A Martian Adventure: An Interactive Geo-Edutainment Tool

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Abstract

Cooperative and simulation games can create an exciting and empirical learning environment. The participants of such games can develop competences which are overlooked in traditional educational methods. Geography as a subject has ample opportunities to apply games of this type during the learning progress.

The goal of the current paper is to present the game „Martian Adventure" which was designed and developed in the Institute of Geography and Earth Sciences of the University of Pécs, Pécs, Hungary. Our goal was to create an interactive teaching method, through edutainment and gamification, which helps students to develop navigational, programming and general STEM (science, technology, engineering and mathematics) competences. During the activity we applied Lego Boost robots on a theoretical Martian surface. The robots moved across various Martian landforms which enabled students to perceive these landforms and their terrestrial equivalents. Our findings indicated that that students' terminology increased in the field of planetary and general surface morphology.

Although high school students are regularly engulfed in astronomy and planetary sciences through popular media movies, still their education in Hungary is only based on conventional teaching methods. However, with the advent and the exponential development of robot and infotainment technology, general terms and definitions used in planetomorphology may be perceived, acquired, and clad with real scientific meanings via interactive gamification. The visual multimedia experience enhances the process of imprinting and students were able to apply the adequate terms in a complex context-valid way. As students used their own mobile phones, scientific resources are not necessarily implemented as traditional source of knowledge obtained via conventional classes but rather attained through entertaining activities.

Keywords: *Mars, Martian Adventure, planetomorphology: Gamification, Lego Boost;*

Introduction

The Red Planet has been in the focus of many humans and is a possible area of survival for humankind. News on satellite photographs, the landed Martian rovers and the new discoveries widely attract the scientific community in many aspects. The exploration progress of rover Curiosity and the landing of the *InSight* were watched with great interest by the public. This attention, however, is not novel. The perihelion opposition of 1877 amplified the scientific interest. Giovanni Schiaparelli the Italian astronomer, thought that there are artificial canals on Mars largely due to an accidental mistranslation from Italian to English. Percival Lowell (1855-1916) believed them to be artificial irrigation channels [1]. The new theories of Martian life became popular after H. G. Wells' novel entitled War of World. Nonetheless, with time, hypotheses on the existence of life on Mars have been refuted [2]. Nevertheless, the Mars has an ever growing and ongoing popularity.

A Games and Simulations in Science Education uses a practical approach [4]. It had a significant influence on the field of STEM (Science, Technology, Engineering and Mathematics) subjects and especially in geography. It summarized the advantages of games in education, and collected the games and simulations available for them. [4]. also encouraged educators to create own games, and gave practical advises to developers and educators. The games that designed with clear educational purpose is called serious game [5].

There has been a lot of research on the application of games in education over the past years. Vigil-Cruz [6] studied PHARM in pharmacist training. The research explained that learning with the game increased the learning performance and it was the most popular learning way among students. Similar

studies have been published about chess [6], *WiseMoney, Scrumia and Deliv*er [8]. Lev Vygotsky (1962) thought that games are the best way of children's development [3].
The objective of the current study was the design of the game „Martian Adventure" (MA) that facilitates the perception of the newest achievements in Mars exploration and the geomorphological features and landforms found on the surface of the red planet. The game simulates the activities of Mars rovers, by using Lego Boost robots on a playfield of a Martian land surface. The game provides an excellent tool to recognize Martian landforms and examine them in contrast to terrestrial terrain. Students were also taught about the forces that formed unique Martian morphological features. Furthermore, the game, due to its remotely-controlled robot technology, functions as a competence developer tool.

Methods and Tools

The Martian playfield

A Martian surface of an arbitrary playfield pattern was created (Fig. 1) by using 25 satellite images (tiles) taken of the surface of planet Mars. These pictures were taken by the ESA Mars Express space probe [9]. The original resolution of the images ranged between 10 to 20 m per pixel. These surfaces, however are not directly adjacent to each other on the surface of the Mars and were arbitrarily adjoined by the authors.
We used large-scale pictures, where the relief's drop shadow did not differ significantly, therefore their boundary is gradual providing a better match between the adjacent tiles of the playfield. The original resolution of the individual tiles were changed, hence the landforms have various scales. This way the playfield had a more integrated look. We used the software GIMP to put the final mosaic together. The playfield was printed out at a 150 dpi resolution on a plastic sheet of 3x4 meters.

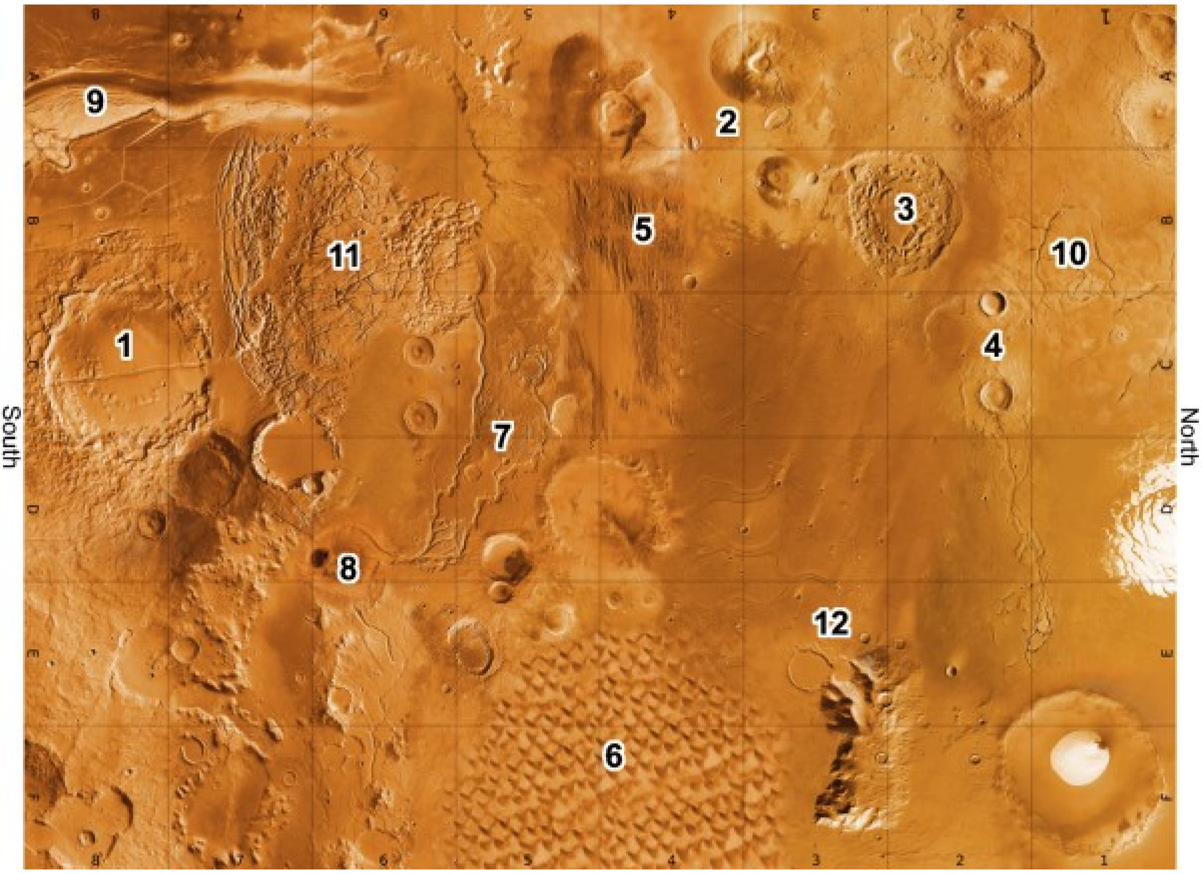

Fig. 1. The playfield of the Martian Adventure.

The numbers indicate typical landforms found on the surface of planet Mars. 1: Fault lines in a crater in the Memnonia Fossae area, 2: Tharsis, Ceraunius and Uranius Tholus volcanic areas, 3: Ismenia Patera, 4: Hephaestus_Fossae, 5: Euminedes Dorsum, 6: sand dunes in Proctor Crater, 7: Valles Mangala, Osuga and Nanedi, 8: Crater in Mamers Valles, 9: a detail of Vallis Kasei, 10: Adamas Labyrinthus in Utopia Planitia, 11: Chaotic terrain in Iani Chaos, 12: 'hourglass'-shaped craters in Promethei Terra

The playfield creates a north-south cross-section of the Martian surface from the North Pole to the South Pole. The landforms of the highlands of the southern hemisphere and the vast plains of the northern hemisphere as well as the shield volcanoes, dune fields and the ancient riverbeds, fault line structures are visualized on the playfield (Fig. 1). The Martian surface has been formed by the same internal and external forces that has been acting on the surface of the Earth. Although significant geomorphic differences do exist on the surface of the two planets, due to the intensity, scale of the processes and forces acting and also the characteristics and dimensions of the landforms, still their quantitative and qualitative comparison is feasible and may boost the relevant analytical skills of the students involved in the study.

Landforms created by internal forces

As the diameter of the Mars is only slightly more than half of the Earth's diameter it had weaker mantle convections during the tectonically active phase of the planet. Therefore, the Martian lithosphere may have not been split into individual small tectonic plates. However *Valles Marineris* (one of the largest canyon systems in the Solar System) was likely created partly by tectonic forces [10]. Traces of smaller tectonic movements are also found on the surface of Mars, like the fault and thrust lines of 1.5 km width in a crater in the *Memnonia Fossae* area (Number 1 on Fig. 1).

Volcanism, has played a significant role in the geologic evolution of Mars, however there is no evidence of recent volcanism on the planet. Planet Mars, like Earth, had both effusive and eruptive past volcanic activity. These volcanoes were active up to 20 million years ago. The largest areas of past volcanic activity include the *Tharsis* and *Elysium* provinces, while many smaller formerly active volcanic areas are scattered across the surface of the planet. There is no active tectonics on planet Mars today. Therefore, volcanoes are likely positioned above magma plumes generating hot spot-type intraplate volcanism, similarly to the Hawaiian volcanoes in the Central Pacific region or the Yellowstone supervolcano. The playfield shows three small volcanic cones (*Tharsis*, *Ceraunius* and *Uranius Tholus*) (Number 2) with small lava flows on their flanks. Next to them the collapsed caldera of a once-massive supervolcano is found (Number 3).

Landforms created by external forces

Planet Mars has a large number of impact features formed by comets, meteors and asteroids. Complex craters are formed in large craters with central peaks and terraces. The largest impacts created basins. The Martian Adventure's playfield visualizes both younger and older, eroded craters. The Mars has some unique crater types called rampart and pancake craters near the poles. These are surrounded by fluidized ejecta features (Number 4).

Despite the low air pressure in the Martian atmosphere, erosion, deposition and accumulation by wind is dominant process on the surface of the Red Planet. For instance, the parallel valleys of *Euminedes Dorsum* were formed by wind (Number 5 in Fig. 1). The accumulation and deposition of eoalian sediments are represented by an extensive sand dune field (Number 6) (NASA Mars Global Surveyor image).

To sustain human life on Mars the existence of liquid water is indispensable. In the past liquid water was more common than today on the surface of Mars. The space probes have found a large number of river valleys (e.g.: *Mangala*, *Osuga* and *Nanedi)* along the border of the southern highlands and northern plains (Number 7 in Fig. 1). These river channels have created meanders and formed sandbars and islands similarly to the terrestrial rivers. Rivers of planet Mars flew into the northern periodically existing, ephemeral seas or crater lakes (Number 8). The outflow channels that drained seas and lakes, like *Kasei Vallis* (Number 9) had the highest discharges. With a few exceptions the features tend to appear fully sized at fractures in the Martian surface, formed either from chaos terrains or canyon systems or other tectonically-controlled, deep graben-like landforms.

The surface temperature of Mars is usually below 0 °C, therefore water is mainly found in a frozen state on both the surface and subsurface. The largest volume of water ice is locked on and around the north pole during the winter season. The ice there is mainly found in the form of frozen CO_2. The whole Mars has a huge volume of ice under the surface in a form of permafrost. That is reflected on the surface in the northern plains (Number 10) and the chaotic terrain of the southern plateaus (Number 11). The chaotic terrain was formed by the removal of subsurface water or ice. Glaciers have eroded the land and built moraines, like inside the hourglass-shaped craters (Number 12).

The aims of the game design

Our aim for game design is to create a game that teaches children of various age geology and planetomorphology through the learning-by-doing educational approach. With the usage of robots on a theoretical Martian surface we can help the participants to perceive the real Martian landforms and find their terrestrial counterparts.
Henceforth, the MA game helps to convert the knowledge into comprehensible and adaptable knowledge and skills. The interactive experience with tablets and engaging robots and spectacular Martian terrain allows pupils to develop navigational and programing skills.
It helps to move science closer to the next generations. Besides that, our educational system has to concern the pupils' affective domain [11]. The MA game creates a positive environment where pupils can learn from each other in a mutual manner. Furthermore, we can help students to understand the true values of technology by using robots as part of the game.

The gameplay

The Martian Adventure game is designed for participants of 2 to 3 teams. Each team has 3 to 4 members. The team main goal is to perform tasks with a Lego Boost Mars rovers. The tasks mainly focus on Martian terrain and comparing it to our planet's surface. The game starts with a short lecture, where the teacher shows the playfield's main features and talks about the evolution of the Martian landforms.
After the lecture, the turn based game starts with a ruffling, using a spinner with different Landforms and tasks on it. After spinning, students receive a Landform found on the Playfield (Fig1). Both team has to maneuver the Lego Boost rover there, by using the controller tablet. After reaching the square that contains the landform, students pick up an object with the fork of the rover. They have to retrieve the object to the starter position. The rovers always depart from the Martian Research Base of the specific team. The base is transferred to a different position on the field in every turn.
There are random effects which can be triggered by the turn starter spinner. For example, the players can activate Martian dust storms that prevent them to pass over certain field squares affected by storms. The mobility of the rover is also influenced by the terrain. Dirty or hilly surfaces slow down the movement of the rovers. The teams have to account for the changing circumstances when planning their route. The gameplay depends on the time available. The difficulty level of the game and the gaming time can be adjusted to the level of the game-players.

Conclusion and future research

The Martian Adventure game as a geo-edutainment tool can bring the geology closer to the pupils while their controlling skills and other competences are improving. The Martian Adventure game enhances the students' problem-solving and decision-making skills via an entertaining gamification activity. These development areas are considered of primary importance by the European Commission and they are crucial parts of science visibility and popularization monitored by the PISA assessment. Via teamwork skills obtained during the game also help to improve both social and individual skills and on the long run it may contribute to well-functioning interrelations at social level.
The Martian Adventure is favorably applicable in conventional frontal classes or as an optional extra-curricular lessons, activities outside the classroom and at Science Fairs or academic Open Days.
One of the key factors of designing scientific games is based on teachers' and students' reflections [3]. Game designers should avoid the development of excessively challenging or insufficiently engaging game by responding and reacting to the participants' reflections. To further explore the teaching efficiency of the Martian Adventure our future research attempts to test the game on students of various age groups in different schools and compare the outcomes with students of control groups where participants were not familiarized with the game of Martian Adventure.

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