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Exploration of the Moon between communication and science

A virtual reality experience for public engagement in astronomy and space science

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Abstract. This research explores the potential of extended reality technologies, particularly virtual reality, for public engagement. A significant portion of the work involved creating an innovative, science-based virtual reality experience called MOON RESCUER, where users engage in a hypothetical lunar base scenario. The goal was to balance engagement, scientific realism, and user comfort. Aimed at young adults but accessible to a wider audience, MOON RESCUER was tested in various contexts, receiving positive feedback for its ability to engage users and effectively convey scientific content. The project also fostered collaboration between scientists, communication professionals, and the public, strengthening the relationship between science and society

Key words. Public Engagement, Virtual Reality, Moon, Space Science, Immersive, Interactive, Innovative

1. Introduction

In a world in which new media foster the availability of information and the diffusion of scientific contents, the Third Mission plays a main role: making up and promoting a dialectic of science, spreading science contents by the media that modern technologies provide, involving the public in research activity are crucial goals for the scientific community at present day. Communication role consists in bringing people together, make them increase each other's abilities and knowledge, as they can proceed together towards their common goals. Within this context, the goal of this research is to characterize the potential of extended reality technologies, specifically virtual reality (VR), in the context of public engagement. The research was conducted with a proactive approach, as it was not limited to studying the effectiveness of existing extended reality products but instead a considerable portion of the research activity was devoted to the development of an innovative product, based on scien-

tific contents, to be subsequently presented to the public. This allowed us to explore the critical issues related to the development of virtual reality experiences, in order to understand the challenges and opportunities offered by this medium. The primary goal was to develop a product that could achieve a high level of engagement while maintaining a good degree of realism concerning the scientific contents presented and an acceptable level of comfort and enjoyment in terms of experience. The result of this development was the virtual experience MOON RESCUER, in which the user operates within the context of a hypothetical future lunar base camp. The immersion and interactivity that characterize virtual reality allowed the development of a product that is engaging, experiential, effective, and challenging for users. The main target audience for the product developed in this context consists of young adults, who are often attracted to new technologies and interactive experiences. However, the experience was designed and developed with a level of accessibility that allows it to be appreciated by a broader general audience. This research is situated within a very popular field in contemporary science communication. New languages are emerging, and the need to experiment with new communication techniques and new media is becoming increasingly pressing.

2. Public Engagement

As the name suggests, public engagement refers to the direct involvement of the public in an activity. The concept can have political or corporate connotations, but it is also gaining traction in the field of scientific communication, particularly within the dialogue model. Public participation in scientific research can occur at different levels, depending on the type of audience and the specific activity. Figure 1 comprehensively shows the different levels of engagement, highlighting how the objectives change based on the level of active public participation. If at the innermost level we have partnerships and shared decision making, characterized by a high level of active participation, at the other end we find the classic, unidirectional media, such as newspapers, websites, and TV programs, which aim to inform or inspire individuals and the community. It is important, therefore, to emphasize that information - understood as content transfer - does not disappear entirely from the model but is instead placed within a broader and more complex framework. Mutual listening and collaboration between scientists and the public are at the core of this approach, regardless of the level of engagement. Within this model, a communication product takes on plural connotations in its various aspects. Concepts like sender and receiver become much more nuanced, as dialogue also manifests as a role exchange between the different actors involved. In this sense, the creative process of a public engagement product is just as important as the final product. During the design and development of a project, discussions, exchanges, and collaborations occur at various levels among the different actors in the process. Thus, beyond the final target to which the developed product is directed, there are a series of intermediate targets, identified by all the people who have participated or collaborated in some way in the development process. Public engagement is oriented toward ensuring the involvement and personal growth of all the actors at all levels.

3. The scientific context: the Moon

The exploration of the Moon is an astronomical topic that is appealing for innovative research in the communication field. In the history of space explorations, the Moon was the goal that captured and focused the attention of the public much more than anyone else: the legacy of the Apollo program is not confined to the scientific context but it must be considered as a point of reference also under a communicative and cultural profile. The Artemis program is expected to follow the same path in the next years and resources that public and private agencies are spending on space missions suggest that we find ourselves at the dawn of a new space race that will have the Moon as the first goal. From a scientific point of view, the Moon will be a site of interest for many fields of research. The characterization of the lunar geol-

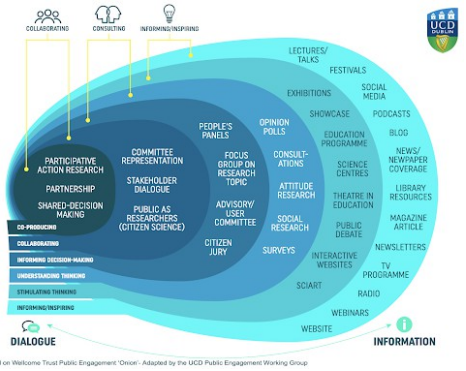

Fig. 1. Public Engagement onion diagram, representing in concentric layers the different types of activities under public engagement. Adapted from University College Dublin.

Fig. 2. User point of view of the lunar basecamp. Streetlamp on: a part of the shadowed zone is lighted and a ball is visible, while the rest of the shadowed zone is completely dark due to the absence of the atmosphere. The ball might be grabbed and threw to experiment with gravity.

ogy can give information about the evolution of the Solar System. In this context, a lot of in-situ missions have been proposed for the nearby future, in order to study the lunar underground by spectroscopy, radar, imaging, chemical analysis and seismic analysis. Also, the Moon is expected to provide new opportunities for lunar-based astronomical observations. The absence of an atmosphere and the long duration of dark sky conditions would guarantee significant observational advantages. Finally, the exploration of our satellite brings hard challenges from a technological point of view: telecommunications, astronauts' support and protection from radiation, in-situ resources utilization (ISRU), and realization of a permanent sustainable basecamp. New research is needed in this direction, which will also have possible implications for our life on Earth

4. The virtual reality experience

MOON RESCUER is a VR experience running on Meta Quest 2 device. This device has been chosen because it does not need external unit for processing or rendering, resulting in a very high versatility and ease in use. The experience was developed on Unity, a Game Engine commonly used in the video-games industry. A trailer is available on: `https://drive.google.com/file/d/1MYnozrERJ9yjP9T22jrkrOI0qg4PErEg/view?usp=sharing`. When the experience starts, the user is completely immerse in the virtual world, within a lunar set: it is also able to interact with the environment and the objects within in order to proceed through the experience as it is a character in a story. The experience is set on a hypothetical future lunar basecamp, where the user has the possibility to explore the environment and get familiar with its characteristics. In this context, constituting the first part of the experience, the user might experiment the effects of the absence of the atmosphere on the Moon by observing the shadows or by throwing objects and checking that they fall with the same speed (Figure 2). By throwing objects, the user might also experiment with the difference between how gravity works on the Moon and how it does on Earth. The user is then taught about how to drive a lunar vehicle to move within the whole environment, beyond the limits of the real space. Driving the vehicle is fundamental to reach the places where tasks proposed to the user must be completed. Tasks resolution represents the second part of the experience. One task is connected to the solar panel (Figure 3) that provide energy to

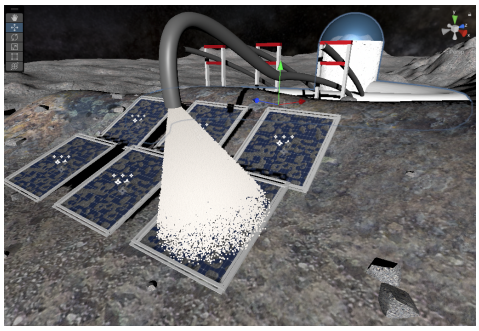

Fig. 3. Cleaning of the dust covering the solar panel that provides energy to the astro-biology laboratory.

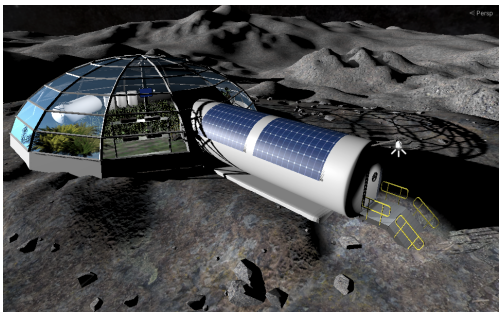

Fig. 4. Greenhouse in the virtual environment.

an astro-biology laboratory while the other one is connected to a crack in the glass of a greenhouse where plants are cultivated as food sources (Figure 4). The user must resolve the proposed task by a time of three minutes or the lunar base is compromised. The immersion is powered by the storytelling and the interactive approach also foster a hands on learning of the scientific contents proposed: gravity, lack of atmosphere, lunar dust, food production, energy provision problem: the user is immerse into those problems and supposed to become familiar with them.

5. Tests

MOON RESCUER was presented to the public at SPARKme in Matera. SPARKme is a visitor center focused on space exploration. The center hosted the first public tests of MOON RESCUER. The experience was integrated among the various attractions of the center: a $4m$ diameter polycarbonate dome was reserved for the user wearing the headset, while a 50-inch screen outside the dome was used for mirroring, allowing others to observe what the user was seeing inside MOON RESCUER. Clearly, this context did not allow for the selection of a single category of audience, as all visitors to the center could experience the virtual tour as part of their visit. However, since the visitor center frequently collaborates with schools, the visitor base also included the primary target audience for MOON RESCUER. Feedback from public were collected by questionnaires inspired to the work by Kersting (2021). Moreover, the experience was tested by scientist of different levels of career during conferences all around the Europe.

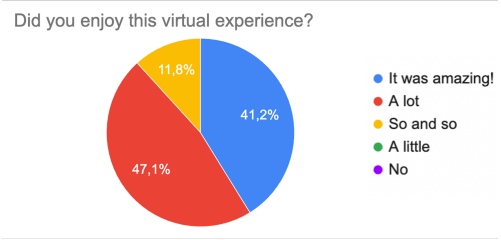

Fig. 5. Public general opinion about MOON RESCUER.

6. Results

Nowadays qualitative impact - positive experience and communication effectiveness - is more important with respect to quantitative one - the number of people reached by a public engagement activity. Regarding the number if people reached, MOON RESCUER ones are low: aside from those collected from the scientific community, only 34 feedback responses were gathered. The reasons for this are partly due to the characteristics of the media used and partly due to the context in which it was proposed. MOON RESCUER is a single-player experience lasting about 6-7 minutes, requiring a specific device and a floor area of at least 9 m^2 to function as the virtual room. Despite the quantitative results, feedback shows that MOON RESCUER has proven to be highly ef-

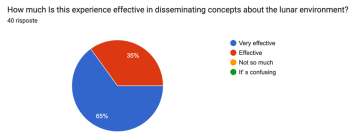

Fig. 6. Scientists feedback about MOON RESCUER effectiveness

fective qualitatively in terms of engagement. The target audience, the general public, and scientists all appreciated the virtual experience. Positive feedback from questionnaires (Figure 5) is complemented by external impressions: when a user wore the headset, people nearby, even if not actively participating in the experience, displayed curiosity and enjoyment. The involvement of third parties was even stronger when mirroring allowed them to see what the headset user was seeing. In any context where it was proposed, MOON RESCUER created a very positive atmosphere. Many users explicitly reported feeling ”engaged” as if they were ”part of the environment” they were immersed in. This engagement made them particularly proactive in exploring and discovering the new environment. This confirms that MOON RESCUER is a virtuous example of leveraging VR capabilities for engagement. Judging by the interview results, the impact of MOON RESCUER in terms of communicating scientific concepts was of medium level. Excellent feedback was received for those concepts addressed in the first part of the experience: lunar gravity and lack of atmosphere. The opinion of scientists, who positively assessed the experience for both the accuracy of representation and effectiveness in conveying scientific content, confirms the high level that MOON RESCUER achieves as a scientific communication product (Figure 6).

7. Conclusions

The development and the test of MOON RESCUER has achieved excellent results in the characterization of virtual reality in the context of public outreach. The development process highlighted several critical points and brought forth some successful approaches to tackle the more complex aspects. A simple and comfortable user experience, supported by guidance provided through audio recordings, has the advantage of enhancing user immersion within the virtual environment while minimizing instances of disorientation. Beyond technical development, the public engagement dimension related to the relationship between internal and external actors of the scientific community has been fruitful. Interaction with members of the scientific community made it possible to create a product with good realism in terms of visual representation and accuracy of the themes. On the other hand, interaction with professionals in extended reality and communication was crucial to creating a product that was both effective and appealing to the public. Once development was completed, the testing phase allowed for collaboration with the SPARKme visitor center, which hosted part of the tests. This strengthened the collaboration between INAF[1], the promoter of this research, and the visitor center, forming a bridge between academia and the third sector, one of the fundamental layers on which communication in the public engagement model is based. The presentation of MOON RESCUER at national and international conferences has attracted the attention of additional visitor centers, and new collaborations in this regard will be possible in the coming years. Finally, the project reports excellent results regarding the feedback MOON RESCUER received from both the public and scientists. Feedback from the public indicates that the virtual experience achieved a high level of user engagement. We conclude that the immersion and interactivity of this medium were excellently exploited, ensuring active, enjoyable, and emotionally satisfying participation. The experience shows good results in terms of effectiveness in conveying scientific content: confirmation of this comes from both public and scientific feedback.

References

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