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PERSPECTIVE

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# Climate change games as tools for education and engagement

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**Scientists, educators and policymakers continue to face challenges when it comes to finding effective strategies to engage the public on climate change. We argue that games on the subject of climate change are well-suited to address these challenges because they can serve as effective tools for education and engagement. Recently, there has been a dramatic increase in the development of such games, many featuring innovative designs that blur traditional boundaries (for example, those that involve social media, alternative reality games, or those that involve direct action upon the real world). Here, we present an overview of the types of climate change game currently available, the benefits and trade-offs of their use, and reasons why they hold such promise for education and engagement regarding climate change.**

Imagine you have the ability to travel through time and hear voicemail recordings from 100 years into the future. If present trends in sea-level rise or atmospheric warming continue, what kinds of story would be told regarding everyday life in these voicemail messages? Picture yourself seated at the table of global political negotiations as a key decision-maker on climate policy. How would you balance your nation's demand for economic development with the need for environmental stewardship for future generations? Take responsibility for polar bears, ringed seals and other animals in the Arctic. How would it feel to be in control of human decisions and forces of nature that lead to carbon pollution and other impacts on the environment? These are the kinds of new experience and perspective afforded to players when they participate in climate change games such as *FutureCoast*, *Fate of the World* and *EcoChains: Arctic Crisis*. They are part of an entire genre of climate change games that offer powerful tools for education and engagement.

Public concern about climate change has declined since peaking in 2007[1]. Many have become wary of information shared about the topic, while attitudes, perceptions and beliefs about climate change continue to be strongly mediated by political ideologies[2,3]. Programmes such as the United Nations Decade of Education for Sustainable Development have made global calls to teach about climate change[4]. These calls are now increasingly reflected in international assessments of science education[5]. Many countries have responded with curricular reform[6–8], creating a demand for tools that can help teach about the physical and social processes that cause long-term atmospheric warming. Clearly, there is an urgent need for effective ways to engage diverse audiences about global climate change.

Climate change games may offer the tools necessary to address these challenges. We define climate change games as games and simulations that have climate change as a central theme and focus on the processes, role of human systems and potential impacts regarding climate change. As in a previous study[9], we exclude games where climate change forms only a minor aspect, such as in emissions calculators and interactive tools. While we attempt to provide a balanced review of digital and non-digital formats, we also highlight current trends that reflect a dramatic increase in the development of computer and mobile-based games. We conclude with a consideration of the strengths and weaknesses of game formats that can help inform scientists and educators in their use and utility.

## Natural tools for education and engagement

Games are natural tools for climate change education and engagement. They can engross players and place them in climate-centred scenarios, as shown by participation in the games mentioned above.

In this way, games provide 'designed experiences' where players can learn through doing and being, rather than absorbing information from readings and traditional lecture formats[10]. This can be extremely powerful, as decision science has shown that first-hand experience is a much better teacher than exposure to information because of the emotional pathways it triggers[11].

These experiences are not only highly engaging, they also allow players to build empathy by taking on various roles and perspectives[12,13]. They allow for visioning — for example, being able to envision oneself in the future — and seeing consequences of actions at different points in time[14]. Furthermore, games deliver experiences that tap into a range of human emotions, from fear and aggression to joy and wonder[15]. Climate change games are thus able to target affective outcomes, such as players' motivations, attitudes and values[16]. For instance, games can promote a winner's mentality, which is what some have described as 'urgent optimism' and the belief that an 'epic win' is always possible[17]. An 'epic win' refers to finding solutions to difficult problems, which is particularly apt for addressing climate change. Finding new, more effective solutions often involves a trial and error process, and games can make it easier and less intimidating to identify new strategies[11].

In a game, one is able to simulate complex models or provide a level of control that is not possible in the real world. This is particularly advantageous when dealing with global atmospheric systems that would be otherwise difficult to bring to a hands-on level. One game that does this is *The Farmers*[18], a card-game that involves the management of common-pool resources and integrates second-order delayed effects of carbon emissions and political actors with individual goals and asymmetrical abilities. The thoughtful mechanics are intended to allow players to experience the gradual impact and complexities of real-world climate negotiations. We suggest that games such as *The Farmers* may allow players to develop a better understanding of complex systems composed of interconnected parts, broadly known as systems thinking[19]. Systems thinking has been argued to be a key skill necessary to address complex issues such as climate change[20–22].

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**Figure 1 | *Clim'way*.** A computer game in which players take action to reduce greenhouse-gas emissions in various sectors, such as energy production, agriculture and travel.

Some games allow for participation in interactive models, which enables policymakers, educators and scientists to quickly and easily test decisions and predict outcomes from actions on climate change. For example, *Climate Interactive* (http://www.climateinteractive.org) is a collection of simulations that allow for the manipulation of hundreds of variables such as fuel prices, energy consumption and population growth to model the resulting effects on world climate. The simulations are based on peer-reviewed scientific data and can be used in a variety of facilitation contexts[23,24]. As the simulations allow for direct interaction with complex models, they enable participants to inform and update their own mental models[24,25].

Climate change games are considered 'serious games' that are designed to have underlying objectives beyond mere entertainment such as instructional goals[26–28]. Game characteristics such as goals, rules, or the use of fantasy not only promote player engagement, but also influence learning[28,29]. Research supporting game-based learning extends back to the 1970s, when one of the first large-scale reviews synthesized seven years of research and included an examination of more than 150 studies[30]. Since then, empirical evidence supporting cognitive gains from instructional games has accumulated[31,32]. The impact on affective and motivational outcomes has also been identified[33,34]. Although some studies have suffered from a lack of rigour and validity in experimental design[35], the conclusion that people can learn from playing games is overwhelmingly supported by a large base of empirical evidence[30–34,36,37].

Aside from the versatility and learning opportunities that games provide, they are fun. This quality is perhaps what is most compelling about the role of games in climate change education. A good game is able to engage players for long periods of time, engendering a desire to continue playing and learning about the topic in hand by trying and experiencing alternative approaches and outcomes[38]. In other words, good games possess high intrinsic value and are naturally motivating and engaging[39]. More and more people are playing games: a nationally representative survey in the USA recently found that close to 60% of Americans play videogames[40], or an estimated 185 million people[41]. As a result, gamers represent a large potential audience for raising awareness and promoting engagement. Tapping into even a small fraction of that user base could provide ample opportunity for these endeavours[42].

## The landscape of climate change games

The first environmental games relating to climate change were designed more than 30 years ago, beginning as board-games that modelled increasing levels of $CO_2$ in the atmosphere[43]. From there, climate change games slowly grew in number and sophistication. By the time the first review article was published 14 years later, they covered a variety of topics and had a predominant focus on understanding mechanisms[44]. Technological developments also enabled a broader range of formats, with about half of the reviewed games making use of computers[44].

Since then, the number of climate change games has risen dramatically, especially in the past ten years. An extensive web-based search of climate change games was recently conducted[9]. The authors found that role play and management games comprise the most popular category, followed by online games and then board-games. Whereas climate change games were once predominantly produced at academic institutions, commercial entities and governmental agencies are becoming increasingly involved[9].

A notable example of this is *Keep Cool*, one of the first commercially available board-games about climate change[45]. In *Keep Cool*, players represent groups of countries that negotiate with each other on issues of economic growth and the mitigation of climate change. Players can choose between low- and high-emitting factories, invest in scientific research and development on mitigation, and account for lobbying groups such as oil companies and environmentalists. Extreme events such as droughts and floods increase with the rise in global mean temperature, forcing players to balance a host of economic, political and environmental factors. *Keep Cool* represents an advanced board-game that provides a tool for players to discuss a variety of issues on climate change.

Not all climate change games are as complex as *Keep Cool*. Computer games, in particular, now offer a great diversity on the topic of climate change that vary widely in quality and technical sophistication. A significant number of online climate change games exist as mini-games or simple simulations. These are generally found on websites geared towards younger audiences. Notable examples are the National Aeronautics and Space Administration's *Climate Kids* (http://climatekids.nasa.gov) and Earth Day Canada's *EcoKids* (http://www.ecokids.ca). These games employ relatively simple mechanisms such as puzzles, trivia, or actions requiring hand-eye coordination. We find that most of these focus on environmentally friendly practices such as recycling, reducing waste, or taking alternative forms of transportation. Although some of the games discuss long-term climate effects, very few contain information about the mechanisms and processes believed to cause anthropogenic climate change.

While simple online games targeted towards children have flourished, more serious climate change games continue to increase in complexity. These incorporate detailed mechanics and cover a broad range of physical, biological and sociopolitical topics. Take as an example *Clim'way*, which uses a highly graphical and interactive simulation of a metropolitan city[46]. Players make key decisions regarding city infrastructure (Fig. 1). They watch their city evolve over 50 simulated years, while learning about the scientific basis of their actions. *Clim'way* exemplifies computer games that are more complex, well-developed and scientifically informative.

## Emerging trends in climate change games

In a way similar to personal computers, the proliferation of mobile technology has made possible the emergence of many new types of climate change game. Making use of ubiquitous internet connectivity and location-sensitive hardware, they are part of a larger trend of pervasive games that blend digital and physical mediums[47–50]. Notably, climate change games have also begun to vary greatly in where player action takes place. These changes have been described as the difference between a virtual game (that is, played on a computer) and a real-world action game, which takes place in physical space (that is, in the 'real' world)[51].

The goal of most climate change games could be described as preparation for future action. That is, they may raise awareness for or educate about a particular issue, but the gameplay itself is limited



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to the confines of a board, room, or computer. Now, climate change games increasingly blend real-world and digital elements, providing opportunities for concrete action as part of the game experience. *PowerAgent* is one of the first examples to illustrate this concept[52]. Originally released for Java-enabled mobile phones, players of *PowerAgent* complete missions to reduce power consumption in their homes, such as adjusting heating levels and switching off stand-by appliances. The game is able to use actual power-consumption data from in-home metering devices to provide measurable feedback during play.

Pervasive games have since taken advantage of developments in graphical and location-based hardware. A great example of this is found in the game *Habitat*[53]. Players can collect location-based pins confirming the completion of certain missions. The game provides a hybrid experience that combines highly appealing 3D visuals and location-based features (Fig. 2).

Pervasive games also now incorporate the use of social networking. For example, in *Greenify*, players respond to real-world missions in the form of open-ended sustainability challenges[54,55]. *Greenify* allows players to generate creative ideas for sustainable living, share them with their social networks and earn points as part of the game. Later, we discuss the growing interest in how emerging technologies are creating new affordances in civic engagement. We suggest here that socially connected mobile games such as *Greenify* may provide powerful opportunities to educate and engage large networks for tangible action regarding climate change.

## A diversity of formats

The large variety of climate change games currently available can be summarized using categories and examples (Table 1). Offline facilitated experiences are played in person without heavy reliance on technology. One example of this is *SMARTIC*, a negotiation-based activity that invites players to manage climate change impacts as a stakeholder in Arctic marine spatial planning[56]. Card- or board-games include examples such as *EcoChains: Arctic Crisis*[57], a multiplayer card-game based on diminishing sea ice as a result of climate change (Fig. 3). Computer games are designed for desktop or laptop computers and can be offline or online. *Fate of the World*, a turn-based game that involves management of international policies, is a notable example[58,59]. Mobile games, on smartphones and tablet devices, are designed for on-the-go play. One example is *Climate Mission 3D*, where players learn how to reduce their carbon footprint as they tackle a collection of mini-games[60]. Finally, pervasive games involve the use of multiple formats and can involve elaborate fictional narratives enacted in real life. For example, *FutureCoast* is driven by an authentic fiction involving tangible real-world artefacts and online voicemail recordings from the future[61].

Each game format has its relative advantages and disadvantages depending on the intended goals and outcomes. If teaching about climate change is the primary goal, facilitation and debriefing are key considerations. Debriefing sessions allow for student reflection and discussion of findings, while facilitators can target specific learning goals[62]. This process is seen to strongly support learning after gameplay[27,37,63]. Offline facilitated experiences are particularly well-suited for the incorporation of debriefing. However, the requirement of a teacher or subject-matter expert may be a barrier in some instances. Card- and board-games are also well-suited for facilitation and debriefing. Furthermore, they tend to be relatively inexpensive and require less technology, but may be more difficult to scale-up for larger classrooms and audiences.

Another intended goal may be the in-game assessment of learning[32,37]. Through the use of points, levels, or questions, most games contain inherent assessment mechanisms[32]. These could be used to probe players' knowledge regarding climate change. Computer, mobile and pervasive games have special advantages regarding in-game assessment. They are able to handle player data electronically and allow for rapid large-scale assessment. Their electronic format also aids data analysis, storage and presentation. As one potential drawback, we suggest that assessment in computer and mobile games may be limited to low-level learning and behaviour as delineated by the game itself. In contrast, in-person formats allow for qualitative observation and appraisal that may reveal knowledge and practices not captured by in-game assessments[32].

ELEVATOR ENTERTAINMENT

**Figure 2 | *Habitat.*** Players care for a 3D animated polar bear by completing mini-games and real-world missions focused on environmentally friendly actions.

Finally, if the intended goal concerns actual behaviour regarding climate change, we argue that pervasive games possess advantages over other formats. Examples such as *Habitat* and *Greenify* incorporate real-world behaviour into game mechanics and intrinsically require action as part of gameplay. Some games provide tangible measures of behaviour, as is the case in *PowerAgent*[52]. Researchers are beginning to investigate whether such games can result in long-lasting behavioural effects but have yet to yield conclusive results[64]. Although pervasive games can deliver new, highly engaging experiences, one trade-off is that some may be dependent on expensive hardware or less intuitive to learn if they have many complicated rules. This may be especially the case for games that involve employing alternate reality and hybrid approaches.



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**Table 1 | A summary and comparison of formats of climate change games.**

| Game format | Key features | Pros and cons | Examples | Goals and outcomes |
|---|---|---|---|---|
| Offline facilitated experience | Facilitated activities, often involving teams or role play | Flexible and adaptable, but facilitation requirement a potential barrier | *Climate Diplomat*[71]; *SMARTIC*[56] | Facilitated learning with debriefing; qualitative assessment |
| Card-/board-game | Short gameplay session, usually involving a small number of players | Typically low in cost and technological requirements, but may be harder to scale | *Arctic Saga*[72]; *EcoChains: Arctic Crisis*[57]; *Keep Cool*[45] | Facilitated learning with debriefing; qualitative assessment |
| Computer game | Computer-based role plays, simulations or management games | Consistent and scalable experience, but requires computer hardware | *Anno 2070*[73]; *Climate Challenge*[74]; *Fate of the World*[58] | In-game assessment |
| Mobile game | Highly graphical with short, on-the-go play sessions | Able to provide portable, location-based games, but requires smartphone technology | *Climate Mission 3D*[60]; *WB Climate*[75] | In-game assessment |
| Pervasive game | May include a combination of online and offline activities | New experiences with multiple entry points, but may be less intuitive to learn | *FutureCoast*[61]; *Greenify*[54,55]; *Love Letters to the Future*[76] | In-game assessment; concrete behaviour and actions |

The selected references are representative rather than an exhaustive list.

## Conclusion

Throughout this Perspective, we have argued that games are uniquely suited to get people to understand, care about and take action on climate issues. We have discussed how games can serve as engaging tools that allow players to experience the complexities of climate systems. They can provide interactive models where players participate in decisions affecting climate change and immediately see the resulting outcomes. Games can target a variety of learning domains, and when done well, they are fun.

Climate change games now vary greatly in format, technical sophistication and scientific accuracy. This wide range provides flexibility when selecting tools for education and engagement. Consideration of their benefits and trade-offs can help to tailor them to specific needs regarding learning, assessment, or behaviour. We have suggested that pervasive games, in particular, may be especially suited for promoting concrete action regarding climate change.

JOGOLABS

**Figure 3 | *EcoChains: Arctic Crisis*.** A multiplayer card-game involving building, managing and protecting food webs of Arctic species.

Broadly speaking, making progress on climate change can be considered a matter of civic engagement. Civic engagement represents the ability of people to acquire and process information, voice and debate opinions and beliefs, and take action[65]. Strong engagement is needed to provide political, business and community leaders with a forum for discussion, planning and action on reducing greenhouse emissions and implementing sustainable practices.

The developments outlined here are promising for increasing civic engagement in local and global communities, which are all affected by climate change. There is growing consensus that the networked digital technologies of this century afford new opportunities in civic engagement[65–67]. Gameplay, in particular, is seen as uniquely positioned to foster trust and engender empathy during community planning and development meetings[68,69], but whether this results in tangible behavioural change is yet to be seen[70]. In the same way, research on whether pervasive games can produce long-term changes in behaviour remains inconclusive.

Future research should therefore focus on whether the use of games can result in long-term, observable changes in behaviour regarding climate change. Experimentation with new game types can help expand the field of pervasive gaming, while the development of new methods to assess behaviours such as power consumption or waste reduction would prove helpful to game developers. Such research could potentially result in new ways to promote tangible action.

There is also scant research on how climate change games may affect players' attitudes regarding environmental policy or scientific explanations of climate processes. Investigating this could help inform how games might be used to move beyond political ideologies and overcome the distrust of scientific information. This would also add to the understanding of how games may be best used in promoting civic engagement around climate change. We are hopeful that addressing these questions will provide a better basis for education and engagement in the years ahead. In this way, games will be better able to overcome many of the challenges that we face in fully addressing climate change.



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## Author contributions
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## Additional information
An inventory of several game-based tools that address climate change can be found at http://thepolarhub.org/search/site. Correspondence should be directed to J.J.L.

## Competing financial interests
The authors declare no competing financial interests.



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