Virtual Gardening: Identifying Problems and Potential Directions for ‘Ecological Awareness’ Through Soil Management and Plant Recognition Gaming

Introduction

Though perhaps not immediately obvious, and even seemingly contradictory to the context in which they are played, gardening and farming are relatively common themes for videogames. *Farmville* (Zynga, 2009), *Stardew Valley* (ConcernedApe, 2016) and *Caesar III* (Impressions Games, 1998) are examples of successful games with a prominent theme of what is perceived as nature-related gameplay. From farming and life simulators to wilderness survival games to plant and animal management games, different variants of games that construct a relationality between human player and virtual biosphere are increasingly available to players. Nevertheless, it is extremely rare that video games take an approach that is beneficial for environmental education. As noted by Alenda Chang, video games “exert an important influence on how millions of players conceptualize country life, food production, and right relations between humans, animals, and the environment. Contemporary farm games represent an array of missed opportunities to model more meaningful game ecologies” (Chang, 2012, p.251). With this in mind, we can wonder whether or not games could be efficient tools for environmental education.

‘Ecological awareness’ includes a focus on plants, animals or the landscape, and can be considered more specific than ‘environment awareness’ which includes climate change and ecology on a global scale. Following Chandler and Swartzentruber (Chandler and Swartzentruber, 2011) as well as Fisman (Fisman, 2005), this awareness can then be defined as a person’s ecological knowledge and their awareness of the form and features of their local environment. Plant blindness, a specific issue, related to the human-centric lack of ecological awareness, could be a particularly interesting issue to address in a video game. Wandersee and Schussler, define plant blindness as “the inability to see or notice the plants in one’s own environment—leading to: (a) the inability to recognize the importance of plants in the biosphere, and in human affairs; (b) the inability to appreciate the aesthetic and unique biological features of the life forms belonging to the Plant Kingdom; and (c) the misguided, anthropocentric ranking of plants as inferior to animals, leading to the erroneous conclusion that they are unworthy of human consideration” (Wandersee and Schussler, 2001).

Decreasing plant blindness to increase ecological awareness has shown to be a topic of particular interest for The Eden Project, which is an educational charity focused on environmental sustainability. They began their activities in 2000, when they completed the restoration of an abandoned Cornish clay pit into a botanical garden. They brought thousands of plants from all over the world and planted them in monumental plastic domes simulating their natural habitats. They also have a

roster of other activities across the world to raise awareness about environmental issues.
As part of this pilot study, it was proposed that we develop, with their assistance, an experimental video game and evaluate its impact after playtest. Our main objective was to start exploring whether a gardening mobile game could meaningfully promote ecological awareness and how. We were specifically trying to increase ecological awareness and we limited the natural elements present in this experiment to flora, soil, and water resources.

Development of *Tevi* was also made possible thanks to the Pl@ntnet research project (Goëau et al., 2013), which granted us access to their API for the plant-recognizing mechanics of the game. The research project was consequently created with a mixed-method (Lieberoth and Roepstorff, 2015), where research-creation provided insight into the creation process and intents, while the playtest allowed for analysis of player reception of the prototype. To explore our research question – whether a gardening mobile game could meaningfully promote ecological awareness and how – in this paper, we begin by undertaking a review of relevant games and literature. Secondly, we present the prototype created using a research-creation methodology to illustrate the hypothesis. The effects of this prototype are then studied through the analysis of a survey. This paper is concluded with a discussion on the limits and benefits of such an approach.

Games for purpose, learning and ecological awareness

The idea of using games to change or influence behaviour is not a new one and the act of play has long been identified by biologists and psychologists as a healthy mode of learning (Bateson and Martin, 2013) In recent years there has been a growing interest in exploring uses for games beyond pure entertainment, including for learning, variously termed ‘educational games’, ‘games for learning’ and ‘serious games’ (Boyle et al., 2016). Interrelated to this, an intersection of environmentally conscious ‘eco-media’ with video games, sometimes termed ‘green games’, has developed as some academics and game creators explore the function and utility of games in our understanding of the natural environment (Chang and Parham, 2017).

In 2016, Boyle et al. conducted a meta-study of papers that demonstrated empirical evidence of the learning impacts of playing games, focusing specifically on papers about ‘serious games’ and ‘games for learning’ which they identified as being used synonymously within the literature (Boyle et al., 2016). Their study drew on research from the disciplines of social science, science, education, and engineering, and focused on 143 papers deemed to be the highest quality from an initial sample of 7117. They concluded that, in general, serious games tended to perform better for knowledge acquisition than the control condition. Similar findings were reported by another meta-analysis conducted by Backlund and Hendrix (Backlund and Hendrix, 2013).

Among some of their more specific findings, Boyle et al. found simulations to be the most represented genre among their studied sample of learning games. This should not be surprising as simulations have a long history of use in teaching and training across many disciplines (Arnseth, 2006). Simulations afford learning by allowing the

user to interact experimentally and playfully with the simulated system. They may also aid the understanding of a complex system by presenting the user with a simplified version (Bogost, 2006). Digital simulations particularly can capitalise on these affordances, granting the ability to modulate the users' interaction in ways that would not be possible in other media, for example, by adjusting the speed of the simulation (Bogost, 2006, p.95).

In his book *Unit Operations*, Ian Bogost discusses simulations at length and highlights cellular automata as being of particular use in the simulation of natural systems. Cellular automata are systems created by a series of rules relating to cells on a grid. Each cell follows the same simple rule set to work out if it is 'alive' or 'dead'. Despite the simplicity of the set-up, cellular automata have been shown to exhibit tremendous complexity of emergent behaviour and produce outputs that can mirror those seen in evolutionary design, for example, the behaviour of simple lifeforms. Cellular automata, in computer science, are defined as "mathematical idealizations of physical systems in which space and time are discrete, and physical quantities take on a finite set of discrete values." (Wolfram, 1983, p.1). Cellular automata, therefore, can provide an excellent basis for simulations about the biosphere and in particular, observing the complex results of simple rules interacting over time (Bogost, 2006).

Many, if not all, games contain some element of simulation, a metaphorical mapping between the system described by rules and the presentation of that system to represent something. Philosopher Alfred Korzybski famously remarked that the "map is *not* the territory" (Korzybski, 1958). So too can simulations in games not reach the same level of complexity as the systems they seek to represent. When deciding how to represent something, designers can include, exclude, exaggerate, or minimise various elements. This allows space for rhetoric to be constructed to advance a particular argument. Bogost coined the term 'procedural rhetoric' for designing a system in this way (Bogost, 2010). The use of games to advance arguments has already achieved some success with what Bogost's terms 'advergames' (Bogost, 2010) and the 'newsgames' of Gonzalo Frasca (Newsgaming.com, no date).

A further tactic that games can employ that has been shown to have a significant positive effect on learning is termed 'tangential learning' (Mozelius, Fagerström and Söderquist, 2017). Coined by Floyd and Portnow (Floyd, 2008), tangential learning refers to users continuing to seek information on a topic after having been exposed to it within an engaging, often fun, context. One of the clearest examples of this style of learning would be players becoming interested in various historical periods after playing *Civilization* games, for instance, *Civilization II* (Microprose, 1996). The in-game encyclopedia or 'civilopedia' in the *Civilization* games prefigured Floyd and Portnow's advice to capitalise on the players' self-directed learning by including an encyclopedia within the game or internet links to other sources of information that can but do not have to be accessed during gameplay.

It is these affordances that lead Smith to claim that games could be the "ideal media for 'green' or environmental thinking since the player is consistently expected to manipulate their environment."(Smith, 2017, p.105). However, as he points out, the procedural rhetoric of many grid-based management games "encode a set of narratives in which nature is the location of resources to be extracted and

used."(p.103). Similarly, in the inherently grid-based cellular automata, we can see the dividing up of the perceived natural world into discrete units of function in a highly mechanised vision of organic life. Despite these and similar concerns, however, Alenda Chang and John Parham share Smith's optimism that green games could expand players' ecological understanding and awareness, or even move them to acts of environmental responsibility (Chang and Parham, 2017).

In one of the few available studies on what they call 'nature awareness' (a term that unfortunately reinforces the false nature/human culture divide), Chandler and Schwartzentruber (Chandler and Swartzentruber, 2011) define three types of 'nature experiences' within a teaching context: direct, as in a walk in a forest; indirect, for example visiting the zoo; and vicarious, which includes computer games, books, and film. They show that students with higher incidences of these nature experiences (and by definition, therefore, higher nature awareness) show a significant increase in science understanding as measured by science grades. The proposed method for this relationship is "backward-reaching high road transfer" (Salomon and Perkins, 1989), where learners formulate an abstraction for use in a current task by the use of past knowledge and experience. These findings are supported by Wandersee & Schussler, who cite specific education coupled with a variety of "personal, guided, direct experiences with growing plants" (Wandersee and Schussler, 2001) as being perhaps the best way to overcome plant blindness. They add that capturing *one's "botanical sense of place" (p. 7*) via photography of plants helps to recall prior knowledge of plants, which can be used to conceptually support the learning of new knowledge in a method highly reminiscent of backward-reaching high road transfer.

In light of this research, the creation of a video game was proposed that would utilise elements of simulation, cellular automata, procedural rhetoric, and photography in an attempt to increase players' ecological awareness and reduce plant blindness.

***Tevi*: A Proposed Solution**

The prototype for the garden management video game for mobile devices, *Tevi,* was developed over nine months, using a research-creation methodology. This methodology is used by artist-researchers trying to answer and share their results on a research question through creation (Bruneau and Villeneuve, 2007, p. 34). A large focus is made on "autopoïetics", the study of the creation process by the creators themselves, based not only on memory but also on creation documents - in this case game design documents, meeting reports, screenshots and videos of early prototypes, etc. - that should be archived (Le Coguiec, 2007, p. 308).The team experimented using procedural content generation (PCG) for the creation and representation of ecological elements and their evolution in real-time 3D as it was considered an interesting tool for this purpose. A user study was planned to analyse the impact of the prototype.

In *Tevi,* players are asked to sustain and take care of a garden on Mars. They are provided with seeds to plant on a five by five grid of soil tiles, and, as the seeds grow into plants, players support them by either watering or providing nutrients to the soil tiles they are planted on (Figure 1). Players can also use their devices' cameras to

take pictures of real plants. Doing so, thanks to access to the Pl@ntnet API, will provide players with a name and basic info on the plant photographed, as well as reward them with some in-game items.

*Figure SEQ Figure * ARABIC 1: Tevi Main screen*

In order to better convey the players' experience, we will describe how each of the core mechanics appear in the game.

In order to simulate a botanical growth process, the behaviour of each plant is simulated using a model based on cellular automata concepts and by using data provided by botanists at the Eden project. For each plant, the game checks their resource consumption, if their soil has too much water or nutrients, and how many neighbouring plants they have. It also simulates their fruit production cycles, life cycles (how many times they can produce fruit before dying), and how many offspring it spawns in its own and adjacent soil tiles. The game simulates five plants: Banana Plants, Shampoo Ginger, Breadfruit, Sugarcane, and Wild Indigo[1]. This creates a sprawling, autonomously developing garden with plants growing, flowering, fruiting, dying, and leaving seedlings to begin the cycle again. If players fail to add water and nutrients, the ecosystem keeps going until all resources from all tiles run out, and nothing can grow anymore until players start feeding and watering the soil again (Figure 2).

[1] Respectively Musa species, Zingiber zerumbet, Artocarpus altilis, Saccharum officinarum and Tephrosia purpurea.

*Figure SEQ Figure * ARABIC 2: Different stages of garden development. The last one is a completely dead garden.*

Other than the two soil resources already mentioned, each plant also produces certain ratios of resources. These resources are directly borrowed from the story of the canoe plants (Anderson-Fung and Maly, 2002, p.20), the collection of plants that, it is believed, Polynesian people brought with them when colonising Hawaii. This is a selection of 26 plants they judged sufficient to sustain a new human community, plants that would provide the five resources considered essential for a civilization: food, fuel, construction, medicine, and culture (Figure 3). The game continually calculates the ratios of production for each of these resources based on the plants currently present in the garden. This system was expected to help players interpret their garden as an evolving ecological system without accumulating resources.

*Figure SEQ Figure * ARABIC 3: UI showing the garden resources ratios*

The Pl@ntnet tool uses a mix of citizen science and machine learning techniques to identify a plant when given a picture of it. Building on techniques popularised by AR games such as *Pokémon Go*, Tevi allows players to bring up the Pl@ntnet menu at any time during gameplay, which accesses the device's camera and allows players to take pictures. If a plant is recognised in said picture, the player is provided with the scientific and common name of the plant, as well as an accuracy rating of the API prediction, and finally, a link to the Wikipedia page of the plant. The photo is then stored in the player's in-game plant gallery. Players are rewarded for their contribution with water, fertiliser, or new seeds to plant (Figure 4).

*Figure SEQ Figure * ARABIC 4: Pl@ntnet menu of the game*

Finally, the game delivers a tutorial and some narrative context, through quests, that also reward them with seeds and soil resources when completed (Figure 5).

*Figure SEQ Figure * ARABIC 5: Quests*

Design process and game development

A research-creation methodology was used. Taken from the field of the arts (Gosselin and Coguiec, 2006), research-creation studies the process of the creation of a work from within, based on the authors' log books and work documents. With this methodology, the reflective study of design is conducted by the designers of the artistic work themselves. In the case of the research presented here, the research-creation was conducted by the three designers of the games authoring this paper: Edwige Lelièvre, Giovanni Rubino, and Tim Phillips, from the MetaMakers Institute at Falmouth University.

A researcher external to the creation process, Rory Summerley, was also involved in analysing the results and writing this paper for the sake of critical distance from the project.

Tevi was developed in nine months in Unity 3D, with graphic and audio assets created in external software. *Tevi* was developed The team built on their experience of promoting engagement with national heritage sites through games and the richness of Cornwall's natural landscape to start the project with the explicit intention of creating a digital game able to contribute to the valorisation of Cornish natural heritage sites. This made collaboration with the Eden Project an obvious first step. From an initial conversation with Eden it arose that the demographic they had the most trouble reaching were young adults (defined by Eden as 18 – 25 years old) who are not necessarily already interested in ecological awareness and sustainability. Video games were identified as a possible entrance point to reach them, focusing

specifically on successful mobile games (for accessibility and immediacy purposes) (Google, 2019). The design of *Tevi* was therefore inspired by games that the team identified as popular with young adults and mechanically compatible with sustainability themes. Specifically *Clash of Clans (Supercell, 2012)*, *Animal Crossing: Pocket Camp (Nintendo EPD and NDCube, 2017)*, and *Pokémon GO (Niantic, 2016)*.

As part of the preliminary design process, research was undertaken into what are generally recognised as challenges in nurturing ecological awareness. Tackling plant blindness was identified by the Eden Project as being particularly important among these challenges. As a result, the team resolved to find ways to make plants the central focus of *Tevi*. The advisors also identified the need to simulate and educate about sustainable gardening. This incurred a set of problems related to common approaches in management games: namely a game economy that was capitalistic and exploitative in values (Dyer-Witheford and Peuter, 2009) and focused on getting the higher numbers possible, be it in resources, scores, or game objects. These approaches were found to conflict with ideas of sustainable gardening (Smith, 2017, p.107).

Equipped with this knowledge, a team of Falmouth University's Games Academy researchers and staff was assembled to lead a discussion on designing a game addressing the requirements and early inspirations of the project. The team quickly agreed that the best way to encourage direct contact with plants would be to have said contact be essential for gameplay and achieving the objectives of the game. For this purpose, they identified plant-recognition technology as a possibly useful tool.

The team also agreed that principles of cellular automata algorithms could be used to simulate the growth and spread of plants. Through cellular automation, the value of each tile is influenced over time by the values of neighbouring tiles. In *Tevi*, as we've discussed, plants are simulated individually, and the result of their simulation affects neighbouring tiles.

Finally, the team settled for a science fiction theme for the game's narrative, involving an attempt at escaping Earth's crumbling environment by building gardens on Mars protected by domes similar to the ones found at the Eden Project. The team also discussed the possibilities of introducing some cooperative multiplayer elements by including competing factions each player can join, visiting other players' gardens, and planning real live events connected to the game at the Eden Project.

Prototype user experience playtest at the Eden Project

As a part of the research project and partnership, the team was invited to present the project from the 16th of February to the 23rd of February 2019 at the Eden Project. This was the week of the holiday winter break in the UK, a period used mainly by families to visit the site. The Eden Project is a charity and popular destination that attracts more than a million visitors each year (ALVA, 2018), who are mainly families, according to Eden Project's advisors. The project was presented in a room called "The Lab", situated in the "Core" building, dedicated to science and art mediation.

At the Eden Project, visitors are encouraged to see a lot of plants, both local and from other parts of the world. Strong interactions with plants, like touching plants or taking leaves, are discouraged for practical and botanical reasons (diseases spread, harming plants, etc.) Gardening is not currently a part of the Eden project mediation of the botanical world. The visitors can take pictures freely both in Eden Project's gardens and biomes. Plant identification is encouraged through labels next to most plants, guided tours, and occasional non-digital games for children.

The study of *Tevi* reception and user experience (UX) at the Eden Project was the first public presentation of the prototype. This event was designed to help the researchers of the team to test their hypothesis, get feedback on the game design, as well as to test its technical aspects. Because the game was still a prototype, it was not finished or completely polished and was presented as a scientific experiment to the players. "The Lab" has been designed to show researchers at work – the team consequently used their time there not only to conduct a survey but also to improve the game, which was updated several times during the week.

UX research methodology

The purpose of the UX research was to explore the primary research hypothesis of whether users learned new ecological knowledge through playing *Tevi.* A user experience survey was created as part of the game design process, and it was expected that the pilot testplay would have a relatively small sample size both in terms of the number of users and in terms of duration, as it was likely that the players could only be asked to play and respond to the survey once.

The survey was done on paper. It included twelve visual analogue scales (VAS, also called graphic rating scales or unipolar line scale) and four open questions (Figure 6). We have chosen VAS as this measure is particularly exact and easy to understand for participants. As described by Daly-Jones, the VAS used in this study is standard. It "consists of a line between two extremes, in the current study between 'Not at all', on the left and 'Very' on the right. Participants were asked to make a mark on the line, which could include the extremes" (Daly-Jones et al., 1997).

*Figure SEQ Figure * ARABIC 6: Questions of the survey*

The graphical scale questions can be divided into two sets: general and technical questions on the game (Q1, Q2, Q3, Q8, Q9, Q10, and Q11) and questions on ecological awareness in the game (Q4, Q5, Q6, Q7, and Q12). Both sets were designed to avoid leading the responders, following the recommendations of Singly (Singly, 2012). It was particularly important to allow the responders to freely answer the open questions at the end of the survey: Q13, Q14, Q15, and Q16. It was decided to leave the open questions at the end of the survey to avoid discouraging the responders from answering previous questions, as open questions could be more intimidating and take more time. All of these forms of data can be considered subjective measures, according to Landers and Bauer (Landers and Bauer, 2015, p.151). In addition to these questions, the date of the survey was gathered, which was important as the game changed during the week, as well as personal but not identifying information (age and gender). Twenty-four visitors participated in this study. They were aged from 6 to 54, with seven children and seventeen adults, eleven women and thirteen men.

The right to use survey methods on children was only granted from the 19th of February onwards. The children completed the survey with the help and agreement of their parents. Completing the study took about ten minutes and was done after a *Tevi* playtest of various durations inside The Lab, mostly on the mobile smart devices provided by the team, but also sometimes on the players' own devices. In addition to playing, some players in the sample set received an oral presentation of the game by the project team or Eden's mediators. There was a video trailer explaining the gameplay displayed in the Lab. All the responders also received an oral and written explanation of the purpose of the survey.

After arriving, the team was told by Eden mediators that the Lab is generally visited at the end of most visitor's experience, after the two biomes and the garden. The team's experience was consistent with that expectation, as the number of visitors increased greatly after noon every day. As a result, we believe that the players in our sample set already visited a large part of the Eden Project before testing the game.

For this reason, the last open question (Q16) was no longer of use to the survey as none of the responders tested the game in the biomes before coming to the Lab. If they did go afterwards to play the game in the biomes, unfortunately they did not come back to the Lab to answer the survey.

Playtest user experience results and analysis

The game had an overall slight positive appreciation (6.7/10 average on Q1), which increased over the week (Figure 7). This could be explained by the improvements that were implemented into the prototype across the week (bug fixes that notably allowed players to take pictures).

*Figure SEQ Figure * ARABIC 7: Game enjoyment for each responder, ordered by date*

The average opinion of the seven children was higher than the global score (average 8.5/10), and their rating was very consistent, which was not the case for adults. The relatively small size of the sample makes it difficult to conclude that the game is appreciated more so by children, but its enjoyment by children is also consistent with observations during the week. It is nevertheless interesting to note that some adults enjoyed it as much as the children, and that the need for reading, which required adult supervision, did not prevent children from appreciating the game.

The general appreciation of the game (Q1) is correlated with pride in one's garden (Q4), taking pictures in the game (Q8), and interest in replaying the game (Q10) (above 7). Contrasting this, ease of playing the game (Q2), and understanding of the plant's growth process (Q12) have a low correlation with the general appreciation of the game (below 4). The high correlation (7.37) between Q1 and Q10 seems to indicate a consistent behaviour. The low correlation between Q1 and Q2 probably indicated either a disconnection between the game accessibility and how fun it was perceived or players' understanding of the fact that it was a prototype with its technical limitations.

The pleasure of taking pictures in the game (Q8) shows the highest correlation with the general enjoyment of the game (7.4). The plant recognition system through picture taking was not working properly on the first days of the survey. The score for

Q1 and Q8 for each responder, except for the three participants that did not answer Q8, is illustrated in Figure 8.

*Figure SEQ Figure * ARABIC 8: Correlation between picture-taking and game enjoyment*

The high correlation leads us to speculate if there is a causal relationship between this feature and the game enjoyment, despite the small size of the sample. The open questions Q13 and Q14 seem to indicate that, at the very least, taking pictures in the game played an important role for some users. Indeed, seven of them noted “taking pictures” as one of the aspects they liked the most in the game. Also, five responders noted that their difficulties with the camera or their inability to take pictures were one of the things they liked the least about the game. From the development team point of view, the plant recognition system through picture taking was the most innovative feature of the game. However, its link with the game was not very tight, as the game was designed to not rely on this feature. In fact, initially during the development phase, the *Tevi* team was afraid of not being able to integrate Pl@ntnet properly due to technical and legal reasons. The users in this inital playtest considered this feature one of the most interesting, regardless.

Game enjoyment

Q4 asked users if they felt proud of their garden. This relatively high correlation with game enjoyment (Figure 9) could indicate that the users who appreciated the game also felt some pride in their garden.

*Figure SEQ Figure * ARABIC 9: Correlation between garden pride and game enjoyment*

No one mentioned the state of their garden directly as something they particularly appreciated in the open question Q13. Rather, they appreciated the process of growth, which can be seen in the following comments by respondents:

> “Doing something to make things progress/grow.”
>
> “Watching the plant grow.”
>
> “Planting the seeds”

Futhermore, several respondents mentioned the unhealthy state of their garden and their inability to make it better as something they liked the least in Q14:

> “No success, despite watering and fertilizing. No visible sign that watering or fertilising is done. Everything dies no matter what I do.”
>
> “I didn't get much fertiliser & watering cans, meaning my plants kept dying :(”

These responses indicate that *Tevi’s* virtual garden was considered as a place for the action of cultivating plant life rather than just a space to decorate a virtual space. If the virtual gardening offered by the game was considered to be interesting by some players, it seems that understanding of the growth process played no part in it. The correlation between Q1 and Q12 is unusually low (2.79), which throws into question the pedagogical potential of the game and the use of cellular automata to simulate a growth process.

These conclusions should also be considered preliminary given the sample size of our survey as well as the specific context of this playtest. It is likely that the users in our study were already interested and sensitive to plants, at the very least, due to their apparent desire to visit the Eden project. In addition, the sample size of our survey limits our ability to make final conclusions. However, this study still points us towards several interesting directions in user experience: the importance of taking

pictures of real plants within a gardening game, the possibility of addressing a broader audience than the initial target demographic, the interest of virtual gardening, and the pedagogical limitations of the prototype.

Discussion

Although the original goal was to design a game for smart device platforms that would promote short-term ecological awareness and prevent plant blindness in young adults, the user experience results from the play test indicate that *Tevi* did not achieve this goal. As a result, the development team conducted further research to understand the myriad of reasons why *Tevi* did not produce the expected results and to open up several directions for future development of the game.

Managing Contradicting Rhetorics and Player Expectations

Woolbright (Woolbright, 2017) has noted the difficulties of communicating eco-positive messages through critiques of several games. One risk is that players may perceive a sanctimoniously preachy or doom-laden tone about ecological issues that would prevent receptivity to the intended rhetoric. Chang (Chang, 2013: 43, 47, 53) has discussed how tensions in *Farmville*'s procedural rhetoric differ from real farming functionally and ideologically, leading to a disregard (intentional or not) for farming's history and contemporary issues. Smith has also noted that games tend to be a difficult medium for progressive ecological rhetoric and tend to 're-inscribe ideological and cultural norms that are ecologically regressive' (Smith, 2017: 117). Rendering ecological issues as abstract or fictionalising them as fantasy risks making real world issues seem like a disconnected fantasy that will never affect a player's real-life (Woolbright, 2017: 94) and emphasising the harsh reality of such issues can be perceived as preachy or negative. The challenge is to encourage a particular way of interacting with one's environment that is not contradicted by systems within the game. In this case, does the underlying procedural rhetoric of *Tevi* contradict its goal?

The goal for *Tevi* was to emphasise the benefits of plants to both humanity and the individual while not sugar-coating the difficulty of co-existing with one's environment in an eco-friendly way. *Tevi*'s design ethos aimed to avoid a disposable, material approach to the growing and cataloguing of plants in the player's garden. This was intended to guide the player away from adopting capitalist rhetoric that sees 'nature' as a resource to be managed and exploited for a purely instrumental purpose without consideration for the impact on the global or local ecosystem. It is possible, as Smith suggests, that the level of simulation abstraction and goal-oriented nature of games makes games a potentially unsuitable medium for challenging a hegemonic value system that capitalises on the natural world.

The team ultimately resorted to using previously agreed elements in the game to critically subvert expectations of management games, for example, by aiming to implement what are effectively predatory mechanics commonly referred to as microtransactions, but linking them to plant-recognition technology. Normally, these systems create a need for in-game resources through game mechanics and, when engagement is maximised, remove free access to said resources, requiring people to buy them with real money instead. Contrary to this, in *Tevi*, players are required to go out and take pictures of real plants. To solve the problem, the team has theorized

the possibility of approaching the game economy from perspectives that challenge dominant capitalist paradigms, and by reinforcing the idea of plant death not being a fail-state, but a natural consequence of life.

Similarly, the team recognised that the resource-based economy present in the game is at odds with the uncontrollable cellular automation of the garden's growth. These systems were intentionally designed to exacerbate the differences between the two and highlight the need to find a way for the player's control to facilitate the natural evolution of the garden, as opposed to imposing players' objectives and control over it.

The focus on garden management in *Tevi's* systems and core game loop, may be undesirable if the goal is to get players to care about the plants they grow as well as balance the eco-systemic processes that preserve species in the long-term. In retrospect, it might be worth considering ways in which the fundamental design of the game could be adjusted to incentivise caring for plants, not only virtually but for real world plants the player might encounter in their daily life. The lowest rated response in the questionnaire was for the question 'How alive did you feel the plants were?' It is suspected that the abstract nature of the simulation brings with it some unintended simplifications that may lessen the degree to which players feel like the plants are living things worth being emotionally invested in.

It was mentioned in the player feedback that players would appreciate a greater deal of contextualisation with regards to the fiction of the world – specifically characters representing player action. This feedback may speak to a desire to have some form of diegetic player avatar that might make empathy with the character and plants in the game more likely. However, this runs counter to Woolbright's (Woolbright, 2017: 98) critique of avatars reinforcing anthropocentric approaches to the natural world. Likewise, op de Beke (op de Beke, 2018: 82–83) sees the focus of the caretaker relationship of environmental awareness as being more a question of context than direct characterisation through an avatar.

When asked about what players liked least about the game or what they would have liked to do that was not possible in the tested version, familiar conventions common to games were mentioned that might contradict *Tevi's* message. Expansion of property was often mentioned as a desired feature, as was the presence of rewards or the ability to 'use' harvested fruit. The detail of the qualitative feedback is limited, but it is clear that a significant portion of players brought expectations of expansion and reward to the game, which may be informed by genre conventions or the player's existing understanding of gardens and farms, and is also informed by values and norms of capitalism that the development team sought to avoid (such as private property, utility, etc.).

Smith has noted that the genre of games that involve resource management and adopt a top-down perspective, sometimes referred to as 'god games', "draw on a philosophical tradition that asserts man's control over nature, and so are aligned with potentially dangerous geo-engineering interventions" (Smith, 2017: 117). The grid-like nature of *Tevi*'s garden calls to mind vaious resource management games (Mojang, 2011; *Ice Water Games, 2015;* Crawford, 1990; *University of Washington, 2012;* Tlön Industries, Forthcoming; *Firaxis Games, 2010;* Teuber, 1995). All of these

games challenge the player to make efficient use of limited space, often in order to maximise value. It is clear that the systems of *Tevi* align with various farming, gardening, or resource management sims, but the experience cannot and should not necessarily be reduced to these genre labels.The expectation brought about by game genre, or 'game grammar', is one that should be addressed and managed through design; otherwise, the player may inadvertently assume the game is about simply maximising nature's output as a genre convention. Any quantification of 'nature' and plants may be something that needs to be reconsidered or avoided when developing a game to promote ecological awareness.

There are many games that explore the theme of 'nature' that are not tied to genres commonly associated with resource management. Examples include *Flower* (thatgamecompany, 2006, 2009; *Tale of Tales, 2013;* Nintendo EPD, 2001; *Tiger Style, 2012;* O'Reilly, 2014, 2017; *Giant Squid Studios, 2016; Novotrade International, 1992*). These games, while often fantastical, encourage players to think about the effect of human activity on their surrounding world. By leveraging the role-playing property unique to games, these games place the player in the role of a non-human organism to experience its perspective. This approach could reframe the player's perspective on other beings in future projects and has been advocated by Woolbright (Woolbright, 2017: 91). This brings to the forefront a related discussion of the role of fiction in the game.

Contextualising the Player Experience through Fiction and Characterisation

It was mentioned in the player feedback that players would appreciate a greater deal of contextualisation with regards to the fiction of the world – specifically characters representing player action. This feedback may speak to a desire to have some form of diegetic player avatar that might make empathy with the character and plants in the game more likely. However, this runs counter to Woolbright's (Woolbright, 2017: 98) critique of avatars reinforcing anthropocentric approaches to the natural world. Likewise, op de Beke (op de Beke, 2018: 82–83) sees the focus of the caretaker relationship of environmental awareness as being more a question of context than direct characterisation through an avatar. The question of how the player even knows to be aware of their environment and where they should intervene (with care) should be more open-ended than necessarily prescribing a garden-gardener relationship through a fictional character and their environment. Nature should not be framed as Other or separate from human life, and the game should not posit the player's awareness of plants around them as a particular moral position but rather a normal yet beneficial one. Previous research, however, may run counter to player expectations of what a game about gardening might involve.

During the project, a 'store listing' experiment (Figure 10) was conducted that randomly assigned an artwork to *Tevi's* page on the Google store. The artwork was either a screenshot of the game (Figure 11), an image that contained character artwork (Figure 12), or panoramic artwork with no character (Figure 13). The image with the character artwork garnered the most attention in terms of unique installs, and this likely reflects the playtesting UX feedback regarding the desire for human characters in the game. Our artist, Phoebe Herring, was not given any specific direction for the character's design.

Integrating Subversion and the Benefits of Camera Integration

Players generally did not pick up on the subversive intentions of *Tevi,* which is partially the result of not properly signalling these intentions when managing expectations (discussed above). There is a potential to push the subversion further with regards to the futility felt by some players. One participant's comment captured the potential of using frustration to make ecological awareness clear: 'Everything dies no matter what I do'. Trying to preserve one's surrounding ecology, especially large-scale efforts to prevent global climate change and species preservation, are difficult undertakings that the game could subversively represent through frustrating gameplay. In one critique, Woolbright (2017: 97) mentions that the opportunity to fail

and have serious consequences for environmental failure could be a useful rhetorical tool but potentially off-putting to a casual audience.

The initial success of the integration of a camera in *Tevi* is encouraging, though, and suggests it should be further developed and indicates that even the most novice players know how to use a smart device to take a picture. This level of simplicity would engage a broad audience in a more direct way, similar to the way that *Pokémon Go* or Geocaching (Geocaching.com, 2000) have become popular. Thus, the camera could be a constructive and efficient way of redirecting focus to the biodiversity of the natural areas a player inhabits.

Trying to reward the collection of plant species in a codex was highlighted by players as a positive, and this desire to collect could be exploited to encourage players to engage with their environment. In the same way that the quantification of plants (via gridding the garden and giving short-term rewards) might subvert the promotion of ecological awareness, taking pictures might highlight plants in a way that is closely aligned to ecological awareness. When taking a picture of a plant, a player must consider their relation to an individual plant more directly, and in a way that is unlikely to be exactly the same way every time a picture is taken (as opposed to the repetitive placement of plant assets in a uniform grid). The information they receive about the plant may also be made more accessible by time-stamping the date that they took the picture and through additional contextual information such as the etymology of the plant's scientific name and additional trivia.

Motivations of achievement-completion, as identified by the Quantic Foundry model of player motivation (Yee, 2015), are strong incentives to play in popular resource management games as well as games for smart devices platforms that integrate a real camera such as *Pokémon Go*. However, as mentioned above, the framing of the game may reduce plants to nothing more than collectable 'QR codes' in the eyes of players who may quickly forget the semantic nature of the game in favour of focusing on collection for its own sake. This is a criticism that has been jokingly levied at the *Pokémon* franchise. Ostensibly one is meant to train and care for their Pokémon but the manner in which players capture and store unused Pokémon, coupled with the series' slogan "Gotta catch 'em all", leads to a grim utilitarianism that leads people to churn through and discard Pokémon in a dispassionate simulation of artificial selection. The same dispassion may be a risk for games that aim to give the player a mutually beneficial relationship with non-human organisms such as plants. There also exist specific spatial and legal risks associated with augmented reality games such as *Pokémon Go* (e.g., trespassing, sudden crowding of public spaces) (Koster, 2017).

Conclusion

The answer to the research question we set out to answer, 'how could a game for smart devices effectively promote short-term ecological awareness for a general audience?' is uncertain. Several potential paths to promoting ecological awareness to a general audience have presented themselves. In summary, it is difficult to make general conclusions based on the preliminary amount of user experience data we collected. However, there were several useful findings that came out of the research. The most positive response to the project was from children. Although this is not

conclusively indicative of a change in the short-term ecological awareness of children, it does help us understand what might be appealing about future projects with similar goals.

Unexpectedly, taking pictures through the game's interface to interact with plants was generally considered a significant factor in players' enjoyment. Although some players noted that they disliked the feature, this could be ascribed to the poor functionality of the feature at the time of testing. The feature was not as well-contextualised with the rest of the game as it could have been, and there were numerous technical and legal questions surrounding its feasibility. However, despite the problems it posed to development, it was felt by the team that this feature was one way in which the game showed the most promise as it guided players' attention toward real plants in their immediate environment and offered the potential for cultivating learning about plants via an integrated codex.

The playtests' analyses showed that the game, in its current state, was not effective at educating players about processes related to plant biology. Instead, the game, possibly due to genre expectations, was understood as a basic simulation of gardening, which, despite the principles of cellular automata, may have been too simplistic to generate deep engagement with procedural rhetoric associated with ecological awareness. This suggests the critical role that genre and medium expectations would have in the design of a project trying to promote ecological awareness.

It is clear that this area of research is ripe for investigation along numerous lines of enquiry. The integration of fiction, cultivation of expectations about the game, development of systems to encourage direct interaction with plants (such as the camera integration), and the potential for subversion are all possible avenues of critical study and game design.

References

ALVA (2018) *ALVA | Association of Leading Visitor Attractions*, Available from: http://www.alva.org.uk/details.cfm?p=423 [Accessed 29 March 2019].

Anderson-Fung, P.O. and Maly, K. (2002) *Hawaiian Ecosystems and Culture; Why Growing Plants for Lei Helps to Preserve Hawaii's Natural and Cultural Heritage*, PUBLISHER?

Arnseth, H.C. (2006) Learning to Play or Playing to Learn - A Critical Account of the Models of Communication Informing Educational Research on Computer Gameplay. *Game Studies,* [online], 6 (1), Available from: http://gamestudies.org/06010601/articles/arnseth [Accessed 29 March 2019].

Backlund, P. and Hendrix, M. (2013), Educational games - Are they worth the effort? A literature survey of the effectiveness of serious games, In: *2013 5th International Conference on Games and Virtual Worlds for Serious*

Applications (VS-GAMES), [online], September, 2013, Poole: IEEE, pp. 1–8, Available from: http://ieeexplore.ieee.org/document/6624226/doi:10.1109/VS-GAMES.2013.6624226 [Accessed 28 March 2019].

Bateson, P.P.G. and Martin, P. (2013), *Play, playfulness, creativity and innovation*. Cambridge, New York: Cambridge University Press.

Bogost, I. (2006), *Unit operations: an approach to videogame criticism*, Cambridge, MA, USA: MIT Press.

Bogost, I. (2010) *Persuasive Games: The Expressive Power of Videogames*, Cambridge, MA, USA: MIT Press.

Boyle, E.A., Hainey, T., Connolly, T.M., Gray, G., Earp, J., Ott, M., Lim, T., Ninaus, M., Ribeiro, C. and Pereira, J. (2016) An update to the systematic literature review of empirical evidence of the impacts and outcomes of computer games and serious games, *Computers & Education*, 94, pp. 178–192, doi:10.1016/j.compedu.2015.11.003.

Bruneau, M. and Villeneuve, A. (2007), *Traiter de recherche création en art : Entre la quête d'un territoire et la singularité des parcours*, Quebec: Presses de l'Université du Québec.

Chandler, K. and Swartzentruber, M. (2011), *A Correlational Study of Nature Awareness and Science Achievement*, [online], Available from: https://eric.ed.gov/?id=ED520105 [Accessed 29 March 2019].

Chang, A. and Parham, J. (2017), Green Computer and Video Games: An Introduction, *Ecozon@*, 8, pp. 1–17.

Chang, A.Y. (2012) Back to the Virtual Farm: Gleaning the Agriculture-Management Game. *Interdisciplinary Studies in Literature and Environment*, 19, (2), pp. 237–252, doi:10.1093/isle/iss007.

Chang, A.Y. (2013), *Playing Nature: The Virtual Ecology of Game Environments*. [online], (no place) UC Berkeley. Available from: https://escholarship.org/uc/item/9ch2w332 [Accessed 29 August 2019].

Chris Crawford (1990), *Balance of the Planet,* [Mac OS].

ConcernedApe (2016), *Stardew Valley,* [Microsoft Windows, iOS and Android.].

Daly-Jones, O., Monk, A., Frohlich, D., Geelhoed, E. and Loughran, S. (1997) Multimodal messages: the pen and voice opportunity. *Interacting with Computers*. 9 (1), pp. 1–25. doi:10.1016/S0953-5438(96)01041-7.

David O'Reilly (2014), *Mountain,* [Microsoft Windows].

David O'Reilly (2017), *Everything*, [Microsoft Windows].

Dyer-Witheford, N. and Peuter, G.D. (2009) Google-Books-ID: gsnss__CKoMC.*Games of Empire: Global Capitalism and Video Games*. (no place) U of Minnesota Press.

Novotrade International (1992), *Ecco the Dolphin* [Sega Genesis].

Firaxis Games (2010), *Civilization V,* [Microsoft Windows].

Fisman, L. (2005) The Effects of Local Learning on Environmental Awareness in Children: An Empirical Investigation. *The Journal of Environmental Education*. 36 (3), pp. 39–50. doi:10.3200/JOEE.36.3.39-50.

Floyd, D. (2008), *Video Games and Learning*, [online], Available from: https://www.youtube.com/watch?v=rN0qRKjfX3s [Accessed 29 March 2019].

Geocaching.com (2000), Geocaching, [online], Available from: https://www.geocaching.com/play.

Giant Squid Studios (2016), *Abzu*, [Microsoft Windows, Playstation 4 and Xbox One].

Goëau, H., Bonnet, P., Joly, A., Bakić, V., Barbe, J., Yahiaoui, I., Selmi, S., Carré, J., Barthélémy, D., Boujemaa, N., Molino, J.-F., Duché, G. and Péronnet, A. (2013), Pl@ntNet Mobile App, In: *Proceedings of the 21st ACM International Conference on Multimedia* MM '13, [online], 2013, New York, NY, USA: ACM, pp. 423–424, Available from: http://doi.acm.org/10.1145/2502081.2502251doi:10.1145/2502081.2502251 [Accessed 28 March 2019].

Google (2019), *Top Charts - Games - Android Apps on Google Play*, Available from: https://play.google.com/store/apps/top/category/GAME [Accessed 29 March 2019].

Gosselin, P. and Coguiec, E.L. (2006) *La recherche création : Pour une compréhension de la recherche en pratique artistique*. (no place) Presses de l'Université du Québec.

Ice Water Games, (2015), *Viridi*, [Microsoft Windows].

Impressions Games (1998), *Caesar III,* [Windows, Mac OS].

Klaus Teuber (1995), *Settlers of Catan*, [Board game].

Korzybski, A. (1958), Google-Books-ID: KN5gvaDwrGcC.*Science and Sanity: An Introduction to Non-Aristotelian Systems and General Semantics*, (no place) Institute of GS.

Koster, R. (2017), *Still Logged In: What AR and VR Can Learn from MMOs*, Available from: https://www.gdcvault.com/play/1024060/Still-Logged-In-What-AR [Accessed 29 March 2019].

Landers, R.N. and Bauer, K.N. (2015), Quantitative methods and analyses for the study of players and their behaviour, In: Petri Lankoski and Staffan Bjork (eds.). *Game Research Methods*. (no place) ETC press. pp. 151–173.

Le Coguiec, É. (2007). Démarches de recherche et démarches de création. In M. Bruneau & A. Villeneuve (Eds.), Traiter de recherche création en art: entre la quête d'un territoire et la singularité des parcours. Québec, Canada: Presses de l'Université du Québec. pp. 308-325.

Lieberoth, A. and Roepstorff, A. (2015) *Mixed methods in game research*. In: Petri Lankoski and Staffan Björk (eds.), [online], Pittsburgh, PA, USA: ETC Press. pp. 271–289, Available from: http://dl.acm.org/citation.cfm?id=2812774.2812795 [Accessed 21 February 2017].

Michael, D.R. and Chen, S.L. (2005), *Serious Games: Games That Educate, Train, and Inform*, (no place) Muska & Lipman/Premier-Trade.

Microprose, (1996), *Civilization II,* [Microsoft Windows, Mac OS and Playstation].

Mojang (2011), *Minecraft*, [Microsoft Windows, Mac OS and Linux.].

Mozelius, P., Fagerström, A. and Söderquist, M. (2017) Motivating Factors and Tangential Learning for Knowledge Acquisition in Educational Games. *The Electronic Journal of e-Learning*. 15 (4), pp. 343–354.

Newsgaming.com (no date) *newsgaming.com*. Available from: http://www.newsgaming.com/ [Accessed 29 March 2019].

Niantic (2016), *Pokémon Go,* [iOS and Android].

Nintendo EPD (2001), *Pikmin,* [Nintendo Gamecube].

Nintendo EPD and NDCube, (2017), *Animal Crossing: Pocket Camp,* [iOS and Android].

op de Beke, L. (2018), *Empathy for Ecosystems : On the Environmental Orientation of Videogames*, (no place) Leiden University.

Salomon, G. and Perkins, D.N. (1989) Rocky Roads to Transfer: Rethinking Mechanism of a Neglected Phenomenon. *Educational Psychologist*. 24 (2), pp. 113–142. doi:10.1207/s15326985ep2402_1.

Smith, B. (2017), Resources, Scenarios, Agency: Environmental Computer Games, *Ecozon@*, 8, pp. 103–120.

Supercell (2012), *Clash of clans,* [iOS and Android].

Tale of Tales (2013) *Luxuria Superbia* [Android, Microsoft Windows, iOS].

thatgamecompany (2006), *Flow,* [Playstation 3].

thatgamecompany (2009), *Flower,* [Playstation 3 and iOS].

Tiger Style (2012), *Waking Mars,* [Microsoft Windows].

Tlön Industries (Forthcoming), *Per Aspera,* [Microsoft Windows].

Wandersee, J.H. and Schussler, E.E. (2001), Toward a Theory of Plant Blindness. *Plan Science Bulletin*, 47, (1), pp. 2–9.

Wetlands Restoration Facebook Game (2012) [online], Directed by University of Washington, Available from: https://green.uw.edu/promote/snapshots/wetlands-restoration-facebook-game [Accessed 21 August 2019].

Wolfram, S. (1983), Statistical mechanics of cellular automata, *Reviews of Modern Physics*. 55 (3), pp. 601–644. doi:10.1103/RevModPhys.55.601.

Woolbright, L. (2017), Game Design as Climate Change Activism, *Ecozon@*, 8, pp. 88–102.

Yee, N. (2015), How We Developed The Gamer Motivation Profile v2 *Quantic Foundry*, [online], Available from: https://quanticfoundry.com/2015/07/20/how-we-developed-the-gamer-motivation-profile-v2/ [Accessed 29 March 2019].

Zynga (2009), *Farmville,* [Android, iOS, Adobe Flash and HTML5].