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Serious Games report

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# Literature Review

Games for education is not a novel concept. The application of educational serious games can be seen within a variety of different sectors for example in medicine (Tsopra et al. 2020; Hannig et al. 2012), aviation (Chittaro, Buttussi 2015), and even linguistics (Alyaz et al. 2017). Sustainability is no exception to this as can be seen in games like Imagine Earth (Serious Brothers 2022) and Crabby’s Reef (SeriousGeoGames Lab 2022).

This raises the question of what serious games can achieve that other more traditional methods of education cannot. Research into the use of gaming in education found that it can make “learning easier”, “student-centred” and “engaging” and thus, more effectively deliver the subject matter (Rossano et al. 2017, p.49). Serious games have also been noted to facilitate knowledge and skill acquisition in learners (Papastergiou 2009). Moreover, it’s been found that the gaming dimension can also assist learners in developing their “cognitive abilities” and help some “step beyond the boundaries of conventional learning” (Ullah et al. 2022, p.202).

From the perspective of biodiversity, conservation, and climate change there are a few different ways in which a serious game can contribute to the cause. Sandbrook et al. identify the primary three mechanisms by which games could aid in biodiversity conservation efforts: education and behaviour change, fundraising, and research promotion (Sandbrook et al. 2014).

## User Analysis

Through an understanding of the client’s (Nottingham Trent University 2022) requirements, this project’s game leans towards the education and behaviour change mechanism. The client’s needs denote the need for a game that can be used to facilitate discussion in higher education level classrooms and that would equip players with a more detailed understanding of the chosen United Nations Sustainable Development Goals (UN SDGs) (United Nations Department of Economic and Social Affairs 2022). Thus, the project’s target audience would be university students. The goal of the game is to educate players on the relationship between biodiversity and climate change in ‘winterbourne’ chalk streams (Stubbington et al. 2017; Hampshire & Isle of Wight Wildlife Trust 2021; The Conversation 2022) and as a result, potentially inspire a desire for climate action in this area.

A common criticism surrounding the conversation about sustainability and conservation is that it can sometimes be “too boring” or “too vague” (Down 2006; Dernbach, Cheever 2015). Hence the need for a game that retains the user’s interest while subtly educating the player on key sustainability concepts. The use of gamification and allegory might be the answer to these criticisms. An example of this can be seen in a study on the game entitled ‘The Island’ wherein university students had to manage their resources as they governed a defined territory (Peña Miguel et al. 2020). Within the game, the players had to actively make decisions that would have either positive or negative ecological impacts on their surroundings. The study found that the game helped strengthen students’ understanding of sustainability and that the key factor behind this success was the integration of the UNESCO Education for Sustainable Development competencies. A few more examples of this include games such as Imagine Earth (Serious Brothers 2022) and SeAdventure(Rossano et al. 2017)**.**

In addition to designing a game that is both interesting and educational, the game should also consider the experience level of its players alongside other accessibility factors. The client’s requirements outline the need for a game that can be accessed easily and is suitable for a wide variety of players. A player’s previous gaming experience is a factor in this; not everyone can be assumed to have experience with browser-based games and thus, this emphasises the need for an interactive tutorial screen (Game Accessibility Guidelines 2022). This is to ensure that players do not experience any barriers to understanding the game’s fundamental mechanics. This further ensures that the player can become immersed in the content of the game without having to need to break immersion to query how a certain mechanic works.

Another accessibility factor to be considered is the aesthetic choices made during the game’s design stage. For players that might be visually impaired, modifications made to ensure that the game is still accessible to them are crucial. This includes adhering to guidelines outlined in both the National Learning Network Guidelines (National Learning Network n.d.) and the Web Content Accessibility Guidelines (Web Content Accessibility Guidelines (WCAG) 2022) that discuss how text and visuals should be formatted to improve overall readability.

## Task Analysis

To educate and inspire a potential behaviour change, a serious game’s objectives and tasks need to be designed in a manner that best communicates its key themes to its players. UNESCO’s guidelines on Education for Sustainable Development (Quality Assurance Agency for Higher Education, Advance HE 2021) provide a detailed outline of several different competencies that a game should develop in its players for it to be considered an effective educational tool.

To ensure that the users come away from the game with a base understanding of the issues surrounding the battle between climate change and the chalk stream biodiversity, the game needs to ensure that it facilitates critical thinking, anticipatory and self-awareness competencies (Peña Miguel et al. 2020). By developing a sense of self-awareness within the game, the player will slowly begin to understand how their actions can impact the surrounding world. This understanding can then be converted to active climate action outside of the game.

To develop and shape these competencies in its players, the game needs to include relevant subject material. To achieve this, the game must utilise critical perspectives surrounding the impact of climate change on the chalk stream biodiversity (Stubbington et al. 2017). Moreover, the game should also include discussion surrounding the related Sustainable Development Goals (SDGs) (United Nations Department of Economic and Social Affairs 2022) so that players can link their understanding of the game’s content back to current efforts aimed at sustainability.

## Environment Analysis

Delivery of the game is the final element that must be considered when designing a serious game. As the target audience for the game is university students, this game should be playable during a lecture or similar event. However, not every lecture or seminar occurs within a room that has readily available computers. Moreover, there should not be an expectation for the facilitator to ensure all devices have the game pre-installed onto them. Thus, there is a need for the game to be readily available and accessible to different devices (i.e., personal computers and mobile phones). A web browser-based game can be accessed from any device connected to the internet and through a single web link, the player can immediately open the game without the need to download and install the game's packages (Web Content Accessibility Guidelines (WCAG) 2022).

Another factor to consider is the limited gameplay time as highlighted during the client consultation. The game must convey its message within a time limit of 10-15 minutes. Games like Crabby’s Reef (SeriousGeoGames Lab 2022) achieve this by utilising a repetitive narrative. The game is set in the same scene, however as time progresses the round gets harder as more challenges are thrown at the player. Hence, by designing the game to utilise a simpler story with more complex elements added as time progresses, the game will be able to accomplish its learning objectives within a shorter period.

# Design Matrix

|  |  |  |  |
| --- | --- | --- | --- |
| **Source** | **Observations** | **Requirement** | **Ideas** |
| User Analysis | | | |
| Client notes based on Green Academy’s briefing  Literature Review findings | Players are university students. | The game should uniquely present information so that those who are either new to the material or quite knowledgeable about it can enjoy the gameplay experience. | The game will incorporate a visual novel style of storytelling that involves the player in the narrative’s events. |
| Players might not be experienced ‘gamers’. | The game must include a tutorial (Game Accessibility Guidelines 2022) | The game will include a brief trial level that walks the player through key mechanics. |
| Players might be uninterested in a sustainability-centred game (Dernbach, Cheever 2015). | The game must convey information in a method that captures a player’s sense of intrigue and is memorable. | The game is set in a high fantasy allegorical scenario to drive interest in the subject material. |
| Task Analysis | | | |
| Client notes based on Green Academy’s briefing  Literature Review findings | Encourage critical discussion and exploration of learning. | The game must help players facilitate one or more of the UNESCO ESD Competencies (Quality Assurance Agency for Higher Education, Advance HE 2021). | The game will develop a player’s self-awareness, critical thinking, and problem-solving competencies via its questing and resource management mechanics. |
| Promote a wider understanding of sustainability concerning existing climate change issues. | The game should reference the UN Sustainable Development Goals (SDGs) (United Nations Department of Economic and Social Affairs 2022). | Player interaction with characters will include discussions on life below water, responsible consumption, and climate action SDGs. |
| Designed with a clearly defined ending. | The game should be designed for short-term development and include a definitive ending instead of being an open-ended simulation. | The game ends once the player loses all the village’s eggs to climate change. In the case they trigger the win condition, players successfully save the village with the help of the community. |
| Offers critical perspectives on the topic area. | The game must involve a discussion on climate change’s influence on biodiversity in chalk streams. | The game’s questing mechanic will include tasks based on combating the influence of climate change within the chalk stream fantasy village. It will also include NPC’s (the wildlife) commentary on the negative impact climate change has on their lives. |
| Environment Analysis | | | |
| Client notes based on Green Academy’s briefing  Literature Review findings | Limited time allocated for gameplay. | The gameplay time should run for a maximum of 10 – 15 minutes. | The gameplay is cyclical in nature, alternating between two distinct phases that get across the message within the first few rounds. Additional rounds are used to further emphasise the core learning objectives of the game. |
| The game will be played on a variety of devices. | The game must be easily accessible. | The game will be browser-based so that it can run on any device. |
| Parallel Products | | | |
| Products that address a similar topic or are included within the sustainability and climate change area | Sustainability Games – it’s a quiz-based system that teaches players about the SDGs with a quantifiable outcome after each quiz round. | The game must include a scoring system that allows users to compare and discuss their performance post-game. | The game will include a tracker that stores how many drought phases a player survives and then display this value at the end. |
| Crabby’s Reef – Classic arcade-style game that explores the impact of ocean acidification on marine wildlife (SeriousGeoGames Lab 2022). | The game conveys its message within the first few rounds through its simplistic narrative. | The game’s cyclical design will ensure the learning objectives are conveyed within the first few rounds without the need for a long and detailed narrative. |
| Imagine Earth – A space game that’s designed to be an allegory of our world that’s currently battling against climate change (Serious Brothers 2022). | The game should utilise allegory to simplify complex and difficult-to-understand topics as a means of beginning the initial point of the player’s educational journey. | The game will discuss the chalk stream biodiversity’s survivability through the use of its fantasy allegory where a player must care for a village’s eggs that represent their unique species. The loss of an egg translates to the loss of the species. |
| Design Guidelines | | | |
| Literature Review findings and selected guidelines | Users may have visual impairments. | The game’s text and visuals should be designed with an accessible colour scheme and contrast ratio. | The game will utilise the 3:1 contrast ratio (Web Content Accessibility Guidelines (WCAG) 2022) when designing the game’s visuals in addition to testing its effectiveness via the Colour Blindness Simulator (COBLIS) (Coblindor 2021). |
| Users may have difficulty viewing text. | The game should utilise a font that improves readability. | The game will use a font from the sans-serif font family (National Learning Network n.d.). |
| Users may have difficulty navigating using the mouse. | There should be an alternative method of navigating and interacting with the game. | There shall be keyboard access for all of the menus, controls and other interface mechanisms mapped to unique keys (National Learning Network n.d.). |
| Users may be overwhelmed by high information density. | The game should ensure that the overall information density is not more than 50% of the screen area (National Learning Network n.d.). | The game will utilise multiple conversation scenes to convey information in smaller chunks instead of including large text blocks that take up most of the game’s screen space. |

# Design Document

## Game Overview

The Winterbourne Babysitter is a single-player web-browser-hosted game set in an allegorical fantasy village scene based on the winterbourne chalk streams (The Conversation 2022). The village residents are made up of the whimsical biodiversity that can be found in such a place. Players enter the game as a tiny humanoid dragon, a Kobold, that’s been enlisted to help take care of the villager’s eggs during the drought season. However, when climate change begins to negatively impact the weather conditions, the player must begin to battle against the unpredictability of nature to ensure the community continues to thrive.

## Core Objectives

The core objective of Winterbourne Babysitter is that the player aids the community in surviving and thriving for as long as possible. While they progress through the game, the player will hone several different ESD competencies (Quality Assurance Agency for Higher Education, Advance HE 2021) as they gain a better understanding of the relevant SDGs (United Nations Department of Economic and Social Affairs 2022) and subject material so that they can participate in a classroom discussion upon the game’s completion.

To achieve this, the game is broken down into two distinct, alternating phases. Each contains its distinct game mechanic. The first is the questing mechanic that occurs in the ‘non-drought’ period of the game. Players will have the opportunity to either accept or decline quests provided to them by the village leader, Mr Trutta. These quests will influence how many relevant resources they’re able to gather during the non-drought phase of the game to then later be used during the drought phase. These quests also allow the player to involve other NPC members of the community. The more people they enlist the more resources they can gather in that period in addition to potentially triggering the game’s win condition. This feature of the game will encourage players to understand that there is power in local climate action. Moreover, it will subtly hone their self-awareness competency as they begin to see the impact they can have within the community at a local level and how this could translate into real-life actions.

The other mechanic is the resource management mechanic which occurs in the ‘drought’ phase. During the drought period of the game, players will be tasked with caring for the eggs within the village’s nursery. This nursery will contain an assortment of eggs with unique comfort thresholds based on their species. The goal of this section is to have the player manage and utilise their resources to ensure the highest number of eggs survive the unpredictable drought conditions. As players must be strategic with how they use their resources this feature will encourage them to develop their critical thinking competency.

## Gameplay Theme

The most prominent gameplay theme of the Winterbourne Babysitter can be seen through its use of visual novel-style elements to push forth the allegorical fantasy storyline. In addition to this, the game utilises themes surrounding urgency and the strength in numbers concept to further denote the ongoing concerns at a global scale of how climate change is rather quickly negatively impacting the biodiversity of chalk streams (Sarremejane et al. 2020; Sarremejane et al. 2021). By emphasising the importance of strength in numbers, players are introduced to the idea that by banding together at a local level, there is still an opportunity for them as individuals to rise to the call to action and positively impact their community.

## Game Structure

Winterbourne Babysitter is cyclical in nature. It moves between two distinct phases: drought and non-drought periods. This is in line with client requirements for a game with a clearly defined ending that’s able to present its message within 10-15 minutes of gameplay. The cyclical and simplistic narrative structure of the game allows the player to grasp the game’s core concepts over the limited gameplay duration. This is in line with what successful existing sustainability games like Crabby’s Reef (SeriousGeoGames Lab 2022) have done. Moreover, the variation in gameplay structure and pacing minimises player fatigue so that they’re more receptive to the game (Katsaliaki, Mustafee 2013).

The non-drought periods are an opportunity for the player to connect with the community and gather resources through a series of quests provided to them by the village leader, Mr Trutta. The quests will involve knitting blankets or making fans using environmentally friendly resources in reference to the responsible consumption and production SDG. To create more resources in the same period, players can speak to other NPC villagers to get a helping. However, all these quest actions come with a time cost; players must strategically decide how effectively utilise their resource-gathering time before the next drought arrives.

The drought period will have the player stationed within the village nursery. This is where they’ll spend the entire duration caring for the village eggs. Each egg has a comfort threshold wherein they have specific temperatures that when exceeded could result in them being too hot or too cold. This concept is designed in line with existing concerns about how chalk stream biodiversity might react to turbulent temperatures (Stubbington et al. 2017; Sarremejane et al. 2020; Sarremejane et al. 2021). The fragility of the eggs in the game signifies the underlying fears of researchers that some of these species’ eggs might not be able to adapt in time to ensure their survival, thus resulting in their extinction.

The player needs to use their resources to ensure the eggs remain at a comfortable temperature. Each species’ egg will have a different threshold and thus will react slightly differently to the ever-changing weather conditions. When an egg remains outside of its threshold for too long (i.e., 3 or more days) it will die. This is in reference to the life below water SDG wherein rising temperatures are a concern for certain aquatic species and in the case of chalk streams, the unpredictable temperatures are making it harder for the biodiversity to adapt quickly enough to ensure their survival.

The game increases in difficulty as time progresses, with each passing phase, the drought periods will become less predictable in when they occur, and they will also become more frequent and hotter. This is designed to represent the ongoing influence climate change has on existing real-world drought conditions, thus offering a critical perspective on how climate change is affecting chalk stream biodiversity. Moreover, the growing level of difficulty challenges the player’s ability to survive for multiple rounds within the game as a means of retaining their engagement with the game and its educational content.

## Distinctive Features

To successfully evoke a sense of concern and sadness (Freeman 2004; Schrader et al. 2017) in the player when they interact with the community, the game carefully places the responsibility for the community’s survival in the player's hands. The use of emotion within the game is to engage the player and get them to connect with the narrative’s characters to further strengthen the impact of the overall game. Eggs will represent their species and in the case that no egg of a specific species survives the drought period it was in then the game will dynamically respond to this and cause the ‘extinction’ of the species within the community. Thus, the player will no longer see that species amongst the rest of the community members again.

However, to ensure that the player doesn’t come away from the game feeling defeated, the game provides them with the opportunity to rely on the community for support through the questing mechanic. As mentioned previously, by reaching out to community members for help, players can gather a greater number of resources during a non-drought period than they would have if they’d done it on their own. The more resources a player gathers before the drought period, the more likely they are to ensure the survival of all the eggs. This in turn will evoke a desire for action within the player outside of the game and ultimately further develop their self-awareness competency.

Furthermore, once the player successfully recruits a set number of community members to aid them, they trigger the win condition. This further emphasises the importance of local climate action and of how a joint effort can translate to eventual efforts on a national and enterprise level. This is derived from additional client feedback on the game’s concept where through further consideration, as the target player group are university students, the game should look to equip them with an understanding of local climate action first like in Enercities (Paladin Studios 2021) before starting with more technical and complicated alternatives that might be beyond their reach.

## Important Assets

As Winterbourne Babysitter will move between two distinct periods, it will also utilise two different locations where the player will be based in. This will be the nursery and the workshop. Both scenes will be designed using ‘DungeonDraft’ (Megasploot 2022), a fantasy map creation tool so that its aesthetics are in line with the rest of the game’s fantasy elements.

Within the visual novel-inspired user interface (UI) for conversations and quest decisions, the game will utilise a 2D simplistic rendering of its characters i.e., the player (see Fig. 1) and Mr Trutta (see Fig. 2). These will come with an additional set of design variations that will be used as part of the conversation animations to provide a bit more variation to the game scene. For the moveable player character within the nursery scene so that they may interact with the eggs, a pixel art sprite sheet will be designed in Photoshop to complement the other UI elements.

A person wearing a garment

Description automatically generated with low confidence

Figure - Carl the Kobold's Design

Figure - Mr. Trutta's Design

The other UI elements will be designed with the fantasy theme in mind so that all the different aesthetic choices fit together cohesively.

With regards to music, the game will employ the use of audio tracks such as ‘River Town’ and ‘Hidden Valley’ from ‘Tabletop Audio’ (Tabletop Audio 2022) to further build upon the fantasy village’s ambience so that the player is immediately transported and immersed into the allegorical fantasy world as soon as they hit play.

## Reward and Scoring Mechanism

During the non-drought phase of the game, the player needs to gather resources within the limited time available to them. In the early stages of the game, the non-drought phase will be much longer, roughly spanning 16 to 20 in-game days. This is to allow the player enough time to gather these resources on their own. As seen in the figure below, a player can make a single fan in 6 in-game days or a single blanket in 3 in-game days. After the first drought phase is completed, the player unlocks the ability to recruit other villagers to aid them in their mission. For every additional recruit a player gets, they can make an additional item during that time frame (i.e., 2 recruits and a player will be able to make 3 fans in 6 in-game days).

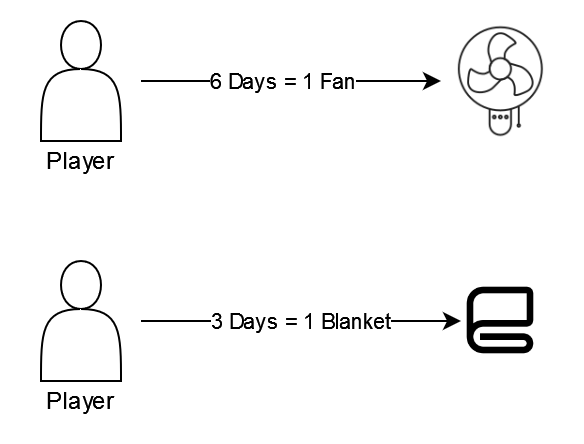


Figure - Diagram detailing the time cost for each resource

Each egg a player is tasked with caring for over the drought period represents the future of its species. In the case a player is unsuccessful in maintaining the comfort threshold of an egg within its boundaries, the egg will die, thus, resulting in the specific species ceasing to exist in the community. For every egg that a player successfully cares for up until the end of the drought period, this will increase the chances of them having more than one egg of a particular species to care for in the next drought period. More eggs of different varieties signify a thriving community that the player has been responsible for. The lose condition occurs when the player fails to protect the eggs during the drought phases thus causing a mass extinction of all the different species living there.

To improve their chances of protecting all the eggs, the player can attempt to recruit additional aid to acquire more resources. However, recruiting helpers will not be a simple process, especially when a player has recently lost an egg during the drought period. Their persuasiveness will depend on how successful they’ve been in safeguarding eggs during the most recent drought. The probability of recruitment success will be calculated based on the ratio of how many eggs survived with the overall number of eggs present at the beginning of the drought.

In addition to the above, recruiting villagers can potentially unlock the game’s subtle win condition that’s designed to highlight the importance of the climate action SDG. Players will need to have recruited a total of 5 helpers over the course of the game to trigger the win condition wherein Mr Trutta will inform the player that the community’s efforts in protecting the eggs have gone viral and external researchers and engineers are looking to help by building them a new and improved nursery that’s adaptable to ongoing drought conditions.

The final challenge, however, is that this takes time; approximately 2 alternating cycles. Thus, to successfully protect the community and win the game, the player must survive two more drought phases once they’ve unlocked the win condition. This creates a high-level rewards mechanism wherein the case a player successfully saves more eggs, they increase their likelihood of recruiting additional aid which ultimately results in an overall heightened chance of them successfully saving the entire village by triggering the win condition (Whittaker et al. 2021).

## Control Mechanism

Winterbourne Babysitter is controlled via a ‘point and click’ navigation and interaction system using a mouse.

## Interface Mechanism

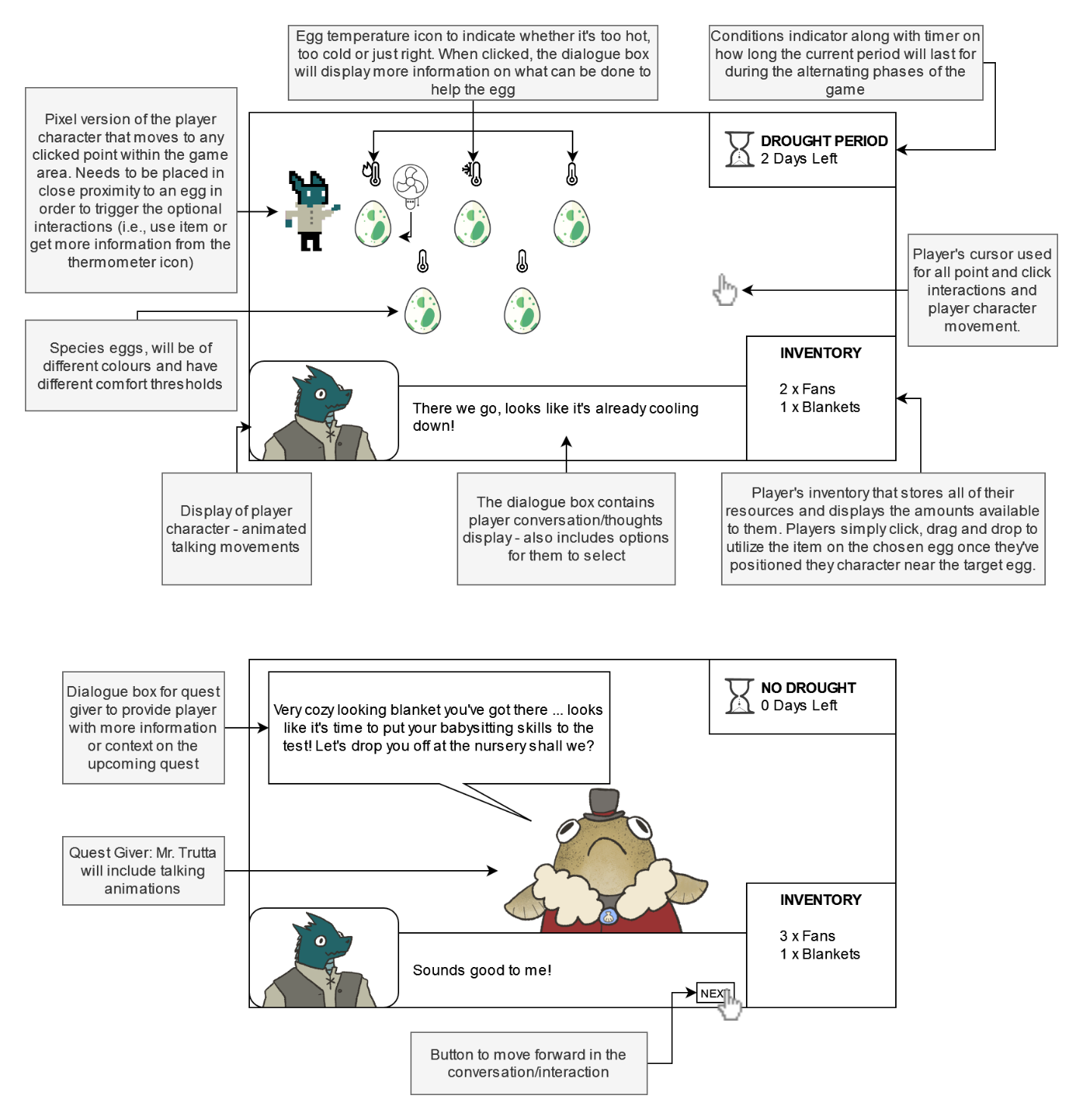
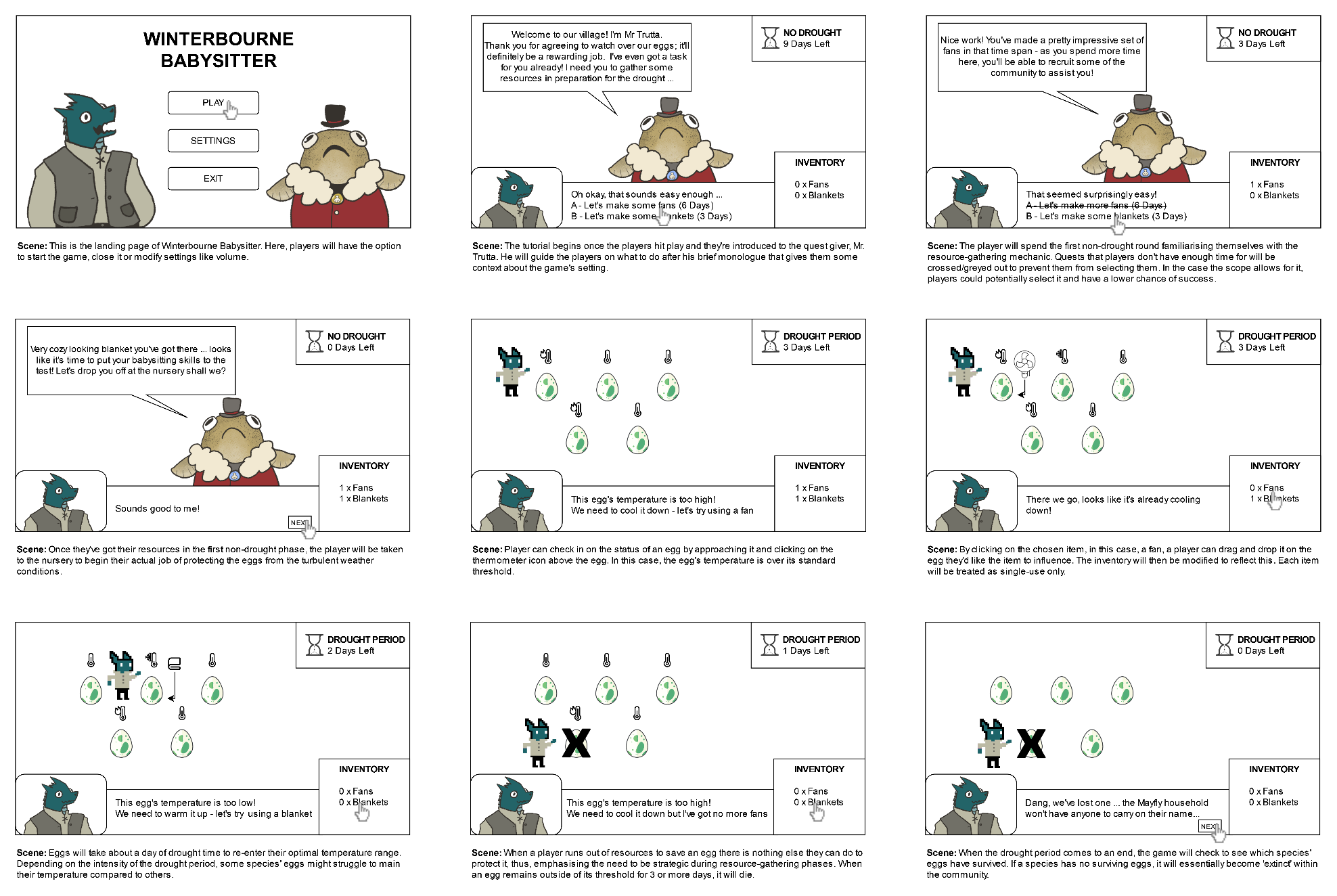
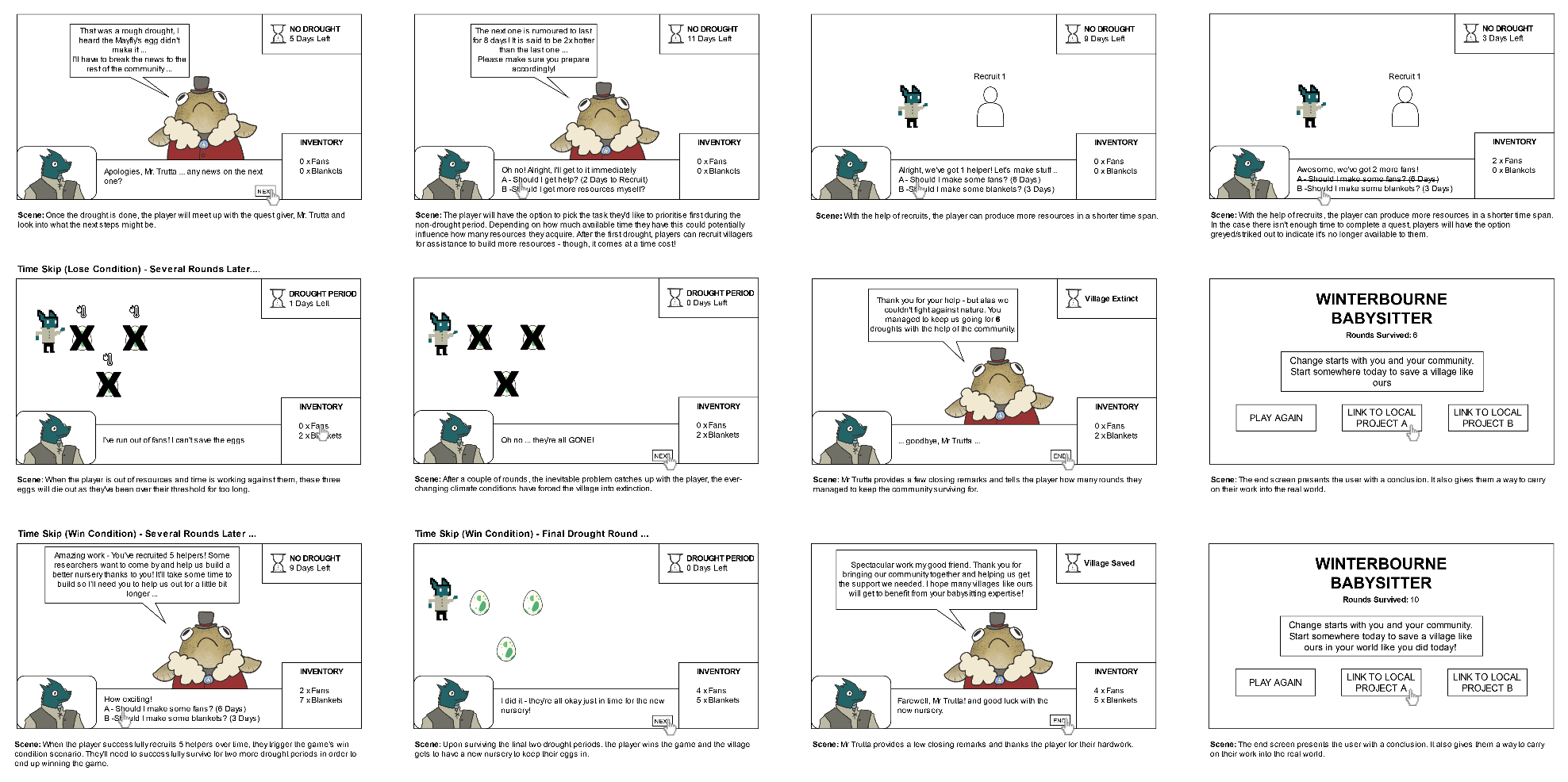


Figure - Interface breakdown of different screens based on the two distinct periods of the game

# Storyboard





# References

Alyaz, Y., Spaniel-Weise, D., Gursoy, E., 2017. A Study on Using Serious Games in Teaching German as a Foreign Language. *Journal of Education and Learning*, 6(3), pp.250–264. 10.5539/jel.v6n3p250.

Chittaro, L., Buttussi, F., 2015. Assessing Knowledge Retention of an Immersive Serious Game vs. a Traditional Education Method in Aviation Safety; Assessing Knowledge Retention of an Immersive Serious Game vs. a Traditional Education Method in Aviation Safety [online]. *IEEE Transactions on Visualization and Computer Graphics*, 21. Available at: http://www.ieee.org/publications\_standards/publications/rights/index.html.

Coblindor, 2021. Coblis — Color Blindness Simulator [online]. Available at: https://www.color-blindness.com/coblis-color-blindness-simulator/ [Accessed 12 December 2022].

Dernbach, J.C., Cheever, F., 2015. Sustainable Development and Its Discontents [online]. *Transnational Environmental Law*, 4(2), pp.247–287. Available at: https://doi.org/10.1017/S2047102515000163.

Down, L., 2006. Addressing the challenges of mainstreaming education for sustainable development in higher education. *International Journal of Sustainability in Higher Education*, 7(4), pp.390–399. 10.1108/14676370610702190/FULL/PDF.

Freeman, D., 2004. Creating emotion in games [online]. *Computers in Entertainment (CIE)*, 2(3), pp.15–15. Available at: https://dl.acm.org/doi/10.1145/1027154.1027179 [Accessed 14 December 2022].

Game Accessibility Guidelines, 2022. Include interactive tutorials [online]. Available at: https://gameaccessibilityguidelines.com/include-tutorials/ [Accessed 12 December 2022].

Hampshire & Isle of Wight Wildlife Trust, 2021. All Change: The Climate and our Chalk Streams [online]. Available at: https://www.hiwwt.org.uk/blog/hiwwt/all-change-climate-and-our-chalk-streams [Accessed 10 December 2022].

Hannig, A. et al., 2012. EMedOffice: A web-based collaborative serious game for teaching optimal design of a medical practice [online]. *BMC Medical Education*, 12(1), pp.1–15. Available at: https://bmcmededuc.biomedcentral.com/articles/10.1186/1472-6920-12-104 [Accessed 27 November 2022].

Katsaliaki, K., Mustafee, N., 2013. Serious Games for Sustainable Development [online]. *http://dx.doi.org.ntu.idm.oclc.org/10.1177/1052562913509219*, 37(6), pp.889–894. Available at: https://journals-sagepub-com.ntu.idm.oclc.org/doi/10.1177/1052562913509219 [Accessed 14 December 2022].

Megasploot, 2022. Dungeondraft [online]. Available at: https://dungeondraft.net/ [Accessed 8 December 2022].

National Learning Network, *NLN Guidelines* [online]. Available at: http://ncam.wgbh.org/richmedia/showcase.html].

Nottingham Trent University, 2022. Green Academy Team [online]. Available at: https://www.ntu.ac.uk/about-us/strategy/sustainability/sustainability-in-curriculum/meet-the-team [Accessed 29 November 2022].

Paladin Studios, 2021. Enercities - Paladin Studios [online]. Available at: https://paladinstudios.com/enercities/ [Accessed 14 December 2022].

Papastergiou, M., 2009. Digital Game-Based Learning in high school Computer Science education: Impact on educational effectiveness and student motivation. *Computers & Education*, 52(1), pp.1–12. 10.1016/J.COMPEDU.2008.06.004.

Peña Miguel, N., Corral Lage, J., Mata Galindez, A., 2020. Assessment of the Development of Professional Skills in University Students: Sustainability and Serious Games [online]. *Sustainability*. Available at: www.mdpi.com/journal/sustainability.

Quality Assurance Agency for Higher Education, Advance HE, 2021. *Education for Sustainable Development Guidance*.

Rossano, V., Roselli, T., Calvano, G., 2017. A serious game to promote environmental attitude [online]. *Smart Innovation, Systems and Technologies*, 75, pp.48–55. Available at: https://link.springer.com/chapter/10.1007/978-3-319-59451-4\_5 [Accessed 27 November 2022].

Sandbrook, C., Adams, W.M., Monteferri, B., 2014. Digital Games and Biodiversity Conservation [online]. Available at: https://conbio.onlinelibrary.wiley.com/doi/10.1111/conl.12113.

Sarremejane, R. et al., 2020. Local and regional drivers influence how aquatic community diversity, resistance and resilience vary in response to drying [online]. *OIKOS*, 129(12), pp.1877–1890. Available at: www.oikosjournal.org.

Sarremejane, R. et al., 2021. Drought effects on invertebrate metapopulation dynamics and quasi-extinction risk in an intermittent river network [online]. *Global Change Biology*, 27(17), pp.4024–4039. Available at: https://onlinelibrary.wiley.com/doi/10.1111/gcb.15720.

Schrader, C. et al., 2017. Rising to the challenge: An emotion-driven approach toward adaptive serious games. In: *Serious Games and Edutainment Applications: Volume II*. Springer International Publishing, 2017, pp. 3–28. 10.1007/978-3-319-51645-5\_1.

Serious Brothers, 2022. Imagine Earth - Planetary Colonization [online]. Available at: https://www.imagineearth.info/ [Accessed 27 November 2022].

SeriousGeoGames Lab, 2022. Crabby’s Reef – Gaming for the Earth [online]. Available at: https://seriousgeogames.wpcomstaging.com/activities/crabbysreef/ [Accessed 27 November 2022].

Stubbington, R. et al., 2017. Temporary streams in temperate zones: recognizing, monitoring and restoring transitional aquatic-terrestrial ecosystems [online]. *WIREs Water*, 4, p.1223. Available at: https://wires.onlinelibrary.wiley.com/doi/10.1002/wat2.1223.

Tabletop Audio, 2022. Ambiences and Music for Tabletop Role Playing Games [online]. Available at: https://tabletopaudio.com/ [Accessed 28 November 2022].

The Conversation, 2022. Chalk streams: why ‘England’s rainforests’ are so rare and precious [online]. Available at: https://theconversation.com/chalk-streams-why-englands-rainforests-are-so-rare-and-precious-172827 [Accessed 10 December 2022].

Tsopra, R. et al., 2020. AntibioGame®: A serious game for teaching medical students about antibiotic use. *International Journal of Medical Informatics*, 136. 10.1016/J.IJMEDINF.2020.104074.

Ullah, M. et al., 2022. Serious Games in Science Education. A Systematic Literature Review. *Virtual Reality and Intelligent Hardware*, 4(3), pp.189–209. 10.1016/J.VRIH.2022.02.001.

United Nations Department of Economic and Social Affairs, 2022. THE 17 GOALS | Sustainable Development [online]. Available at: https://sdgs.un.org/goals [Accessed 29 November 2022].

Web Content Accessibility Guidelines (WCAG), 2022. Web Content Accessibility Guidelines [online]. Available at: https://wcag.com/ [Accessed 12 December 2022].

Whittaker, L., Russell-Bennett, R., Mulcahy, R., 2021. Reward-based or meaningful gaming? A field study on game mechanics and serious games for sustainability [online]. *Psychology & Marketing*, 38(6), pp.981–1000. Available at: https://onlinelibrary.wiley.com/doi/full/10.1002/mar.21476 [Accessed 14 December 2022].