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What happens if ...? Uncertainty in games and climate change education

Fiona van Schaik 

Department of Education and Sports Science, University of Stavanger, Stavanger, Norway

ABSTRACT

Uncertainty complicates the issue of climate change. Climate change education should therefore help students to address uncertainty. The question, then, is how to educate students about that which is ‘in the dark’. Here, we might find a role for games as a resource for climate change education. This study explores which climate change-related uncertainties were represented in three games. A qualitative content analysis was conducted using a framework that distinguishes between different types of uncertainty. Most uncertainties in the games concerned questions such as, ‘What will happen?’ and ‘What should I do?’ Five main topics of uncertainty were represented in the games: (a) climate change measures, action and cooperation; (b) climate change consequences; (c) resource availability and management, and survival; (d) events; and (e) perspectives on the climate crisis, on measures and on the treatment of others. The games approached these uncertainties differently. The study forms a starting point for research on the potential of games for addressing climate change-related uncertainty in education.

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Introduction

Uncertainty can be considered to be one of the complicating factors in climate change education (Hayden 2011; Plutzer et al. 2016; Sezen-Barrie, Miller-Rushing, and Hufnagel 2020), in decision-making about climate change (Head 2008; Levin et al. 2012) and in climate change communication (Moser 2010). Students may develop misconceptions about climate change and associated concepts (e.g. Bofferding and Kloser 2015; Jarrett and Takacs 2020), be challenged with scale issues (Skarstein and Wolff 2020) and experience anxiety (Verlie 2019). Because risk and uncertainty are seen as an inevitable part of ‘real-life’, several authors have now argued for a turn towards the more uncertain in education (e.g. Barnett 2000; Biesta 2014/2015; Block, Goeminne, and Poeck 2018; Christensen 2009; Ravetz 1997; Torgersen 2015), for example through socioscientific or even ‘wicked’ problems, such as

CONTACT Fiona van Schaik  fiona.vanschaik@uis.no  Department of Education and Sports Science, University of Stavanger, Stavanger, Norway.

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climate change (Pietrocola et al. 2021). This study explores which climate change-related uncertainties may be represented in games, to provide some insight into the resources that may be used to address uncertainty in climate change education.

Uncertainty in education

It could be argued that there are several educational approaches that are centred around some form of uncertainty. One may go so far as to claim that, ‘the more pedagogy is attuned to its own complexity, the more apparent is the significant role of uncertainty in any process of coming to know—whether academically, artistically, socially, or personally (self/identity)’ (Rosen 2019, 2). Clear examples are problem-based and inquiry-based approaches – constructivist approaches in which students explore a research question (Prince and Felder 2006). Both student and teacher may be uncertain about the answer to the question, how to answer it and their role in the educational activity. In sociocultural, dialogic approaches to education, too, uncertainty plays a role. These approaches stress the idea that meaning-making takes place when different voices meet and openly engage with each other (Wegerif 2013). Ideally, one would find oneself thinking out loud and considering new understandings. The differences in views that are involved imply that ‘uncertainty is a constitutive element of meaning and a necessary condition for understanding’ (Hardy 2006, 266). Biesta (2014/2015) advocates a similar openness for the unknown in arguing for a pedagogy that embraces the existential unpredictability and openness of education, in which one can be questioned.

A focus on the uncertain (the unknown) in educational settings also relates to ‘dark pedagogy’, which is a form of pedagogy currently being developed in Nordic countries (Lysgaard, Bengtsson, and Laugesen 2019, 16). Lysgaard, Bengtsson, and Laugesen (2019, 16) argue that traditional approaches to education may have neglected the uncertain, and instead promoted expectations of complete understanding and mastery of content, whereas dark pedagogy would stress open-endedness, uncanniness, and strangeness as inevitable parts of reality, and as being highly relevant to education. Although Lysgaard, Bengtsson, and Laugesen (2019) focus on the themes of denial, insanity and death, I understand this to be a suggestion to take note of the different types of uncertainty that we are affected by so as to be able to distinguish between what we can and cannot ‘illuminate’.

Confronting the dark may not always be comfortable, but can instead be uncanny and strange (Lysgaard, Bengtsson, and Laugesen 2019). In encountering uncertainty, teachers may experience feelings of anxiety, self-doubt and frustration, which, in turn, may lead to ‘compromised standards, reliance on routines, conservatism and conformity, blame’ (Helsing 2007, 1319). In attempting to reduce uncertainty, a teacher might find themselves holding onto what they do know, and compromising on quality in the process. When, however, a teacher experiences feelings of freedom and enthusiasm as a consequence of uncertainty, such uncertainty could entail ‘increased knowledge, effectiveness, and expertise through the investigation and experimentation with problems of practice’ (Helsing 2007, 1319). Accordingly, uncertainty could give rise to meaningful learning experiences. Uncertainty can thus have ‘negative’ or ‘positive’ pedagogical implications, depending on the psychological experience of the uncertainty by the teacher (Helsing 2007). Similarly, students may experience too little or too much uncertainty, which can obstruct learning by leading to boredom or stress, respectively (Tauritz 2012). In ‘learning to live-with climate change’ (Verlie 2019, 258), students may have emotional experiences brought about by uncertainty, such as anxiety and hope, and it is therefore important to acknowledge these emotions. Because the climate crisis could potentially be destructive for humankind, it could be argued that not engaging with these affective dimensions of climate change in education constitutes just another form of denial (Foster 2015; Lysgaard and Bengtsson 2020).

Uncertainty in games

To engage students with climate change (Ouariachi et al. 2019; Pfirman et al. 2021) and related uncertainties (van Pelt et al. 2015), games may be a useful resource in climate change education. In educational contexts, games can be regarded as ‘flexible artifacts that may take on different meanings when taught and played across different classrooms’ (Arnseth, Hanghøj, and Silseth 2018, 124). Depending on their use and interpretation, the games could therefore be used for various educational purposes. Games can be seen as models, mesocosms or environmental texts (Chang 2011, 2019) that reflect parts of the world that we are living in. They allow for zooming in on particular aspects of life, more or less realistically, and, through player-interface interaction, they give students some sort of agency about what happens in a particular setting. The simplification of complex, real world problems as seen in games could therefore allow students to explore and reflect on contemporary challenges (Chang 2011; Fjællingsdal and Klöckner 2020), such as ‘questions of environmental representation, knowledge, and ethics’ (Chang 2019, 24).

In games, we tend to find some form of uncertainty (e.g. Costikyan 2013; Kumari, Deterding, and Freeman 2019; Power et al. 2019). For example, we might not have all the information immediately available to us, we do not know what other players will do, or there is some element of randomness as with the throw of a die. Although we might have done everything to avoid confronting the uncertainty in its ‘real-life’ counterpart, one could argue that it is exactly the excitement and tension resulting from uncertainty that keeps us engaged in the game (Costikyan 2013; Kumari, Deterding, and Freeman 2019; Power et al. 2019). Games may even represent a variety of the uncertainties that are associated with climate change (Caracciolo 2022), such as the challenges posed by collective action and delayed effects (Fennewald and Kievit-Kylar 2013). Although the issue of contemporary climate change might not be explicitly addressed in a game, the game could reflect aspects of the climate crisis, such as underlying ideas about human agency, the environment and the relationship between these (Abraham and Jayemanne 2017; Caracciolo 2022).

Research question

Few studies focus on uncertainty in games for use in climate change education. This study therefore forms a starting point for exploring the potential of games as an educational resource for addressing climate change-related uncertainty. This study explores such uncertainty in three different games (*The Climate Trail*, *Frostpunk* and *Another Future*) with the following research question:

How is climate change-related uncertainty represented in the games The Climate Trail, Frostpunk and Another Future?

More specifically, two aspects of this question are analysed by means of a qualitative content analysis. First, the types of climate change-related uncertainty within the games are identified using a framework for types of uncertainty developed by Dewulf and Biesbroek (2018). Second, the main topics of climate change-related uncertainty across the games are explored.

What is uncertainty?

Uncertainty may take very different forms from one context to the next. Experiencing a feeling of uncertainty with regard to making a certain decision, for example, seems to be something that is entirely different to measurement uncertainty – that is, the possible error of measurement. However, both examples are a form of uncertainty. As there is such a variety of (more

or less overlapping) types of uncertainty, one could argue that uncertainty is a *Ballung* concept, which is a concept that is ‘characterized by family resemblance between individuals rather than by a definite property’ (Cartwright and Runhardt 2014, 268). At the same time, both measurement uncertainty and experienced uncertainty in decision-making still share the fundamental idea that there is something that we do not know: we do not know the exact value of a measurement, and we do not know what to do. Although uncertainty may take very different forms from one context to the next, its general meaning does not seem to be altered: there is something that we do not know.

Nevertheless, it seems useful to distinguish between *the ways in which* we do not know, as this informs the measures that we can use in order to look at uncertainty. Although we might contend that, ultimately, our understanding of uncertainty can be traced back to underlying epistemologies (Nearing et al. 2016) and ontologies (Dequech 2000, 2004), we can be uncertain in different ways and on different levels. Drawing from the literature on uncertainty, Dewulf and Biesbroek (2018) identify nine distinct types of uncertainty (Table 1). These have been arranged into a framework, which was developed to be able to design different strategies for dealing with different types of uncertainty in environmental governance. As it is likely that climate change-related games model decision-making situations to some extent, I regard the framework developed by Dewulf and Biesbroek (2018) to be applicable for analysing the uncertainties pertaining to the issue of climate change as represented in games.

Dewulf and Biesbroek (2018) identify nine different types of uncertainty by combining three different natures and three different objects of uncertainty (Table 1). They point out that the nature of uncertainty, at least in decision-making, may be understood as either epistemological, ontological or ambiguous - that is, we can distinguish between whether we are unsure because we lack knowledge (epistemological uncertainty), because of unpredictability in the world around us (ontological uncertainty) or because we have different viewpoints (ambiguity). Dewulf and Biesbroek (2018) also recognise that uncertainty is ‘about something’: uncertainty has an object. We could argue that there are more things to be unsure about, but in order to develop strategies to deal with uncertainty in environmental governance, Dewulf and Biesbroek (2018) identify three objects of uncertainty: content (substantive uncertainty), strategy (strategic uncertainty) and rules (institutional uncertainty). The process of environmental decision-making in consideration of uncertainty begins to sound very much like a game indeed.

Table 1. Nine types of uncertainty (cited from Dewulf and Biesbroek (2018), p. 447).

| Uncertainty | | Nature of uncertainty | | |
|-----------------------|----------------------|---|---|---|
| | | <i>Epistemic</i> | <i>Ontological</i> | <i>Ambiguity</i> |
| Object of uncertainty | <i>Substantive</i> | Lack of knowledge about the substance of the issue (e.g. what is the level of water pollution in the river?) | Irreducible unpredictability of the substantive issue (e.g. how excessive will extreme rainfall events be?) | Different frames about the substance of the issue (e.g. is this water scarcity a water supply or a water demand problem?) |
| | <i>Strategic</i> | Lack of knowledge about the (inter)actions of actors (e.g. who is part of the water policy network?) | Irreducible unpredictability of the (inter)actions of actors (e.g. how will actor A respond when publicly accused of corruption?) | Different frames about the (inter)actions of actors (e.g. is this a genuine proposal for concertation or rather a delaying tactic?) |
| | <i>Institutional</i> | Lack of knowledge about the rules of the game (e.g. what are the formal rules for public-private partnerships?) | Irreducible unpredictability of the rules of the game (e.g. how will the upcoming elections affect the environmental regulation?) | Different frames about the rules of the game (e.g. how should the precautionary principle be applied to this specific case?) |

Methods

This study explores representations of climate change-related uncertainty in three games. I conducted a qualitative content analysis inspired by the framework analysis method (Ritchie and Spencer 1994; Srivastava and Thomson 2009). The study was conducted in three steps: (1) familiarisation; (2) identification and coding; and (3) categorisation. This resulted in the identification of types and topics of climate change-related uncertainty that are represented in the three games.

For the first step, I played the three games selected for this study and made notes, including what happens in the games, what information the player is provided with, and what choices are given and made. During this step, I initially played several games in order to familiarise myself with them, and to see whether they were suitable to be included in this study. Due to the sheer number of games available, the selection of games for inclusion was arbitrary, although I did consider the games' availability, content and type. The games' availability was an important factor here, which affected what games I was able to find and try out in order to be able to select them. In addition, educational institutions might not have the resources to spend much on the purchasing of games, so freely or relatively cheaply available games were preferred over more expensive games. Regarding the content, I considered whether the game could be related to the issue of contemporary climate change. I attempted to select a broad range of games, despite the very limited number of games that would be included in the study. I therefore selected both serious and commercial games, and both digital and non-digital games. Three games were selected for analysis: the multi-platform serious survival game *The Climate Trail* (Volk 2019), the digital city-survival game *Frostpunk: A New Home* (11 Bit Studios, 2018), and the serious climate futures board game *Another Future* (Andthen 2020; Harris 2020). I played these games several times and made written notes, including, for example, the choices given in the game, descriptions, and the occurrence of events.

The US game *The Climate Trail* was developed for educational purposes by William Volk, and published by Deep State Games in 2019. In *The Climate Trail*, climate change has had drastic consequences, and the player attempts to flee from the harsh conditions. Along the way, the player has to make decisions concerning the collection and use of water and food, and how to deal with events such as heatwaves and storms, and set the pace, in order to survive and reach the destination. The game is freely available from <https://www.theclimatetrail.com/>. Developed by the Polish company 11 Bit Studios, *Frostpunk: A New Home* was published in 2018 for PC and 2019 for consoles, and is a commercial game that is set in an alternative past where the world has been frozen over and a group of refugees attempts to establish 'the last city on Earth'. The player is the leader of the group and has to take a stance on a range of ethical issues while trying to ensure that the people survive. The game has a PEGI age rating of 16 (PEGI, n.d.) and is available on Steam, Microsoft Store, Humble Bundle and GOG.com. *Another Future*, which was developed by the Scotland-based consultancy Studio Andthen, is a print-and-play board game that was designed to promote 'futures thinking virtues' (Harris 2020). In this game, each player has their own vision of how to deal with the climate crisis, and together the players form an image of what the future could look like, if they manage to collaborate. This game is not currently available.¹

In the second step, as part of the identification and coding process, I identified uncertainties that are represented in the game, wrote them down as questions, and coded these according to the framework developed by Dewulf and Biesbroek (2018). This resulted in three typologies of uncertainty – one for each game. I developed a set of questions that simplify and operationalise the framework of Dewulf and Biesbroek (2018) (Table 1) in the context of games and climate change education. I used questions (following the example of Dewulf and Biesbroek (2018)), as these, by their very nature, indicate some uncertainty. This set of questions is displayed in Table 2 below. In this study, I have not only focused on uncertainties that a student or decision-maker might have in relation to climate change, but also on uncertainties that result from the game itself. Such uncertainties could concern

Table 2. Framework of different types of uncertainty, adapted from Dewulf and Biesbroek (2018, p. 447), operationalised into simple questions for this study.

| Uncertainty | | Nature of uncertainty | | |
|-----------------------|----------------------|-----------------------|--|---|
| | | <i>Epistemic</i> | <i>Ontological</i> | <i>Ambiguity</i> ¹ |
| Object of uncertainty | <i>Substantive</i> | What is happening? | What will happen? | How to interpret what is happening? What is right? |
| | <i>Strategic</i> | What do I/others do? | What will I/others do? | How to interpret what I/others do? What should I/others do? |
| | <i>Institutional</i> | What are the rules? | What will the rules be? (i.e., How will the rules change?) | How to interpret the rules? |

the game's design, content and configuration, but also the player(s) and the outcome (Costikyan 2013; Kumari, Deterding, and Freeman 2019; Power et al. 2019). I also annotated the notes for each of the games from Step 1 with the codes in Table 2. The coded notes were then written as questions, so they clearly conveyed an uncertainty, and transferred into Table 2 (see also Appendices, A.2). I went back and forth between the games, the notes, the framework and the tables to ensure I was covering the uncertainties within the game as completely as possible. For each of the games, I colour-coded the quantity of questions to indicate how the games emphasise the different types of uncertainties.

In the third step, the questions were categorised into topics across and within the different types of uncertainty of the framework in Table 2. I summarised the coded uncertainties, and presented a typology of uncertainty for each of the games. I then considered the topics of climate change-related uncertainty with which the identified uncertainties could be associated. Finally, I attempted to delineate the topics within and across the different types of uncertainty in the framework and the games. These topics indicate more explicitly how the uncertainties in the games are related to the issue of climate change.

Results

The tables containing questions that show the uncertainties in each of the three games for the different types of uncertainty in Table 2 are displayed in the Appendices (A.2). This section primarily focuses on the typologies of uncertainty per game, and the topics of uncertainty within and across the games and the types of uncertainty displayed in Table 2.

Types of uncertainty in games

During the analytical process, I identified that each of the three games had a main question. This question was typically presented at the very start of the game and formed the starting point of each game. In this section, I will present the main question and the main types of uncertainty for each game in the study. In summary, the types of uncertainty operationalised through the questions of 'What will happen?' and 'What should I do?' seem to be most prevalent across these three games.

The Climate Trail

The Climate Trail presents its main question during the start-up of the game, prior to any gameplay: 'What happens to a society when people stop caring about the future of the planet?' The uncertainties it addresses can mostly be related to the substantive ontological questions one may have about climate change. The game addresses many of these uncertainties in the game, especially the uncertainties that are longer-term, and 'resolves' them by sketching a scenario. This is possible because the game takes place in an imagined future. Within the gameplay itself, the player may

ask themselves ‘What will happen?’ with regard to shorter-term questions about the occurrence of events, the availability of supplies and the consequences of certain strategies. See [Table 3](#).

Frostpunk

Frostpunk revolves around the question of what happens to humanity when people are faced with a changing planet. Faced with many ethical and strategical dilemmas, and with regard to a broad range of issues, the player may wonder, ‘What should I do?’, which was categorised as strategic ambiguity. As such, the player takes many decisions, and forms an answer to the main question of the game. Other questions in this game pertain to what has happened (substantive epistemological uncertainty), what will happen (substantive ontological uncertainty), how people may react (strategic ontological uncertainty) and the ‘right’ way of treating people (substantive ambiguity). See [Table 4](#).

Another Future

As described in the rules of this game, *Another Future* is about people’s collaboration in the face of the climate crisis: ‘You each have a vision for how the climate crisis should be solved; can you work together to build a future for all, or will you work alone to try and build your own ‘preferable future?’ As such, this game focuses on the challenges of cooperation, which is a strategic uncertainty. The game may show the difficulties in cooperation due to this uncertainty: are the others really cooperating (strategic ambiguity), and how will they respond to my own actions (strategic ontological uncertainty)? The game seems to intend to show that cooperation might be difficult to achieve because of the different views of the people involved – i.e. because of substantive ambiguity and, as a consequence, strategic ambiguity. These uncertainties might stimulate the player to question what our future should look like, and how they can ensure that this is achieved (substantive ambiguity). See [Table 5](#).

Table 3. Different types of uncertainty in *The Climate Trail*, which is a multi-platform serious survival game from Volk (2019).

| Uncertainty in The Climate Trail | | Nature of uncertainty | | |
|-------------------------------------|----------------------|---------------------------------|--|--|
| | | <i>Epistemic</i> | <i>Ontological</i> | <i>Ambiguity</i> |
| Object of uncertainty | <i>Substantive</i> | How did everyone die? | What event will take place when, and how often? | |
| | <i>Strategic</i> | | How will people respond to rising waters and heat? | Should I change the rations of water and food? |
| | <i>Institutional</i> | What are the rules of the game? | | |

The questions in this table are examples of the uncertainties in this game for that particular type of uncertainty. The darker the box in which this question is written, the larger the quantity of questions that were identified for this type of uncertainty. The table and the different natures and objects of uncertainty are adopted from Dewulf and Biesbroek (2018, 447), but I have inserted the sample questions.

Table 4. Different types of uncertainty in *Frostpunk: A New Home*, which is a digital city-survival game from 11 Bit Studios (2018).

| Uncertainty in Frostpunk | | Nature of uncertainty | | |
|-----------------------------|----------------------|--|--|-------------------------------------|
| | | <i>Epistemic</i> | <i>Ontological</i> | <i>Ambiguity</i> |
| Object of uncertainty | <i>Substantive</i> | Why has the world become so cold? | What will the consequences of ‘the storm’ be? | How should we treat refugees? |
| | <i>Strategic</i> | Are there other people that are still alive? | How will my people respond to my actions? | What resources should I gather now? |
| | <i>Institutional</i> | What laws can I sign? | What kind of decisions might we face in challenging circumstances? | What can/should we make laws for? |

The questions in this table are examples of the uncertainties in this game for that particular type of uncertainty. The darker the box in which this question is written, the larger the quantity of questions that were identified for this type of uncertainty. The table and the different natures and objects of uncertainty are adopted from Dewulf and Biesbroek (2018, 447), but I have inserted the sample questions.

Table 5. Different types of uncertainty in Another Future, which is a serious climate futures board game from Andthen (2020), see Harris (2020).

| Uncertainty in Another Future | | Nature of uncertainty | | |
|-------------------------------|----------------------|--|--|--|
| | | <i>Epistemic</i> | <i>Ontological</i> | <i>Ambiguity</i> |
| Object of uncertainty | <i>Substantive</i> | What are the characters' perspectives on solving the climate crisis? | What happens if I play this tile (implement this measure)? | How should we address the climate crisis? |
| | <i>Strategic</i> | What are the possible ways in which other players can respond to my moves? | How will other players respond to my moves? | Should I play this tile (implement this measure) even though it triggers an event? |
| | <i>Institutional</i> | Can I lay this tile (implement this measure) here? | What tiles (measures) will be available to me? | |

The questions in this table are examples of the uncertainties in this game for that particular type of uncertainty. The darker the box in which this question is written, the larger the quantity of questions that were identified for this type of uncertainty. The table and the different natures and objects of uncertainty are adopted from Dewulf and Biesbroek (2018, 447), but I have inserted the sample questions.

Uncertainty across the games

Across the games, five prevalent topics of climate change-related uncertainty were identified. These were related to: (a) climate change measures, action and cooperation; (b) climate change consequences; (c) resource availability and management, and survival; (d) events; and (e) perspectives on the climate crisis, on measures and on the treatment of others. These topics are found within and/or across the nine different types of uncertainty. Table 6 indicates which of these topics are thematised per game.

Table 6. Representation of the five major topics of uncertainty in the games the climate Trail (Volk 2019), Frostpunk (11 Bit Studios, 2018) and Another Future (Andthen 2020; Harris 2020).

| Game | | The Climate Trail | Frostpunk | Another Future |
|----------------------|---|---|--|---|
| Central question | | <i>What will happen?</i> ("What happens to a society when people stop caring about the future of the planet?") | <i>What should I do?</i> ("What happens to humanity when people are faced with a changing planet?") | <i>What is right? What should I do?</i> ("You each have a vision for how the climate crisis should be solved; can you work together to build a future for all, or will you work alone to try and build your own 'preferable future?") |
| Topic of uncertainty | <i>Climate change measures, action and cooperation</i> | ✓ | ✗ | ✓ |
| | <i>Climate change consequences</i> | ✓ | ✓ | ✓ |
| | <i>Resource availability and management, and survival</i> | ✓ | ✓ | ✓ |
| | <i>Events</i> | ✓ | ✓ | ✓ |
| | <i>Perspectives on the climate crisis, on measures and on the treatment of others</i> | ✗ | ✓ | ✓ |

The ✓ symbol indicates that the topic of uncertainty is represented in the game, whereas the ✗ symbol indicates that the topic of uncertainty is not represented in the game.

Climate change measures, action and cooperation

A recurrent theme in both *The Climate Trail* and *Another Future* is the question of whether people will do enough to combat the climate crisis. This topic of uncertainty ranges from the uncertainty about the different possible measures, to whether they will cooperate and take enough action. Uncertainties within this topic can be found across the different types of uncertainty, as substantive epistemic uncertainty, substantive ontological uncertainty, substantive ambiguity, strategic ontological uncertainty and strategic ambiguity. This topic therefore encompasses all uncertainty in humans' attempts to mitigate climate change, but does not consider the consequences or implications of climate change.

Climate change consequences

All three games contained uncertainty about the consequences of climate change, particularly as a substantive and strategic ontological uncertainty and substantive epistemic uncertainty. The uncertainty about climate change consequences includes the environmental, social and ethical impacts of climate change, and combinations thereof. This topic concerns the potential consequences and implications of climate change. It does not encompass uncertainty about human actions in attempts to mitigate climate change. The topic also excludes the player's more short-term uncertainty regarding the management of resources and the occurrence of events, although it may include uncertainty about the general consequences of climate change for resource availability and the prevalence of events.

Resource availability and management, and survival

Resources play a particularly important role in *The Climate Trail* and *Frostpunk*, and the player may encounter uncertainties with regard to their availability and their management. If the player fails to gather and manage the resources appropriately, they will not survive. Resources are also, therefore, of relevance to uncertainties regarding the player's survival in a climate-changed world. This topic of uncertainty is primarily classified as strategic ambiguity, substantive epistemic uncertainty and substantive ontological uncertainty. In *Another Future*, the player may also fail to survive, but this risk depends mostly on the extent of their collaboration with other players.

Events

Perhaps the most evident topic of uncertainty, which is found across all three games, is that of events. The events happen suddenly and change the circumstances of gameplay. They may be social (people ask you to do something in *Frostpunk*) or environmental (a heatwave in *The Climate Trail*). These events are seen as unpredictable, and their consequences are important for the player's progress in the game. Because of the rather unpredictable nature of the events, this topic of uncertainty is typically classified as substantive and strategic ontological uncertainty.

Perspectives on the climate crisis, on measures and on the treatment of others

Another major topic of uncertainty pertains to the different perspectives the player(s) may have on a range of issues, primarily relating to the nature of the climate crisis, which climate change measures are appropriate, and how others should be treated (in the challenging circumstances of a climate-changed world). The question of 'What is right?' is central to this topic, which can largely be related to substantive ambiguity. The question of what these different perspectives are, however, may be considered to be a substantive epistemic uncertainty. These ethical perspectives may be important in deciding upon climate change measures, action and cooperation.

Discussion

This study explores the research question *How is climate change-related uncertainty represented in the games The Climate Trail, Frostpunk and Another Future?* in order to consider the potential of games as an educational resource regarding climate change uncertainty. The study finds that the games address a wide range of uncertainties, which is in line with other studies that use different frameworks to analyse uncertainty in games (e.g. Costikyan 2013; Kumari, Deterding, and Freeman 2019; Power et al. 2019). The games seem better suited to represent some types of uncertainties than others. Uncertainties associated with such questions as ‘What will happen?’ and ‘What should I do?’ appeared to be most abundant in the games. These uncertainties relate to *substantial ontological uncertainty* and *strategic ambiguity*, respectively, in the uncertainty framework developed by Dewulf and Biesbroek (2018). Uncertainties associated with rules, *institutional uncertainty* (Dewulf and Biesbroek 2018), were less clearly represented in the three games. This could perhaps be because rules are a part of the game mechanics: the rules do not typically change; by playing the game, a player can usually get to know the rules. This may be different in real decision-making situations, where rules may be informal, and people may have different ideas about which rules are or should be guiding governance processes (Dewulf and Biesbroek 2018).

The questions of ‘What will happen?’ and ‘What should I do?’ pertain to the player’s uncertainty about the future and their own actions, and, in combination (‘What would happen if...?’), pertain to the potential consequences of their actions in the game, and these do not sound unfamiliar with regard to the issue of climate change. In particular, the question ‘What should I do?’ reflects the player’s possibility to take decisions, which Caracciolo also identifies as being important to the ‘negotiation of uncertainty in story-focused video games’ (2022, 161). Such decision-making agency may require a player to act when faced with (and in spite of) uncertainty. In educational contexts, this would mean that each student, as a player of a game, encounters uncertainty and may need to adopt a position. For example, *Frostpunk* demands players to decide on the treatment of refugees. This offers educators the opportunity to encourage reflection on this issue: What choices did the students make, and why? Are there similarities with contemporary climate refugee issues? Besides reflection, educators may consider the different types of uncertainties for developing uncertainty competences (Tauritz 2012, 2016). For example, the ability to entertain others’ perspectives (Tauritz 2012, 2016; Wiek, Withycombe, and Redman 2011) is important in dealing with ambiguity and strategic uncertainty regarding climate change, whereas facing and acknowledging ontological uncertainty may contribute to the ability to accept uncertainty about the future or to explore different future scenarios (Tauritz 2012, 2016; Wiek, Withycombe, and Redman 2011).

Furthermore, this study indicates that the three games can represent the following topics of climate change-related uncertainty: (a) climate change measures, action and cooperation; (b) climate change consequences; (c) resource availability and management, and survival; (d) events; and (e) perspectives on the climate crisis, on measures and on the treatment of others. As models that reflect real-life uncertainties in a simplified way (Chang 2011, 2019; Fjællingsdal and Klöckner 2020), the games may be suitable as a resource for educators if they want to address these topics of uncertainty, whether in the classroom or in other educational contexts. Educators could therefore consider how the games approach climate change uncertainty, with regard to their educational goals and students. For example, *Another Future* focuses on the different perspectives on measures for mitigating and adapting to the climate crisis, whereas *The Climate Trail* presents a doom scenario, where possible climate change impacts and, consequently, a struggle for survival are visualised. Each of the games places a different emphasis on diverse topics of climate change uncertainty. Similarly, educators could reflect on the extent to which students would have the possibility to deal with a specific topic of uncertainty or specific competences, such as interpersonal, anticipatory and systems thinking competences (Wiek, Withycombe, and Redman 2011). A topic as climate change consequences could be linked

to anticipatory competence, whereas the topic focused on climate change perspectives could be associated to interpersonal competence.

Differences between uncertainties in *games* and in *reality* may be of as much didactical relevance as their similarities. These differences could be perceived as limitations to the negotiation of climate change uncertainty in education, but they may also form suitable starting points for discussion or exploration. Notably, three important differences should be considered:

1. The uncertainties in the games have a fictive context. For example: both *Frostpunk* and *The Climate Trail* sketch scenarios of a climate-changed world, in an imagined alternative past and future, respectively, which may never have existed or exist. Other games, such as the simulation game *Sustainable Delta*, may approach a more realistic representation of climate change uncertainty. van Pelt et al. (2015) suggests that water managers and students playing this game gained a better understanding of climate change uncertainties in water management and their attribution to human-induced changes and natural variability.
2. Actions that are performed (or not performed) while facing uncertainty in the games only have consequences within the games. This makes a game relatively safe to play (Caracciolo 2022; Costikyan 2013). For example, the implementation of a measure in *Another Future* does not imply that this measure is implemented in reality. Other games directly stimulate consequences in real-life through nudging and/or gamification (Schijven and Kikkawa 2022).
3. The player can resolve uncertainties through gameplay or repeated gameplay, whereas it might not be possible to resolve these uncertainties in reality. For example, the future will remain uncertain in reality, whereas in fiction, the future is given (e.g. in a book one can read *the ending*) or is somewhat limited (e.g. if you reach a certain day in *Frostpunk*, you will always be confronted with a pre-defined choice between two options) (Caracciolo 2022, 32; Currie 2006, 19). Ontological uncertainties may therefore be represented more epistemologically in games than they appear to be in reality. Other ontological uncertainties, such as the (virtual) unpredictability in chance elements of games (for more about this topic, see Johnson 2019), remain ontological, although one could question whether the real-life uncertainties that they represent are equally unpredictable.

This discussion of similarities and differences between games and reality primarily relates to the games with regard to possible learning goals and encourages reflection. In addition to these three domains (game, learning goals, reflection/evaluation), educators are encouraged to consider how they talk to the students and how they take the students and their backgrounds into account (Arnseth, Hanghøj, and Silseth 2018). Uncertainty, climate change and climate change-related uncertainty may be sensitive themes that one would do well to approach with care. Educators need to take into account the students' age, maturity, level and context of education, and previous experiences. Such previous experience includes experience of playing (these and other) games (Arnseth, Hanghøj, and Silseth 2018), but also experience in relation to the topic(s) of the game and the educational activity. Students might experience psychological distress, presumably especially if they have previously been impacted by climate catastrophes or other adverse and uncertain circumstances. One could argue that games are particularly relevant for privileged students who have not yet been confronted with climate change uncertainty. However, the playful and fictive nature of games could perhaps also make it easier for some students to discuss their own experiences, or climate change-related uncertainty more generally. Games could help students to contextualise and make sense of their tacit knowledge about climate change uncertainty gained from such experiences (van Pelt et al. 2015) in the 'safe space' that games have theoretically been suggested to offer, without the need for students to be exposed to (even more) real risks (Caracciolo 2022; Costikyan 2013).

The way in which the educator talks to their students and engages them in conversation is of relevance, as this might affect how the climate change-related uncertainties in the games

are interpreted in the educational setting. The meaning of the game depends on its dialogic relationships: what are the characteristics of the game, and how is it ‘talked into being?’ (Arnseth, Hanghøj, and Silseth 2018, 126). Although this study indicates the presence of climate change-related uncertainties in games, they might not necessarily be picked up by the students or the educator. Should an educator intend to teach their students about uncertainty regarding climate change cooperation, it would not suffice to just play a game such as *Another Future*. Although the game almost inevitably allows a player to deal with uncertainty, educators have an important role in the negotiation of climate change-related uncertainty (Caracciolo 2022, 161). The context in which the students play the game is of importance. Gameplay may be followed by the more in-depth exploration of certain questions that are posed by or discovered within games, for example through inquiry-based methods.

Along with other recent studies (e.g. Caracciolo 2022; van Pelt et al. 2015), this study provides a starting point for considering the educational potential of games as resources for addressing climate change-related uncertainty. Such research appears to be promising, due to the importance of uncertainty in the climate change issue (e.g. Head 2008), gameplay (Costikyan 2013; Johnson 2019; Kumari, Deterding, and Freeman 2019; Power et al. 2019) and education (Rosen 2019). However, this study was limited to exploring the climate change-related uncertainties in three games. Whether these or other games are successful educational resources also depends on how educators and students interact with and in response to them. For example, the way in which educators perform their role in interpreting and conveying the climate change-related uncertainties that this study identifies remains to be explored. Future research could also identify appropriate teaching strategies. Similarly, further research would need to look into the students’ perception of climate change-related uncertainties in games, and the associated educational outcomes (e.g. competencies, see Tauritz (2012)). In addition to its scope, this study was limited by its focus on just three games, its reliance on a content analysis that depends on the interpretation of just one author, and its choice of theoretical framework. Although these limitations do not pose a threat to the merit of this study, its outcomes could be verified by other studies that focus on more or other games, with more authors, possibly other methods and/or other theoretical frameworks.

In conclusion, educators who want to address climate change, which is one of the most pressing issues of our time, and the factors that make this issue as challenging as it is, may use games to explore the question of ‘What would happen if...?’ together with their students. This study identifies a range of different uncertainties in climate change games, with reference to the uncertainty framework developed by Dewulf and Biesbroek (2018), which the present study has introduced to the field of educational research. By making an explicit link between in-game and real-life climate change uncertainty, the study indicates that games can provide an educator with different types and topics of climate change-related uncertainty that students can experience and discuss. The games address uncertainties about climate change measures, action and cooperation, but also concerning the consequences of climate change, whether in the form of general trends or survival challenges, with regard to resource management or, for example, encountering extreme weather events. Games may also portray differences in perspectives on the climate crisis, measures and associated social dilemmas. Students can experience taking action and making decisions when encountering uncertainty by playing games, and the educator could use this opportunity to stimulate important educational dialogues about uncertainty in relation to contemporary climate change.

Notes

1. The games are described in more detail in the Appendices (A.1). For more information about the games, visit <https://www.theclimatetrail.com/> for *The Climate Trail*; visit <https://www.frostpunkgame.com/> for

Frostpunk; and visit <https://medium.com/andthen-journal/designing-another-future-64e9ededcf9d> for *Another Future*.

2. It could be argued that the questions in this category should be separated into two different natures of uncertainty: one pertaining to differences in interpretation (ambiguity: *How should this be interpreted?*) and one pertaining to differences in values (axiological uncertainty: *What is right/good?*).

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The author reports that there are no competing interests to declare.

ORCID

Fiona van Schaik  <http://orcid.org/0000-0002-2794-3194>

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Appendices

A description of the games in this study

The Climate Trail (Volk 2019)

The background images in *The Climate Trail* are coloured in vibrant orange tones, the landscapes are barren and the cities look destroyed. They reflect *The Climate Trail's* answer to the question that is posed at the very beginning of the game: "What happens to a society when people stop caring about the future of the planet?" *The Climate Trail's* answer looks very grim. The game is set in a climate-changed future, where the climate has changed more than expected, because feedback loops were underestimated and people would not listen to the warnings of the scientists. Various actors inform the player at the beginning of the game that the USA, where the story is set, has experienced sea level rise, heat and destructive wildfires referred to as "the Burn," followed by short but catastrophic wars over resources. In the game, the player takes *The Climate Trail*, which is a route from Atlanta to Canada, to flee from the heat, which threatens to exceed the deadly wet-bulb temperature of 35 °C. On the road, the player is faced with multiple events (e.g. rain-fall, heatwaves), and must make strategic choices concerning the pace and rations for the player and their companions. If the player is successful in the management of their resources (and, perhaps, lucky) they arrive at the town of Sault Ste. Marie in Canada. In contrast with the other towns displayed in the game, this town is located in a green valley, with fresh water and many trees. This represents that 'there is another way', in which people may be successful in combatting climate change, attributed to both luck and planning. However, in the game, this "may have bought [them] only a few decades" and life may be threatened in a way similar to that of the Permian mass extinction, with anaerobic oceans and hydrogen sulphide-producing bacteria. People are blamed for the catastrophe: "If only people had taken this seriously..."

Frostpunk (11 Bit Studios, 2018)

The game *Frostpunk: A New Home* does not concern contemporary climate change. Instead, the dark, grey-toned game is set in the year 1887, and the world has frozen over. In these circumstances, the player is the captain of a group of refugees that tries to survive in spite of the extreme declines in temperature. The refugees have fled north from London, to establish themselves at a generator that provides some warmth in exchange for coal, which is located in a crater that offers some form of protection. As the refugees build their city of New London and roam the icy surroundings looking for other settlements, and as temperatures fluctuate, the player receives hints as to why it has and will continue to become so much colder. Gameplay consists largely of the management of workforce and resources for building new facilities, maintaining the generator and ensuring the survival of the people. In addition, the player can sign laws, which adds an ethical dimension to the game. Such laws concern, for example, the treatment of children, the sick and the dead, and whether it is possible to work extended shifts and to build a fighting arena. Each of these decisions may influence the hope and/or discontent of the people in New London, and this affects the player's position as a captain. At a certain point in the game, a particular discovery reduces people's hope significantly. People want to flee to (old) London. To restore hope, the player has to choose whether they want to pursue the path of order or the path of faith, each of which has its own sets of laws and facilities. In the struggle for survival, the player may be tempted to take more and more controversial decisions. These are not without consequences: as captain, the player may be banished, or, even if they survive, the game could bring into question whether the player had crossed a line.

Another Future (Andthen 2020; Harris 2020)

Another Future is about contemporary climate change, and is set in the present. Rather than presenting a 'doom-and-gloom' scenario, this game mostly consists of simple white tiles with coloured dots, and offers the players the opportunity to develop their own collective image of what the future could look like. The game is played by four players. Each player plays one of four characters, who want to tackle the climate crisis. However, the characters have different views on how this should be done. The character Hal Bass advocates technological solutions to the problem of climate change and argues for innovation, whereas Areal Pike suggests that these solutions will only postpone the climate crisis and argues for changes in values and a move away from overconsumption. Fin Pollock believes in switching to a green model of economic growth. Rae Flounder, on the other hand, argues that humans should take a few steps back in order to reinstate a balance or harmony with nature. To some extent, the interests of the characters overlap: Fin Pollock, for example, also has some sympathy for the

ideas of Hal Bass and Areal Pike. Each of the players can implement measures that they want to be part of their collective future. Some of these measures are favoured by two or three characters, some only by one. When a measure that is only supported by one character is implemented, this triggers an event. The events, which are typically disasters, such as a nuclear radiation contamination, sea level rise, crop failure and a landslide, have consequences. They may knock out some of the measures that have been implemented, or limit the players' choice of measures. Players may also choose to replace some of the measures that had already been implemented, so they might ruin other players' chances to win or help other players or themselves. The game ends when a set of 16 measures have been implemented, and the game is won by the player/s who has/have shaped this 'future' the most to their favour. There are, however, a limited number of measures available. When players replace too many measures and/or are faced with many events, they may end up with an incomplete set of measures – the players have not been able to avert the climate crisis, and they all lose. This game therefore challenges the players to work together despite their different viewpoints, or to build their own preferred future while risking disaster for all.

Uncertainty in games by type of uncertainty

Table A.2.1. Questions reflecting uncertainty in The Climate Trail.

| Uncertainty | Nature of uncertainty | | Ambiguity |
|-----------------------|---|---|--|
| Object of uncertainty | Epistemic | Ontological | |
| <i>Substantive</i> | <ul style="list-style-type: none"> How much warming seems likely to occur? How did everyone die? Have people become crazy from the heat? | <ul style="list-style-type: none"> "What happens to a society when people stop caring about the future of the planet?" How much warming will occur? Will people survive? What places will be submerged by sea level rise? Will people get the plague from permafrost melt? When will there be heatwaves? Is it really cooler and green in Canada? Will the wet-bulb temperature hit 35 °C, and if so, how long will it take for the wet-bulb temperature to reach this temperature? Will it occur in Atlanta? Will wildfires become widespread? Will people survive? What will Atlanta be like in a climate-changed future? What event will take place when, and how often? How long will it take for me to get to Canada (or locations en route)? If we wait for a storm or heatwave to pass, how long will this take? How much water will I collect when I choose to collect rainwater? How much supplies will I find if I try to find these? How much water will I find if I go looking for it? How much supplies will I find in the truck when I see one? Will we encounter Malcolm along the way? Will he be able to sell some supplies? Will there be opportunities to buy food/water along the way? How often, and how much? How much food and water will we be able to get along the way? | |
| <i>Strategic</i> | | | <ul style="list-style-type: none"> How much water and food should I buy? What should I do in the town? (How) Should I change the rations? (How) Should I adjust the pace? Should we wait or travel in case of storm or heatwave? Should I collect rainwater or travel? Should I use the (possibly polluted) water that I found? Should I give the Feral Boy some water, a lot of water, or ignore him? With what strategy could I finish the Climate Trail? |
| <i>Institutional</i> | <ul style="list-style-type: none"> What are the rules of the game? | | |

Black: uncertainty in game. Orange: uncertainty that the game scenario answers (mostly in the background story). Blue: meta-narrative questions of the game. The underlined question is the main question of the game. The quotation marks indicate that the question is cited from the game. The framework is obtained from Dewulf and Biesbroek (2018).

Table A.2.2. Questions reflecting uncertainty in Frostpunk.

| Uncertainty | | Nature of uncertainty | |
|-----------------------|---|---|---|
| Object of uncertainty | Epistemic | Ontological | Ambiguity |
| <i>Substantive</i> | <ul style="list-style-type: none"> • What weather circumstances can I expect? • Why has the world become so cold? • What resources can I find? • How long will my supplies last? • Are there nearby settlements? | <ul style="list-style-type: none"> • When can I expect 'the storm', how long will it last and what will the consequences of this storm be? • Will we be able to survive? • How much of each resource will I be able to collect, and for how long? • What can I find at nearby locations? • <u>What will people's living conditions be like in a frozen world?</u> • <u>What will happen to humanity when people are faced with a changing planet?</u> | <ul style="list-style-type: none"> • How should we treat people, including children, sick, refugees, people that want to leave, and the dead? What are my principles? • What gives people purpose? |
| <i>Strategic</i> | <ul style="list-style-type: none"> • Are there other people that are still alive? | <ul style="list-style-type: none"> • How will my people respond to my actions? • When can I expect social events (people proposing certain actions)? • <u>What will happen to humanity when people are faced with a changing planet?</u> • <u>How might people act in extreme circumstances?</u> | <ul style="list-style-type: none"> • What is the best strategy for survival? • What resources should I gather now? • What facilities should I build? • What laws should I sign? • How should I design the city? • How should I allocate the workforce? • What purpose should I use the resources for? What are my priorities? • Should I search for other people? • How should I treat people, including children, sick, refugees, people that want to leave, and the dead? • How do I give these people purpose? Through religion or order? • How far can I go with the laws that I sign? Where should the line be drawn? • How should we cope with extreme circumstances due to climate change? |
| <i>Institutional</i> | <ul style="list-style-type: none"> • What are the rules of the game? • What laws can I sign? | <ul style="list-style-type: none"> • How will the laws that I sign affect my people? • <u>What kind of decisions may we face in challenging circumstances?</u> | <ul style="list-style-type: none"> • What laws should I sign? • How should we organise society? • What can/should we make laws for? • Where should the line be drawn? |

Black: uncertainty in game. Orange: uncertainty that the game scenario answers. Blue: meta-narrative questions of the game. The underlined question is the main question of the game. The framework is obtained from Dewulf and Biesbroek (2018).

Table A.2.3. Questions reflecting uncertainty in Another Future.

| Object of uncertainty | Nature of uncertainty | |
|-----------------------|--|---|
| | Epistemic | Ambiguity |
| Substantive | <ul style="list-style-type: none"> Who seems likely to win? <u>What are the characters' perspectives on solving the climate crisis?</u> What measures might contribute to solving the climate crisis? | <ul style="list-style-type: none"> What should our future look like? How should we address the climate crisis? Which measures are the best? What do I find important? What is my perspective on solving the climate crisis? What perspectives may other people have? Why do we have different perspectives on solving the climate crisis? Why might it be challenging to cooperate? How does the text on the tiles (the measures) relate to solving the climate crisis? How does a tile (measure) relate to the players' perspectives? Why/how are tile (measure) and perspective related? |
| Strategic | <ul style="list-style-type: none"> What are the possible ways in which other players can respond to my moves? | <ul style="list-style-type: none"> Which tile should I play? Which measure should I implement? Do we cooperate or not? What is the strategy of other players? Is it better to gain points sooner in the game or later? Should I play this tile (implement this measure) even though it triggers an event? Should I choose to act for a collective future, risking that others only play for winning on their own, or play in my own interests and risk that we all lose? <u>"You each have a vision for how the climate crisis should be solved: can you work together to build a future for all, or will you work alone to try and build your own 'preferable future?'"</u> |
| Institutional | <ul style="list-style-type: none"> What are the rules of the game? How can I score points/win? Can I lay a tile here? | <ul style="list-style-type: none"> What tiles will I get? What measures will be available to me? |

Black: uncertainty in game. Orange: reality-related questions about the game. Blue: meta-narrative questions of the game. The underlined question is the main question of the game. The quotation marks indicate that the question is cited from the games' rules. The framework is obtained from Dewulf and Biesbroek (2018).