activity).

**Fig. 3.** A student experiencing virtual reality with the help of an operator

### 3.3. Virtual reality of Moon and Mars

By using low-immersivity virtual reality, pupils were invited to observe (wearing goggles and seating on swivel chairs) a reconstruction of the Apollo 11 landing site on the Moon and a 360° (with original audio-recordings) photographic representation of a Martian location as captured by Perseverance mission (Fig. 3). The basic capability that these virtualizations provide to users, of being able to turn their sight in any direction, enhance *per se*, remarkably, the classical power of standard screen-shown 2D images as "mediators between places and the knowledge of observing subject" Giorda & Pettenati (2018).

### 3.4. Virtual reality within and without the ISS

A more immersive type of virtual reality was used – by Oculus Meta Quest 2 visors, with the Mission ISS app – for introducing children to the general architecture and features of present-day spaceships. The app, allowing the user to "move" subjectively inside the various ISS spaces and providing some interactive explanations about equipment, systems and devices, offered quite an effective experience. Children could understand how cramped the

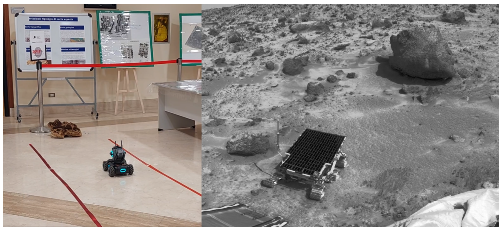

**Fig. 4.** The rover on the outlined red path, moving towards the rock to be photographed (left). Source: GREAL. The rover Sojourner approaching rock "Yogi" during the 1997 Mars Pathfinder mission (right). Source: NASA.

stations' spaces are, the fact that perception of high and low are relative in microgravity and that, in such conditions, the only way to move is to exert some pressure on a certain element or grab it to push oneself in the desired direction. In a second situation, the user was invited to simulate a spacewalk, in this case acquiring familiarity with the need for a pressurized suit and the complexity of moving in outer space by operating gas thrusters.

### *3.5. Rover guidance*

A simulation was put in place in a 100-square metres area for guidance of an explorative rover. The pupils worked in pairs as the ground crew, alternating roles between driver, controlling the rover, and navigator, using the map to guide the driver, through a path outlined on the floor. Avoiding obstacles, they had to reach a final target and "study" rock samples, capturing photographs through the rovers' camera (Figure 4). Children were seated at a remote-control station, positioned in such a way that the rover and its surroundings were out of sight. They, therefore, could rely only on real-time images and data from the rover's camera, displayed on a screen. This activity aimed to help children develop a better understanding of the first-person perspective of explorative navigation and its bi-univocal relationship with mapping.

### *3.6. Mechanical arm*

Following the rover navigation activity, pupils learnt about the functionalities of rovers as explorative tools. A specific focus was on how mechanical arms are used for remote samples collection. Using the Lego Educational set, groups of five students were guided to the construction of a robotic arm, following detailed instructions. Once assembled, the robotic arm was able to grab small objects, so pupils simulated the rock sampling process. This made it also possible to associate a typical robot construction activity with the exogeographical concept of planetary geology.

## 4. Conclusions

The extracurricular activities on exogeography and space travel were met with great enthusiasm by the attending primary school pupils. Although these activities were designed as prototypes, they have proven to be an effective and engaging way to introduce young students to new concepts. The hands-on experience and the use of virtual reality allowed us to see the potential of continuing in this direction, showing that immersive and interactive methods could serve as powerful tools for education.

From the feedback we gathered, it emerged that pupils not only enjoyed the activities but also felt that they had learnt something new in an engaging way. One pupil noted: "For me, the thing I liked the most was the VR, through which I really felt like being there, I thought it was boring but it was beautiful" [4]. Another remarked: "I don't like geography very much, but the teachers were good anyway, they explained it in a good way for children, they didn't explain in a way for adults, it was very understandable and it was perfect".

The variety of exercises – from VR to the guidance of a rover – provided an engaging platform for students to explore and understand concepts outside of their usual classroom environment. As one child commented: "These things were very beautiful and even for a per-

[4] Pupils' comments are translated by the author

son who perhaps didn't like science or geography you opened up a different world".

These activities, while still in an early phase of development, have shown that there is a significant potential for further refinement and expansion of the educational approach. The emotional impact and hands-on learning seem to offer a promising way for making complex and new subjects more accessible and enjoyable for young students.

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