LONG PAPER

Video games for environmental awareness: the accessibility gap

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Abstract

Video games addressing environmental issues have the potential to raise awareness among players about the pressing ecological crisis and motivate them to take individual and collective action towards sustainability. For these games to generate change on a large scale, everyone should be able to play them. However, persons with disabilities often encounter accessibility barriers that prevent or hinder their access to these games. This paper aims to bridge the gap between environmental awareness and accessibility by analysing three video games: *Plasticity*, *Alba: A Wildlife Adventure*, and *The Sims 4: Eco Lifestyle*. First, their environmental themes are examined. Second, their accessibility features are listed and assessed using a mixed-methods tool that combines a quantitative checklist with a user qualitative evaluation. Results show that these three games are similar in their exploration and slow-paced mechanics but lack a specific focus on accessibility, particularly regarding visual, hearing, and haptic stimuli. This leads to a reduced gaming experience for some players, and complete unplayability for others, especially users in need of visual accessibility features. To improve the situation, accessibility should be co-created with users and implemented from the design stage of the game. Future research includes analysing a larger selection of games, directly involving players in the assessment of accessibility features, and reception research examining the impact of environmental awareness on players with and without disabilities. In short, to bridge the accessibility gap in environmental awareness, it is crucial to prioritise inclusivity in video games so that everyone can participate in creating a more sustainable world.

Keywords Accessibility · Disability · Environmental awareness · Video games · Sustainability

1 Introduction

Humanity is currently facing a triple planetary crisis related to climate, pollution, and biodiversity loss, with dire consequences for the planet and its inhabitants. [1]. Aiming to mitigate them, the protection of the environment is the overarching theme for all seventeen of the United Nations' Sustainable Development Goals, which include efforts to improve the availability and sustainability of water management, sanitation, energy, marine resources and terrestrial ecosystems [2]. Similarly, the European Green Deal fights the environmental crisis through energy, mobility, trade and sustainable development initiatives [3]. Among these actions, raising awareness plays a significant role

in engaging citizens and communities across the world to lead a more sustainable lifestyle, as highlighted by both the United Nations and the European Commission [4, 5]. In fact, limited knowledge about these issues and how to approach them appears to be one of the main psychological barriers preventing an increase in ecological behaviours [6].

Video games for environmental awareness, or *environmental games*, may be used as digital communication tools for educational purposes [7]. They inform users about ecological problems and solutions through "a system of rewards and goals which motivate players, a narrative context which situates activity and establishes rules of engagement, learning content that is relevant to the narrative plot, and interactive cues that prompt learning and provide feedback" [8]. Interactivity is what distinguishes video games from other forms of media and contributes to the players' perception of being the drivers of change, increasing knowledge application in real-world situations and promoting sustainable actions [9].

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There are entertainment and serious environmental games. The purpose of entertainment games is to deliver an enjoyable experience, while serious games aim to change players' attitudes, beliefs, risk perceptions, knowledge, or skills about a serious topic in an entertaining manner [10]. Some environmental games are based on scientific data and research, such as *Ice Flows*, created at the University of Exeter in 2018 [11]. This game accurately portrays the impact of climate change on the Antarctic ice sheet and is targeted at secondary school students. Others take a more imaginative approach, using fiction and allegory to explore potential future scenarios. It is the case of Ubisoft's *Anno 2070*, set in a world where the Arctic ice cap has melted. Players build new cities by exploiting resources, which may or may not be sustainable, impacting gameplay.

The Playing for the Planet Alliance, facilitated by the UN Environment Programme (UNEP), recognises video games' potential to raise environmental awareness. Its more than forty members, which include game development studios, publishers, and associations, are committed to reducing the industry's carbon footprint and inspiring environmental action through games. In 2022, the Alliance focused on integrating green activations in games that result in real-world actions, such as planting trees, creating a new decarbonisation standard for the industry, and presenting their work at events and conferences. Players support these actions, as shown by the Alliance's *Green Game Jam Player Survey 2022*. Some 81% of the 389,000 participants would like to see more environmental content in video games, and 73.4% are willing to take more sustainable actions after playing an environmental game [12].

Additionally, environmental games have the potential to reach and build communities with traditionally excluded demographics, such as children and elders. In UNEP's words, "games are often self-explanatory and intuitive, features which can benefit environmental projects, especially in terms of accessibility and social inclusivity" [13]. However, persons with disabilities are not specifically mentioned by UNEP as a target group for this type of games, although environmental information is often inaccessible to them [14]. This extends to risk management strategies and plans, which often overlook the needs of persons with disabilities, increasing their vulnerability during crisis situations [15]. As a result, they are doubly excluded from participating in discussions and actions related to the environment, which can hinder their understanding of the risks and potential solutions [16].

Therefore, environmental games should be accessible to all members of society, preventing interaction barriers long noted by users [17], the gaming industry [18], and research [19]. This paper analyses the environmental content and accessibility of three games as a starting point for bridging the gap between sustainability and inclusivity. First, the concepts of video games for environmental awareness and game accessibility are examined. Then, quantitative and qualitative results from the analysis of the selected games are presented, which are *Plasticity* [20], *Alba: A Wildlife Adventure* [21], and *The Sims 4: Eco Lifestyle* [22]. Lastly, potential accessibility improvements are identified and future directions for research are suggested.

2 Video games for environmental awareness

Environmental games raise awareness among players about the natural world, the impact of human activity, and the actions that individuals and communities can take to tackle ecological issues such as the climate emergency, air and water pollution, and deforestation. According to UNESCO [23], awareness and education are essential for building the knowledge, skills, values and attitudes necessary for sustainable development.

Video games are a particularly effective medium to raise environmental awareness, as interactive and immersive experiences can show the complexities and interconnections of natural systems, as well as the potential consequences of ecological degradation and the benefits of conservation efforts [24]. For example, in the game *Beyond Blue*, by E-Line Media, players explore the ocean and its fauna through the eyes of a deep-sea diver, providing a glimpse into the intricate ocean life and the interdependencies among species. Similarly, Mojang Studios' *Minecraft* may be used for environmental education, as players can use and explore real sustainable practices in the game world through the lens of creativity [25].

The notion of agency, that is, the ability of players to make in-game decisions that impact their experience, is key here. In environmental games, players explore different strategies and approaches to addressing ecological challenges that often mirror reality. This fosters reflection about in-game and out-game events, which may be encouraged by prompts within the game or discussions with other players [26]. Reflection is a valuable tool for learning, as it enables players to process and internalise new information, make connections between the game and real-world situations, and examine their own experiences [27].

The influence of environmental games on players' real-life behaviours is a subject of discussion. On the one hand, the already mentioned Playing for the Planet Alliance's *Green Game Jam Player Survey 2022* provides compelling evidence that video games possess the ability to promote positive attitudes and actions towards the environment [28]. Not only did the survey successfully reach an extensive audience of 389,000 players, but 73.4% of them, after playing environmental games, stated that they were willing to take actions towards sustainability, such as eating less meat and

planting trees to protect forests. Additionally, other research has found that these games encourage players to engage in sustainable behaviours such as conserving energy [29, 30] and recycling [31], thanks to immersive narratives and effective communication strategies.

On the other hand, some studies have called into question the ability of video games to effectively promote long-term changes in environmental attitudes and behaviours. Ahn et al. note that experiencing a highly interactive virtual environment promoting sustainability results in a higher self-assessed environmental behaviour in real life up to one week after exposure [32]. Later than that, however, no significant differences are found between environments with high and low levels of interactivity. Similarly, in a review of research on simulations and serious games about the environment, Halllinger et al. conclude that empirical studies addressing the learning outcomes of environmental games are still largely lacking [33].

In any case, it is important to acknowledge the value of video games as tools for environmental communication. As Amadori points out in relation to younger generations, who tend to consume less traditional media such as TV and newspapers, "we can wonder if and how video games can be used to pursue strategic communication objectives in the environmental field, bringing certain issues to public attention and to criticize the most problematic aspects" [34]. For Abraham and Jayemanne, broadening the scope to games that not only tackle environmental themes, but also address the causes of the climate crisis, contributes to overcoming the limitations of serious games—"which largely do not succeed at having the widespread transformative effects they aim for" [35]—and identifying which design elements impact player behaviour. The Greening Games research project takes this further by stressing the link between environmental education and the game industry: sustainability should be discussed early when training developers, so that they lead the way towards sustainable practices in gaming [36].

3 Game accessibility

Accessibility is crucial for the inclusion of people with disabilities in issues related to sustainability. The Convention on the Rights of Persons with Disabilities states that disability is a result of environmental and attitudinal barriers hindering a person's "full and effective participation in society on an equal basis with others" [37]. Applied to video games, accessibility prevents or overcomes interaction barriers between the player and the game [38]. Interaction is based on three steps: receiving stimuli from the game, determining the response, and providing input to complete the interaction [19]. For players with visual disabilities, receiving stimuli through the visual channel is an access barrier. For players

with hearing disabilities, the issue lies in the acoustic channel. For players with cognitive disabilities, deciding what action is needed to progress in the game may be challenging. For players with motor disabilities, the barrier may be the possibility to physically use the input device that enacts the chosen action, such as pressing a button on a controller or a keyboard.

Game accessibility is beneficial for all players, with and without disabilities. In fact, disabling situations are unique to each person, so instead of disability profiles, it is often more accurate to talk about needs. For example, a person may need captions to access sound in video games for several reasons, such as having a hearing disability, playing in a noisy environment, being a younger or older player, or being a language learner. In this case, the barrier of receiving sound stimuli is overcome by providing the same information through the visual channel in the form of written text.

As previously mentioned, environmental games should be accessible for all members of society, as they would reach a greater number of players, potentially increasing their social impact. They would also improve the access of persons with disabilities to environmental information. The close link between awareness and accessibility is noted by Games for Change, an international non-profit organisation about serious games for social change. Its Game Directory compiles 150 games addressing topics such as education, politics, or empathy [39]. Games may be filtered by age rating, gaming platform, cost, number of players, and accessibility, which is divided in the following categories: general, auditory, visual, colour, and fine motor settings. However, no further information is provided about what these categories entail in terms of accessibility features, and none of the filters yields any results. It is possible that the feature has not been implemented yet on the website, as content tags cannot be filtered either. Instead, to search for games about a certain topic, the tag must be manually typed in the search bar.

The Game Directory's acknowledgement of accessibility is quite unique, as research about environmental games often fails to address players with disabilities. Generally, accessibility is used in the sense of the game or the gaming device's availability. For example, Fisher et al. [40] study how Nintendo's *Animal Crossing: New Horizons* promotes sustainability, particularly regarding nature conservation. Accessibility is mentioned in the sense of personalisation—the player may customise the physical appearance of their character and choose in which hemisphere to live. Similarly, Boncu et al. [41] conduct a systematic review of 29 serious games that educate players about the environment. Here, accessibility refers to the widespread availability of video games, mobile devices, and technology.

A notable exception is a study by Fernando et al. [42] about *Trash Attack*, a PC and mobile video game that educates players about waste segregation. Researchers

incorporated visual accessibility into their game, which 36 players evaluated with a fair score (3.2 points out of a maximum of 5) through a survey. No further information about accessibility is provided, but the paper concludes that, according to survey participants, the game succeeds in raising environmental awareness.

Our review of the literature seems to indicate that accessibility is more present in serious games about topics other than the environment. Two approaches have been identified—creating an accessible serious video game and analysing the accessibility of existing games. An example of the first case is *My First English Game*, a mobile game for learning English. It was developed to be accessible for persons with hearing disabilities through subtitles, speaker tags, and presenting key information through multiple channels, not only audio [43]. Another example is *PC TRAVEL*, a game to learn about computer architecture developed to be accessible not for a certain disability, but for the largest number of players as possible [44]. The game includes accessibility features such as subtitles, high contrast, and save points.

Regarding serious game analysis, Jaramillo-Alcazar et al. [45] assess the cognitive accessibility of five mobile games according to the recommendations of four guidelines. Salvador-Ullauri et al. [46] evaluate 40 serious web-based games according to their accessibility for players with low vision using the barrier walkthrough method and the Web Content Accessibility Guidelines. Francillette et al. [47] review 17 games for players with mental illnesses according to five criteria: aesthetic, controls, graphic user interface, feedback, and narration. These categories are based on the Game Accessibility Guidelines and recommendations for designing serious games for players with Alzheimer's disease and players with autism.

Each of these studies develops its own criteria to evaluate accessibility in serious games, although they all draw from existing guidelines. The lack of a common, unified approach hinders result comparison, not only in research about serious games, but game accessibility in general. To avoid the same issue, this paper applies a mixed-methods analysis tool that integrates existing guidelines to evaluate the accessibility of three selected environmental games, as it will be further discussed in Sect. 4.

4 Methods

Aiming to bridge the gap between sustainability and inclusivity, this paper analyses the accessibility features and barriers of three environmental games. Although the sample is small, it serves as a starting point towards mapping the current state of accessibility in environmental games and to advance towards more inclusive tools for ecological awareness and education. The games were selected with the following criteria: to address environmental themes, to have been released in the last 5 years, and to be available for PC. This platform was chosen because it is popular among players in general [48] and with disabilities [49, 50].

The selected games were *Plasticity* [20], *Alba: A Wildlife Adventure* [21], and *The Sims 4: Eco Lifestyle* [22]. *Plasticity*, developed as an indie game by thirty students in the Games Programme at the University of Southern California, is tagged in Games for Change's Game Directory as tackling "Education" and "Empathy." *Alba,* developed by a medium-sized studio, is also included in the Game Directory and tagged as a game for "Environmental Impact" and "Empathy." Finally, *Eco Lifestyle* is part of the hugely popular Electronic Art's franchise *The Sims 4*, which was played worldwide for 1.4 billion hours in 2022 [51].

The games were played on PC by each of the authors of the paper, separately. First, their environmental themes were reviewed using content analysis. This research method involves systematically analysing and interpreting the content of a particular text or other forms of media, including video games [52]. Here, it allows for a closer look at how environmental issues are tackled in the game's narrative, mechanics and aesthetics, and how they encourage players to think about and engage with them. On this basis, it is a tool to understand how sustainability is presented and incorporated into video games, and its potential to raise awareness.

Second, the accessibility features of the selected games were listed and assessed using a mixed-methods analysis tool developed by Larreina-Morales [53]. On the one hand, quantitative data are collected through a checklist that integrates four game accessibility guidelines, compiling the recommendations of players with disabilities, the game industry, and research: Accessibility Reference Guides [54–58]; Xbox Accessibility Guidelines V2.5 [59]; Game Accessibility Guidelines [60]; and Accessible Player Experiences [61]. The checklist is organised into access design patterns, which guarantee the interaction between the player and the game, and challenge design patterns, which address the progress of the player within the game [61]. Access features are further classified into input, control, presentation, and output options; and challenge features into performance, training, progress, socialisation, and moderation options [62]. Each feature is either available, unavailable, or not relevant to the mechanics of the analysed game. These options appear on the checklist as "Yes," "No," and "N/a" (not applicable), respectively.

On the other hand, qualitative data are collected from accessibility reviews written by users and published online. Reviews are selected from relevant forums, social media platforms, and other online spaces where players discuss video games, aiming to represent different accessibility needs and preferences. This approach involves studying online discussions and interactions among players of

environmental video games to understand their experiences with and attitudes towards accessibility.

Finally, quantitative and qualitative data are merged and compared in a convergent mixed-methods design to gain a deeper understanding of the adequacy of the accessibility features of the analysed games, as well as their barriers [63]. As a result, accessibility is analysed through the double lens of how many accessibility features are provided and how their users perceive their quality.

5 Results

Results are organised according to the three analysed games: *Plasticity*, *Alba: A Wildlife Adventure*, and *The Sims 4: Eco Lifestyle*. First, the game's content is analysed, identifying its potential to raise environmental awareness. Second, quantitative data collected through the checklist is presented and merged with qualitative data assessing the accessibility features. The full list is available in Appendix.

5.1 Plasticity

Plasticity is a puzzle-platformer video game released in 2019 and developed by thirty students of the Games Programme at the University of Southern California. It was nominated for the Best Student Game Award in the 2020 Games for Change Awards and selected for the indie game booth at the 2020 Game Developers Conference. Set in a plastic-polluted world in the year 2140, the game follows a young girl, Noa, in her journey to find a healthier place to live. The central theme of environmental pollution sets a moody, depressive atmosphere, reinforced by the auditory and visual design. A melancholic music score and a muted colour palette further convey the protagonist's despair and hopelessness. Noa reflects on the state of her world, the loss of her mother, and the consequences of inaction in the face of the ecological crisis through short sentences that appear at the bottom of the screen. These design elements work together to immerse the player in a thought-provoking and emotionally impactful experience.

To progress in the game, the player can perform three basic mechanics: moving forward and backwards, jumping, and interacting with objects. Noa's journey starts on a landfill, continues through an abandoned coastal town, and finishes on an island, whose degree of pollution will depend on the player's actions throughout the game. These actions are environmentally motivated and include cleaning up litter and saving seagulls trapped in fishing nets. However, interactive objects are indistinguishable from the background, so it is in the hands of the player to discover which actions may improve the environment.

For example, at the beginning of the game, Noa drinks from a plastic bottle and throws it on the ground. Then, the player may or may not interact with the bottle by pressing a key on the computer keyboard. If they choose to interact, Noa throws the bottle in a bin and avoids further polluting her world. If they do not interact, either by choice or unaware that they can do so, they contribute to the deterioration of the environment. The more sustainable actions the player performs, the better ending they will get. By showing the dire consequences of pollution and the positive results of environmental preservation, the game has the potential to inspire players to adopt sustainable behaviours in their own lives. In fact, a study by Bekoum Essokolo and Robinot [64] used *Plasticity* to explore the impact of immersive media in reducing psychological distance dimension and triggering emotions. The authors found that the game rose environmental awareness among players, who were willing to take actions to reduce plastic consumption after playing.

Unfortunately, *Plasticity* is a largely inaccessible game. It offers just one accessibility feature out of the 28 relevant ones included on the checklist (see Table 1). Only customising the output device is possible, that is, adjusting the settings of the PC screen, such as the brightness or the contrast. Still, the game's design may support accessibility for some players. For example, Noa's internal monologue is not presented audibly, but in text at the bottom of the screen. As a result, players without access to the acoustic channel may have access to the story. In turn, players with visual disabilities may miss it, because the game is not compatible with a screen reader. It is also not possible to change the font or size of the text to improve its readability. Although the protagonist's comments are not essential to progress in the game, they contribute to raising environmental awareness. Similarly, controls are limited to the arrows on the keyboard and the Ctrl key, and they do not require toggling, holding, or repeated pressing. This simplicity may contribute to cognitive accessibility, but players with no access to the keyboard will be unable to interact with the game.

These issues are highlighted in user reviews published on Steam, the platform that distributes *Plasticity*. Players criticise the lack of motor accessibility, especially regarding controls, which are said to be stiff, slow, and buggy, negatively impacting the overall gaming experience [65] and the control of the character [66]. Interaction with elements outside the flat plane cause frustration for some players [67]. The movements of the character are described as awkward and detracting from the visually appealing background and aesthetic [68]. The way to progress in the game is also considered to be problematic: "The audio in the game is good, some downsides of the game include that there are no save [options] and the controls feel a bit clunky and awkward" [69]. In fact, if the player quits *Plasticity* during gameplay, they must start from the beginning the next time they open

it. Additionally, the lack of tutorials, explicit goals, hints, or difficulty customisation may make it very difficult for some players to progress in the game, particularly those with visual disabilities, as there are no options to accommodate the visual stimuli through sound, like a screen reader or additional sound signals. To overcome challenge barriers, players have created a guide listing the actions needed to get "the good ending" of the game [70].

It is important to note that *Plasticity* was developed as a student project with limited resources. This might be the reason for the bugs and awkward controls pointed out by the reviewers. Similarly, it may be argued that the design choice of making interactive objects undistinguishable from the background highlights the message of the game—only conscious, deliberate environmental actions will save the planet. However, accessibility does not mean compromising the game's nature, artistic vision, or educational aim. As noted by AbleGamers, a non-profit organisation advocating for game accessibility, "in some cases, you may not be able to make every experience accessible to everyone. But then again, not every player wants to have the experience you are offering" [61]. Instead, accessibility is designing a game that may be played by as many players as possible, catering to their diverse needs and preferences.

In the case of *Plasticity*, a feature that increases the contrast between interactive objects and the background would make it easier for players to identify and interact with these objects. Naughty Dog's *The Last of Us Part II* successfully uses this strategy to improve the accessibility of the game—the High Contrast Display mutes the background and colours allies, enemies, items, and interactive objects so that they are clearly identified by players [71]. Adding accessibility features such as high contrast to *Plasticity* would also contribute to the environmental message of the game, as it would improve the identification of behaviours that result in a less polluted world, in both the game and everyday life.

5.2 Alba: A Wildlife Adventure

Alba: A Wildlife Adventure is a single-player video game released in 2020 developed by Ustwo Games, a London-based studio. The game is about Alba, a young girl visiting her grandparents on the Mediterranean coast, and her efforts to protect the environment. The gameplay is based on exploring an open world, interacting with other characters, and finding objects, making it suitable for players of all ages, particularly younger ones. Moreover, UsTwo Games commits to its ecological message by planting one tree for every copy of *Alba* that is downloaded or sold. In 2021, the milestone of planting one million trees was reached [72]. The game's potential to raise awareness was recognised with the 2021 Apple Design Award for Social Impact and the Game of the Year Award at the 2021 Games for Change Awards.

The game has a vibrant, colourful atmosphere that evokes the feeling of childhood summer holidays. The player visits local landmarks, like the beach, a restaurant or a castle, all with names in Spanish, connecting the game with the real world. Through Alba, they interact with other characters and learn about the upcoming destruction of a nature reserve as the result of the construction of a luxury hotel. To avoid it, they must complete different quests related to environment preservation, such as collecting signatures, cleaning up litter, and identifying and photographing wildlife. Exploration is the main mechanic in *Alba*, which allows players to discover different areas of the game world and interact with other characters and wildlife species. Players also capture photos of the animals they encounter and add them to their in-game journals. Other tools, such as binoculars and a mobile phone, add to the immersive gameplay experience. This design, with unlimited time to complete the quests, may inspire players to make similar small, everyday actions to protect the environment and learn about their local wildlife.

Regarding accessibility, *Alba* offers 14 of the 28 relevant features on the checklist (Table 1). It performs particularly well in the challenge options, as it provides 8 out of 11, including tutorials, hints, manual and auto-save, and reviewing the progress made by the player. There are only 6 out of 17 access options. Notable examples include alternative input devices to control the game (the mouse and an external controller plugged into the PC), the additional sound and visual signals, and the independent volume control. As in *Plasticity*, the straightforward mechanics in *Alba* work in favour of its accessibility. The focus on exploration and the unlimited time to complete quests translates into a relaxed experience that may improve accessibility for players with cognitive and motor needs. The latter may benefit from playing with the mouse or the controller, customising the input device's sensitivity, and not having to toggle, hold, or repeatedly press the buttons. Dialogues between characters, which provide key information about the quests, are only rendered in the text and in short sentences, which contributes to hearing and cognitive accessibility. In fact, access to the acoustic channel is not essential to progress in the game, although the sound of birdsongs, the waves and the wind enhances immersion.

Alba is largely lacking visual accessibility features. Although there are some additional sound signals, such as a click when the player focuses the camera on a wild animal before taking a photo, or sea and wetland sounds that may help with orientation, players with visual disabilities may find it particularly difficult to interact with this game. Besides the lack of a screen magnifier and a screen reader, the unavailability of an assist mode or the possibility to bypass parts of the game may make it impossible for some players to independently complete the quests.

The game has been praised for the accessible features of its design: "The missions are clearly listed, and you can always access a well-annotated map. There is no sonar-style directive audio ping, but you can listen to the sound of the animal you need to find and use that sound to home in on its location in the game world" [73]. Text-based dialogue and visual cues complementing sound signals, which may be particularly useful for users with cognitive disabilities, are also applauded [74]. Players also notice the game's accessibility limitations. For example, Ortiz [75] wishes the game's music score was heard more often, although they recognise that there may be silent moments to underline the sound effects that characterise each wild animal, which may help players with visual disabilities. Wainwright [74] notes that players with low vision may use the easily recognisable silhouettes of the animals. Lastly, the lack of control features may result in a poor gaming experience for some users: "I have never seen a game have this few [control] options. It feels uncomfortable to use on keyboard and mouse, and given the practically non-existent game options, [they] are impossible to improve" [76].

In short, *Alba* has a great potential to raise environmental awareness, as noted by players themselves: "*Alba* challenges you to give back to your own local community, to explore your own nature preserves, to capture the twittering of rare species hidden in the branches" [77]. It is also on the right track regarding accessibility. Some of the features are embedded in the design, such as additional sound and visual signals, hints and review of the progress, while others require explicit configuration by players, like controller sensitivity and independent volume control. Even some of the not applicable features contribute to accessibility. There is no need for difficulty, speed, and time limit customisation options, because *Alba* is already a slow-paced exploration game. That said, more accessibility features could easily be implemented in *Alba*, particularly for players with visual disabilities. Compatibility with a screen reader would be key to access the written dialogues and objectives, as well as a screen magnifier, the customisation of interactive visuals, and the intentional design of sound signals for orientation in the open world. Lastly, an assist mode or the possibility to bypass certain parts of the game would be useful to avoid players getting stuck throughout the game.

5.3 The Sims 4: Eco Lifestyle

The Sims is a life simulation video game series developed by Electronic Arts where players create and control virtual people, known as Sims, and manage their everyday lives. Since the year 2000, the franchise has released numerous sequels and expansion packs, such as *Cats & Dogs*, *Discover University* and *Eco Lifestyle*. The latter, released in 2020, focuses on sustainable living. *The Sims 4* has colourful,

cartoon-like aesthetics. The user-friendly interface is quite intuitive, and controls are limited to the keyboard and pointing and clicking with the mouse. Despite its casual design, it is important to note that the game and its expansions are rated PEGI 12.

The Sims 4 has a double dynamic of building and living. The player designs the Sims' appearance and personality, builds and decorates the houses they live in, and runs the simulation while controlling one Sim at a time. In live mode, the player takes care of the Sims' physiological and social needs and decides which action they will perform next by clicking on an object or another character. For example, when selecting a Sim's laptop, the player chooses between several actions, such as playing a game, finding a job, or writing a book. Each of these boosts different skills and changes the Sim's personal development. Some actions may be autonomously performed by the Sims without player instruction. For example, a hungry, unsupervised Sim may decide to watch TV instead of cooking a meal. Neglecting the Sims' needs results in a bad mood, low energy, and ultimately death. Time only passes in the live mode, and the player can choose to pause it, speed it up, or slow it down. For example, when the Sim is sleeping, time goes faster. Additionally, when a message that requires user input appears on screen, the game automatically pauses.

The novelties of *Eco Lifestyle* are that players can use renewable energy sources in the Sims' houses, grow their own food, reduce waste by recycling and composting, and participate in neighbourhood action plans to get involved in activism projects. There are also community spaces that can be used for gardens, crafting and recycling, or marketplaces for handmade and upcycled objects. Moreover, players' choices have an impact on the world: picking sustainable materials, energy sources, and action plans will result in clear skies and abundant nature, while the opposite will result in pollution, rubbish on the street, and acid rain. By allowing players to experience the consequences of their actions in the game world and learn about sustainable living practices, *Eco Lifestyle* may potentially raise awareness and promote pro-environmental behaviours. As in *The Sims 4*, *Eco Lifestyle* lets the player explore and live in the game world, without imposing a fixed story or series of quests. This means that players are free to run the simulation as they like.

Eco Lifestyle offers the same accessibility features as the main game, *The Sims 4*, which are 14 out of the 31 relevant features on the checklist (Table 1). There is a lack of access features, as the game only provides 5 out of 18. Among them, the user interface customisation stands out because *Plasticity* and *Alba* did not offer it. The customisation, however, is limited to scale. Additional sound and visual signals are also worth mentioning. These include overlaid arrows indicating where to go next, small sized maps, and sound

effects made by the interactive objects and the Sims themselves. Challenge features are well represented, as the game offers most of the applicable ones: 9 out of 13. All training options are covered: there are tutorials, a training mode, and the possibility to review instructions, goals, and controls at any point of the gameplay. Mechanics also favour accessibility, in the sense that the player can adjust the speed of time. Similarly, there are no time constraints to reach the goals, which are ultimately not mandatory to continue playing the game. The only exception are the needs of the Sims, which need to be satisfied for them to survive.

Notable accessibility pitfalls of *Eco Lifestyle* are the lack of an alternative input device and control options in the PC. As a result, players who cannot use the mouse or keyboard may not be able to interact with the game. Similarly, text size cannot be customised and there is no screen reader, so players with visual disabilities may find it difficult or impossible to play because text is key to interact with other characters and perform the actions. Lastly, there are no trigger warnings or disabling options for the game's sensitive content.

A particularity about *The Sims 4* when compared to *Plasticity* or *Alba* is that there is a big online community of players that create and use fan-made modifications to customise the game beyond its official settings. It is important to note that this is the only big budget game analysed in this paper. Some of these modifications may contribute to the game's accessibility, intentionally or not. For example, the user interface may be changed to the dark mode with *Dark Mode UI for The Sims 4* [78], the loading song may be disabled with *No Tune After Loading* [79], and the physiological needs of the Sims may be eliminated with *Motives/Needs* [80]. These three modifications may be particularly useful for players with disabilities, as they reduce cognitive load and ease interaction.

It must be noted that no reviews about the accessibility of *Eco Lifestyle* were found, so online publications about *The Sims 4* were analysed. *The Sims 4*'s players demand accessibility options in the game, as the only customisable option in the menu is adjusting the scale of the user interface [81]. Regarding access features, Reddit user Decker12 asks for a way to remap the keyboard controls: "Any mod or method or trick in this great modern year of 2021 to remap the keyboard shortcuts in the PC version of *Sims 4*?" [82]. Other users recommend using AutoHotkey, an open-source scripting language that can modify hard-coded keys in the game. Likewise, Modsey [83] asks for the following accessibility features for players with visual disabilities: text customisation, a screen magnifier, and a screen reader. In the same forum thread, Justme22 [84] mentions issues with seeing the colour green due to low contrast, and Lorne21, a player with a visual disability, asks for a dark mode: "It would be great for us if a dark mode option, which makes it easier to read the texts in the game and which we can choose as an

in-game feature, is added as soon as possible" [85]. Finally, users would like to have an optional auto-saving feature to avoid losing data [86].

As already mentioned, *Eco Lifestyle* does not add any new accessibility features to *The Sims 4* series. As a result, players with disabilities may face barriers when trying to access the game's environmental message about which specific actions individuals and communities can do to lead a more sustainable lifestyle and ultimately have a positive impact on the environment. The most pressing issues are related to motor and visual accessibility, as the game may be played without access to the acoustic channel and actions are limited to choosing between different interaction options that are typically expressed in short, easy-to-read prompts. Compatibility with a screen reader and alternative input devices would be easy fixes for the game's barriers in the live mode, while assistance and pre-sets would be particularly useful in the build mode.

6 Conclusions and future directions

Video games can be tools for environmental awareness and education. There are different strategies for conveying the ecological message, as exemplified by the games that were analysed on this paper. *Plasticity* presents players with a pollution-ridden world, offering them the chance to improve the situation; *Alba: A Wildlife Adventure* uses children's connection to nature and wildlife to show the effectiveness of citizen-led initiatives for protecting local natural resources; and *The Sims 4: Eco Lifestyle* simulates the consequences of ecologically positive and negative choices. All three let players explore and make decisions at their own pace, without imposing time limits or restrictive goals. In this sense, they mirror reality, where individuals and communities decide whether and how to protect the environment.

In fact, the mechanics of these environmental games (perhaps inadvertently) already contribute to accessibility for players with disabilities. For example, dialogues are conveyed by text in all three games, and sound is not essential for progress, positively impacting the gaming experience of players with hearing disabilities. However, accessibility is not explicitly implemented, hindering access. In *Plasticity*, as there are no instructions about how to reduce pollution, nor additional signals highlighting interactive objects, players may not be able to reach the ending where nature is starting to heal. The reason for their lack of environmental action within the game is not due to their unwillingness, but rather the game's inherent design limitations, which hinder accessibility and playability for certain audiences.

These accessibility issues are particularly problematic in the access design pattern. If players are unable to access the basic visual, hearing and haptic stimuli of the game,

interaction will be hindered to the point of rendering the challenge options unusable. For example, *Alba* provides most of the applicable challenge options (8 out of 11), but only a third of the access options (6 out of 17). As a result, players who need control remapping, which is unavailable in the game, will not be able to access progress features such as hints. Brown and Anderson [87], who review the accessibility of 50 games released in 2019, also note that there is a need for more access options, especially in the control and presentation categories, including control remapping, and text, user interface, and colour customisation. As explained in the Accessible Player Experiences resource, accessibility features may be organised in a pyramid, where access is at the bottom, challenge in the intermediate level, and the accessible player experience at the top: "Only when a player has access and can have a chance of overcoming the challenges in the game can they have the player experience you want them to have" [61].

Accessibility means finding the balance between the game's goals and players' abilities, without easing or deleting the challenge factor, which is what makes playing fun. In fact, the optimal experience of play lies in the space between challenge and progress [88]. The three games that have been analysed here would be more inclusive if they provided a greater number of access options to customise visual, hearing and haptic stimuli. To that aim, they should integrate accessibility from the design stage of the game and, ideally, co-create its features with persons with disabilities. In this sense, fans are already modifying games to fit their needs, as the previously mentioned examples of *The Sims 4*. Future research includes analysing a larger selection of games to draw generalisable conclusions, employing netnography to analyse online engagement and interactions among players, involving users in the design and assessment of accessibility features, and reception research examining the impact of environmental awareness in players with and without disabilities.

In short, trends identified in this research regarding ecological themes and accessibility may serve as a starting point for developing more accessible environmental games, particularly by using the checklist and reviews to pinpoint accessibility successes and pitfalls. To bridge the accessibility gap in environmental awareness, it is crucial to prioritise inclusivity in video games, so that everyone can participate in creating a more sustainable world.

Appendix

See Table 1.

Table 1 Availability of accessibility features in *Plasticity*, *Alba: A Wildlife Adventure* (abbreviated as *Alba*), and *The Sims 4: Eco Lifestyle* (abbreviated as *Eco Lifestyle*)

Accessibility feature	Is it available?		
	Plasticity	*Alba*	*Eco Lifestyle*
Access design patterns			
Alternative input device	No	Yes	No
Control options			
Control remapping	No	No	No
Alternating between button toggling, holding and pressing, and repeated pressing	N/a	N/a	No
Controller sensitivity customisation	No	Yes	No
Presentation options			
Additional haptic signals	N/a	N/a	N/a
Additional sound signals	No	Yes	Yes
Additional visual signals	No	Yes	Yes
Controller vibration customisation	N/a	N/a	N/a
Customisation of visuals in motion	No	No	No
Customisation of interactive visuals	No	No	No
User interface customisation	No	No	Yes
Text customisation	No	No	No
Sign language	No	No	No
Subtitles for the dialogue	N/a	N/a	N/a
Subtitles for all sounds	No	No	No
Subtitle text customisation	N/a	N/a	N/a
Colour customisation	No	No	No
Screen magnifier	No	No	No

Table 1 (continued)

Accessibility feature	Is it available?		
	Plasticity	*Alba*	*Eco Lifestyle*
Predefined messages in the chat	N/a	N/a	N/a
Independent volume control	No	Yes	Yes
Audio description	No	No	No
Screen reader	No	No	No
Output device customisation	Yes	Yes	Yes
Challenge design patterns			
Performance options			
Difficulty customisation	No	N/a	N/a
Speed and time limit customisation	N/a	N/a	Yes
Training options			
Tutorials	No	Yes	Yes
Training mode	No	No	Yes
Review of tutorials and goals at any point of the game	No	Yes	Yes
Review of controls at any point of the game	No	Yes	Yes
Progress options			
Assist mode	No	No	No
Hints	No	Yes	Yes
Bypassing parts of the game	No	No	N/a
Manual save	No	Yes	Yes
Auto-save	No	Yes	No
Saving accessibility settings	N/a	N/a	N/a
Review of the progress	No	Yes	Yes
Review, confirm, and undo irreversible actions	N/a	Yes	Yes
Social options			
Playing with others with the same in-game preferences	N/a	N/a	N/a
Playing with others with the same communication preferences	N/a	N/a	N/a
Moderation options			
Warnings about sensitive content	N/a	N/a	No
Customisation of sensitive content	N/a	N/a	No
Total of available options	1/28	14/28	14/31
Access design patterns	1/17	6/17	5/18
Challenge design patterns	0/11	8/11	9/13

Note: Data about the availability of the accessibility features was collected by playing the games on PC. The total of available options is calculated by dividing the available options by the result of subtracting the not applicable features from the total number of features (23 for the access design pattern and 18 for the challenge design pattern)

Declarations

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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