



## Game-based Learning Mars EcoVenture: Rover's Odyssey

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**Abstract.** The project aims to create a gaming app that promotes sustainable practices while simultaneously combining education and entertainment. In the contemporary context, sustainability is extremely important because it has the ability to elevate the overall quality of life, preserve ecosystems, and safeguard natural resources for future generations. In line with the Sustainable Development Goals (SDGs) of the United Nations, the application functions as a medium for promoting awareness of a universal set of objectives and targets, thereby boosting the global agenda for sustainable living. The project aims to address the persistent issues that people and communities experience by putting in place a strong policy framework with realistic targets and a focus on knowledge gaps that hinder sustainable practices. The application strives to empower users with useful knowledge and promote a new approach towards sustainable living in many circumstances, whilst following a strict commitment to accessibility and easy integration.

**Keywords:** Sustainability, Solar Energy, Game-Based Learning.

### 1 Introduction

In today's society, the need for sustainability has grown exponentially because it is essential to maintaining ecosystems, improving quality of life, and using natural resources responsibly for the benefit of future generations. Game based learning is a teaching strategy that helps students achieve learning objectives, it is important because it increases motivation and engagement [4]. This also applies to the game as it will allow players to achieve objectives while promoting learning and behavioural change [2]. It is a good alternative compared to the traditional ways of learning and in the fields of sustainability in education [2]. Gamification concepts, including achievable goals, progression paths, strategy options, immediate feedback, levels, points, rewards, competition, and cooperation, motivate the player assume diverse roles, explore various options, and contemplate their decisions and actions [3]. This game is set on Mars, where players control a rover sent from Earth with a mission: to transform Mars into a habitable planet. As the rover, players will utilise renewable energy and prioritise environmental consciousness to upgrade their habitat and construct a sustainable living environment. The rover will gather resources and construct equipment to contribute to the planet's development. However, it's crucial to also ensure the well-being of the rover, considering the challenging conditions and constraints it faces.

Integrating game-based methods on earlier education stages, enhances motivation and engagement, especially on concepts around science and space. Mathers et.al develop a web-based mission that delivered the benefits of scenario-based learning within a school environment. The *Robotic Mission to Mars* allows students to remotely control a real rover, developed by the Australian Centre for Field Robotics (ACFR), on the VSSEC Mars surface [5]. Key elements of their work demonstrated how scenario game-based learning concepts can engage students in science exploration. Similarly another study from El Mawas et.al [6], investigated the impact of an adventure-based game, focussed on 3D solar system and the learning process for young education STEM level students [6]. An important conclusion of their findings, include that students had a great learning experience when using the prototype game "Final Frontier".

In the context of Mars, sustainable resource management is a crucial theme. The harsh and barren environment of Mars requires players to think critically about how to use limited resources effectively. This includes managing energy sources, carbon cycles, and food production, which are all significant challenges for sustaining life on Mars.

- Energy: Players could manage a mix of renewable energy sources such as solar and wind power, necessitating the design of energy storage systems to handle the diurnal cycle and dust storms of Mars.
- Carbon: The game could involve managing the Martian atmosphere's high CO<sub>2</sub> levels by employing technologies like CO<sub>2</sub> scrubbers or leveraging photosynthetic bioengineered plants to convert CO<sub>2</sub> into oxygen, modeling real-world proposals for terraforming.
- Food: Sustainable agriculture on Mars would be another game element, where players must create closed-loop agricultural systems that recycle nutrients and minimize waste, perhaps using hydroponic or aeroponic systems.

## 2 Purpose and Objectives

### 2.1 Purpose

The objective is to provide the players with a fun and learning experience on ways to provide energy in a clean manner that is also beneficial to our environment whilst also showing ways to keep everything efficient when using and producing things to help further themselves in the game. The target audience is fans of the city-building genre as well as students from educational institutions. The project will target them perfectly as there are a lot of features and elements from that genre, however, it also has other features that make the game unique and won't seem repetitive to these players. There are a lot of popular city-building games such as Cities: Skylines, Frostpunk, etc. which is why the focus is on this community [3]. This genre possesses a diverse fan base, covering various age groups and demographic backgrounds. The games within this genre exhibit distinct themes, complexities, and platforms, accommodating a wide range of preferences. Because of its inclusiveness, it's the perfect platform to engage a broad audience, offering a variety of instructional materials to suit different interests and backgrounds [3].

The United Nations Sustainable Development Goals (SDGs) are a group of 17 global goals strategically designed to tackle a range of social, economic, and environmental issues, ultimately fostering a more just and sustainable society [1]. The project supports multiple Sustainable Development Goals (SDGs) because of its emphasis on renewable energy, environmental awareness, and sustainable development:

The 7th goal in the United Nations list is most relevant in conjunction with the project. Being able to afford Reliable and Sustainable Energy remains a significant challenge that holds the potential to address both climate concerns and the exponential growth of the global population [1]. Unfortunately, the current trajectory is characterised by the reliance on short term solutions for long term problems. As a result, an increasing number of energy sources are implementing damaging and environmentally detrimental practices which have a negative influence on the world and, consequently, on human welfare. In the game, the player starts on Mars with nothing, already deprived from many things. As a learning component, information on how renewable energy can be utilised to build a habitable planet will be provided, with the aim of effectively educating the player.

Goals 14(Life Below Water) and 15(Life on Land) also have relevance to the project [1]. Despite the fact that the game is set on Mars, by encouraging responsible resource usage, the concepts of sustainable resource management and environmental conservation can directly support the objectives of preserving life on land and life below water. By combining these two goals, a diverse environment with harsh terrain will be created. The objective is to encourage a healthy habitable planet whilst promoting these goals.

### 2.2 Target Audience

The target audience for "Mars EcoVenture: Rover's Odyssey" primarily comprises young learners, ideally aged between 10 and 16. This age group is at a critical developmental stage where interactive and immersive learning experiences can be particularly impactful. The game is designed not only to educate them about future technological requirements and environmental sustainability but also to introduce them to the underlying principles of game technologies. By engaging with the game, players will gain a foundational understanding of complex systems such as renewable energy management, closed-loop agriculture, and resource conservation, which are crucial for future engineers, scientists, and policymakers. Additionally, by exploring game design and mechanics, they will also acquire insights into the rapidly evolving field of digital technology, preparing them for

a future where these skills will be increasingly relevant. This dual focus makes "Mars EcoVenture: Rover's Odyssey" an educational tool that bridges the gap between current educational content and future technological trends, making learning both fun and forward-thinking.

### 2.3 Game Objectives

The motivation behind the game originates from the urgent need to address the escalating crisis of climate changes as well as discover opportunities for expansion on identify new resources to support future rehabilitation and human life sustainability. The game objectives can be summarised as follows:

- Educate users with an opportunity to learn about different ways in which they can be sustainable by creating a comprehensive and engaging learning experience.
- Incorporate real-world solutions into the game mechanics by conducting thorough research on technologies with a lower carbon footprint and a positive impact on the world.
- Promote ongoing exploration of environmental challenges and solutions, ensuring that the game remains a dynamic and evolving educational platform.

## 3 Game Design

At the beginning of the development process, research will be conducted to discover real word solutions for clean energy and sustainability that can be implemented in the project.

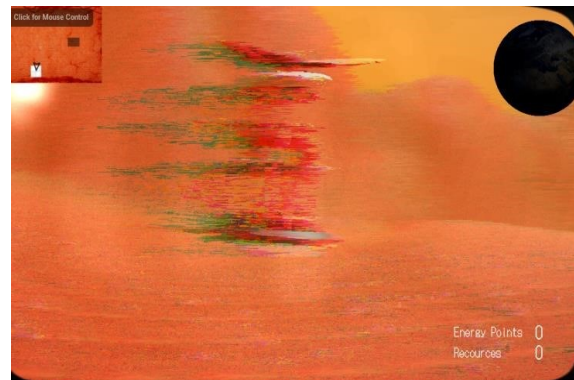
Mars EcoVenture: Rover's Odyssey is a project that uses game-based learning to educate people about clean and sustainable energy whilst allowing them to have an enjoyable and engaging experience. Doing this in a game can educate people by immersing them in a new world and having them be responsible for managing it and making progress.

The project is designed to show people that progress can be made using renewable resources and energy rather than starting using harmful methods. The player can progressively grow and build their own world, this gives them first hand control on how their society is built. The game encourages players to compare these in-game methods with those currently used in our world and initiate conversations that could prove to be helpful.

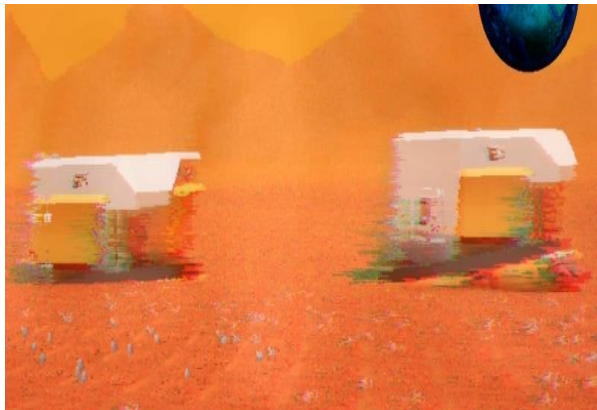
The player will be able to explore Mars in the form of a rover by using the WASD keys, this is an easy way of exploration as it allows them to gain more visual information of their surroundings. On the screen, the player can view how many energy points they've collected, they can use them to make Mars more habitable by building and powering structures using renewable resources. This is displayed by a 'habitable meter'.



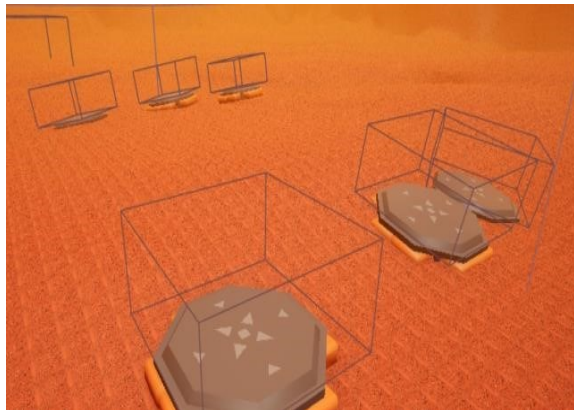
**Fig.1.** Rover.



**Fig.2.** Facility Generator.



**Fig.3.** Habitats.



**Fig.4.** Habitats Platforms.

### 3.1 Game Mechanics

The game's mechanics focus on two primary environments concepts: the main rover avatar (see Figure 1), where the player explores the environment, and the research station establishment (see Figures 2, 3, 4). The game includes elements to support the central hub facility and engage the user to understand necessities for building a sustainable environment, providing the following activities:

- A scoring system has been implemented to encourage the player to use the most optimal renewable material in order to achieve a higher score. This gives the player an incentive to try to use the least energy consuming option.
- A variety of resources representing different types of renewable materials are included to aid with the implementation of a resource collection system e.g. recycling.
- An energy management system that will later be implemented for the rover, it introduces renewable energy sources such as solar panels and wind turbines which will be utilised by the rover.
- A drag and drop building system will need to be developed. This would allow the player to build a certain building or structure when they have the correct number of resources and materials. These would help the player either gain more resources or increase their score.

### 3.2 Future Expansion

In the game, there are various expansions possible, allowing for the integration of additional planets, buildings, and occasional themed packs. These expansions would introduce a variety of resources and materials, providing players with additional objectives to pursue and collect. Furthermore, players could encounter Martian life as part of an expansion, creating opportunities for unique interactions, story-driven missions, or challenges. These kinds of features let the player's planet continue to evolve. Players would be able to compare their planets with others' planets if an internet feature were included.

The introduction of a simple weather cycle could significantly alter the game dynamics, influencing both gameplay and in-game conditions. As the primary goal of the game is to make the planet habitable for humans, an expansion could be implemented where humans are introduced into the game. In this scenario, players would be tasked with managing human involvement in addition to overseeing the development of their planets.

### 3.3 Deployment and Evaluation

The Alpha version of the game will be released online via the itch.io database and reviewed by selected students and experts in Phase 1, aiming to gather user experience information. This data will then be utilized to revise the application. Following this, a revised beta version will be launched and evaluated with schools in Phase 2. This evaluation will involve gathering quantitative measures to assess the game's impact on students' perceptions and learning outcomes.

## 4 Discussion

This project showcases three of the 17's UNs goals. Goals 7(Sustainable and renewable energy), 14(Life Below Water) and 15(Life on Land). The game focuses on educating players on managing and maintaining renewable energy in a gamified way. The game offers rewarding features to players who manage their resources and energy properly. This is a game that can easily have longevity and expansions. This allows it to reach more people and players, resulting in more awareness in the UN's goals.

## Acknowledgements

This project received valuable support from academics at the University of Westminster and UAS BFI Vienna, contributing significantly to its development and progress. Student mobility to collaborate in this project has been sponsored by Quintin Hogg Trust and Co-Creators programs, University of Westminster.

## References

1. The 17 goals | sustainable development, United Nations. Available at: <https://sdgs.un.org/goals>, last accessed 2024/03/01. IRENA: Renewables Readiness Assessment: Solomon Islands. International Renewable Energy Agency, Abu Dhabi (2024)
2. Bycer, J.: A look at the city builder genre. Game Developer. Available at: <https://www.gamedeveloper.com/design/a-look-at-the-city-builder-genre#close-modal>, last accessed 2024/03/01
3. Qian, M., Clark, K.R.: Game-based learning and 21st century skills: A review of recent research. *Comput Hum Behav* 63, 217–228 (2016).
4. Manshoven, S., Gillabel, J.: Learning through play: A serious game as a tool to support circular economy education and business model innovation. *Sustainability* 13(23), 13277 (2021),
5. Mathers, N., Goktogen, A., Rankin, J., Anderson, M.: Robotic mission to Mars: Hands-on, minds-on, web-based learning. *Procedia Comput Sci* 80, 124–131 (2012).
6. El Mawas, N., Tal, I., Moldovan, A., Bogusevschi, D., Andrews, J., Muntean, G., Muntean, C.: Investigating the impact of an adventure-based 3D solar system game on primary school learning process. *Educ Inf Technol* 12, 165–190 (2020).