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Objects of uncertainty in gameplay: An analysis of lower secondary school students' talk during a climate change board game and a digital game

Abstract

Games may offer opportunities for meaningful dialogue in school as they provide problems, dilemmas or, more generally, uncertainties that afford engagement. This potential for meaningful dialogue is possibly even more relevant in climate change and sustainability education, where uncertainty is, arguably, an essential part of the very subject matter. This article explores how lower secondary school students respond to climate change-related games. More specifically, the article addresses the in-game talk among students, with a particular interest in how they relate to different kinds of uncertainties. This study, which analysed audio recordings of 14-year-olds playing both a board game and a digital game, suggests that students discuss their uncertainty about the games' rules more frequently than their uncertainty about the games' content. Independently of the degree of realism in the game or the number of students playing the game, neither of the games seems to have inspired talk about climate change-related topics during the gameplay itself. To stimulate meaningful dialogue about climate change-related uncertainty, teachers need to integrate the games in a broader context of dialogue and activities. The study highlights specific in-game uncertainties as potential starting points for follow-up educational activities in climate change education.

Keywords: climate change education, games, lower secondary school, student talk, uncertainty

Usikkerhet i spill: En analyse av ungdomsskoleelevers samtaler mens de spiller et klima-relatert brettspill og et digitalt spill

Sammendrag

Spill kan gi muligheter for meningsfulle samtaler i skolen, siden de byr på problemer, dilemmaer eller, mer generelt, usikkerheter som kan bidra til engasjement. Disse mulighetene for meningsfulle samtaler er særlig relevante i undervisning tilknyttet klimaendringer og bærekraft, der usikkerhet kan hevdes å være et essensielt element i undervisningsinnholdet. Artikkelen utforsker hvordan ungdomsskoleelever samhandler med klimarelaterte spill. Nærmere bestemt ser artikkelen på elevenes samtaler mens de spiller, med fokus på hvordan de tar opp forskjellige usikkerheter. Studien, som analyserer lydopptak av 14-årige elever som spiller et brettspill og et dataspill, indikerer at elevene snakker mer om deres usikkerheter tilknyttet spillets regler enn om deres usikkerheter tilknyttet spillets innhold. Uavhengig av hvor realistisk spillene var eller hvor mange elever som deltok i spillet, ser det ut til at verken brettspillet eller dataspillet inspirerte til samtaler om klimarelaterte emner mens elevene spilte. For å få fram slike dialoger må lærere gjøre didaktiske grep for å integrere spillene i en bredere sammenheng av dialog og aktiviteter. Studien viser til usikkerheter som ble identifisert i samtalene for å foreslå mulige oppfølgingsaktiviteter innenfor klimaundervisningen.

Nøkkelord: elevsamtaler, klimaundervisning, klimaundervisning, ungdomsskole, usikkerhet

Introduction

Ice. Ice. All around you, the world is frozen. You have fled a long way together with your travel companions, who now spend their days digging coal to avoid freezing in the cold. It is not enough. More needs to be done. The people are freezing, getting sick. It is not going quickly enough. Suddenly, you, their leader, are confronted with the question of whether the children should be put to work.

This scenario occurs in *Frostpunk* (2018), a digital game developed by 11 Bit Studios. The player leads a settlement struggling for survival in an ice-cold world and faces several decisions such as these, confronted with uncertainties that people might face in a world whose climate has changed drastically. In this article, uncertainty is understood in a broad sense and applied to any form of not knowing or not being certain. The uncertainties that a player faces in games like *Frostpunk* may be understood to reflect climate change-related uncertainty (Caracciolo, 2022). One might find similarities, for example between the decision-making uncertainty commonly found in games (Kumari et al., 2019; Power et al., 2019) and the decision-making uncertainty in relation to contemporary climate change (Moure et al., 2023). Players may also wonder whether they can solve a puzzle or execute actions fast enough, or what more is to come or to be discovered during the game (Costikyan, 2013; Kumari et al., 2019; Power et al., 2019). In the context

of contemporary climate change, too, one may be curious to know more about the future.

Even though games set players up for failure (Juul, 2013) and expose them to uncertainty (Caillois, 1958/2001; Costikyan, 2013; Johnson, 2019; Kumari et al., 2019; Power et al., 2019; Salen & Zimmerman, 2003), people still play games. They spend time experiencing uncertainties in relation to the actions they take, the random factors that affect gameplay and the decisions they make (Power et al., 2019). Responding to Huizinga's *Homo Ludens* (1938/2008), who wrote about the play element *of* culture, Caillois' treatise *Man, Play and Games* from 1958 describes uncertainty as one of the central characteristics of play, which is furthermore regarded as an activity that is free, separate, unproductive, and governed by rules and make-believe. Players' lack of knowledge about the outcome in advance of a game is given as the main reason for seeing play as uncertain (Caillois, 1958/2001). According to Salen and Zimmerman, this uncertainty about the outcome contributes to the meaningfulness of play, as it "allows players to feel like their decisions have an impact on the game" (2003, p. 174). Similarly, Kumari et al. (2019) suggest that players report being motivated to play, enthralled from moment to moment, *because* of uncertainties in the game. The players want to find out about further content, about their performance, the reaction of the opponent and the outcome (Kumari et al., 2019). As such, games are suggested to offer a safe space for exploring uncertainty, whereas uncertainty appears to have more negative connotations in reality (Costikyan, 2013). This could offer educational possibilities.

When reading or watching, a student generally cannot influence the course of events. In games, however, students can be more active and, to some extent, affect what happens: "When playing a game, the player adopts a temporary agency that the game frames through its goals and rules" (Kalmanlehto, 2024; based on Nguyen, 2019, 2020). In other words, games are interactive; the player's actions and the game's output can influence each other (Arsenault & Perron, 2008). This kind of circularity is often referred to in scholarly literature (Arsenault & Perron, 2008; Perron, 2006) and provides opportunities for a player to fail and try again (Garris et al., 2002; Gee, 2003; Juul, 2013; Plass et al., 2015). According to Plass et al. (2015), this possibility, or even necessity, for failing and trying again in a relatively low-stakes situation, as well as the possibilities for the game to respond to the player, would be among the main motivations for game-based learning. Other motivations for game-based learning include the engagement students show during gameplay and the various ways in which this engagement can be achieved (Plass et al., 2015). However, games may not necessarily be more motivating than other methods (Wouters et al., 2013). Wouters and colleagues suggest that games might not be more motivating than other methods, because students typically do not decide what, when, or how long to play. This could also be due to the inclusion of educational elements that disrupt the flow of gameplay. Alternatively, the studies that Wouter et al. (2013) reviewed did not measure motivation

appropriately. Previously documented positive results include outcomes that are motivational and affective, as well as knowledge-related, and skill-related (Connolly et al., 2012).

A growing body of research explores the affordances of games for education about climate change and associated uncertainties (e.g., Caracciolo, 2022; Castro Santa, 2023; Schenk et al., 2019; Stoeth & Carter, 2022; van Beek et al., 2022; van Pelt et al., 2015; van Schaik, 2023). Valkering and colleagues' simulation game addresses "water-society interaction, discontinuity, and surprise" (2019, p. 366) in exploring possible future scenarios in water management. Research on a further developed version of the game, *Sustainable Delta,* indicates that it clarifies the role of natural variability and climate change-related uncertainty in water management, although learning effects were not statistically significant (van Pelt et al., 2015). The role-playing simulation game developed by Van Beek et al. (2022) challenges players to imagine future scenarios for specific characters and to attempt to avoid tipping points through the in-game decisions they make. Participants appear to gain a better grasp of tipping points, as these become more 'real' and urgent (van Beek et al., 2022). The role-playing game *Climate Change Summit* would allow students to empathise with a character and make decisions subject to uncertainty. This may contribute to students' contextual understanding of perspectives in decision-making, which consequently might enable them to feel more at ease with uncertainty (Stoeth & Carter, 2022). Recently, Castro Santa (2023) has developed a game designed to, among other things, support teaching about climate change-related uncertainty. The aforementioned games are serious games, in the sense that they are designed for educational purposes (Abt, 1970). However, representations of climate change and its uncertainties can also be found in games that were not developed for use in educational settings (Abraham & Jayemanne, 2017; Caracciolo, 2022). For example, the digital game *Heaven's Vault* (Inkle, 2019), an archaeological science fiction game, would attempt to "attune the player to the intricacies of decision-making on a planetary scale, in the absence of absolute empirical or ethical certainties" (Caracciolo, 2022, p. 178). Van Schaik (2023) has identified various uncertainties in climate change-related games, for example in relation to resource management, climate change adaptation and the different perspectives associated with the issue of climate change.

The potential of games to playfully familiarise or confront students with climate change-related uncertainty (e.g. Caracciolo, 2022) in a relatively safe space (e.g. Costikyan, 2013) may be considered as an indirect approach to real-life problems, where overwhelming conditions and consequences are contained in a model that affords grasping and relating to the entirety of the represented world. In other words, games may turn large, meaningful problems into contained, engaging challenges, on which one can reflect (Abt, 1970). A systematic review of climate change adaptation games by Flood et al. (2018) indicates the potential of the games to contribute to communication, learning, and collaboration in

relation to decision-making situations where the players face uncertainty, engage with risky in-game challenges and may have the opportunity to explore alternative outcomes. In this study, we explore how this may be reflected in players' conversations during climate change-related games by looking at the uncertainties that are expressed.

According to a systematic review by Galeote et al. (2021), most of the research on serious climate change games in the English language seems to be focused on adults, and there is therefore a need for more studies that focus on K-12 students. Those studies with K-12 students that were included in the review appeared to support the idea that game-based experiences offer potential for promoting scientific literacy and critical thinking (Galeote et al., 2021).

In the most recent revision of the Norwegian school curriculum, sustainability is one of three main interdisciplinary themes (Utdanningsdirektoratet, 2020a). Working towards sustainability entails, in some way, dealing with climate change, including its dilemmas, complexities and uncertainties. A competence aim supporting the interdisciplinary theme of sustainability in the Norwegian lower secondary school science curriculum illustrates this: students should become able to "give examples of and discuss current dilemmas related to exploitation of natural resources and the loss of biological diversity" (Utdanningsdirektoratet, 2020b). Another competence aim in the same curriculum asks students to describe the greenhouse effect and the causes of climate change (Utdanningsdirektoratet, 2020b), and climate dilemmas are also referred to in the curriculum's section on the interdisciplinary theme of sustainable development (Utdanningsdirektoratet, 2020a). Games might therefore offer opportunities for dialogue that could be of interest to educators with students at primary and secondary schools. This study explores which in-game uncertainties lower secondary school students talk about while playing games with limited teacher intervention. Previous research conducted at Norwegian upper secondary schools has indicated that in such circumstances students may not truly discuss the core of the problems that they encounter in games and reflect on these in their own lives but instead focus on their in-game options (Sandberg, 2023; Sandberg & Silseth, 2021). Rather than expecting the students to reflect on reality while playing, this study explores the uncertainties that the students *do* talk about. The study aims to identify the potential of games to serve as meaningful references for further learning about and reflection on sustainability in general and climate change specifically.

The research question for this study is as follows:
What uncertainties do lower secondary school students talk about when they express uncertainty while playing climate change-related games?

Theory

The research question is based on a dialogic understanding of learning. Grounded on a sociocultural view of learning, dialogic theory builds on the idea that

dialogue is needed to learn, and, at the same time, learning should lead to being able to participate in dialogue (Wegerif, 2013). Dialogue is here understood in a broad sense and refers to both one-on-one interactions and long-term cultural dialogues, which can be mediated by artifacts such as books and games. Exactly how games could facilitate learning dialogues appears to be little researched, but can be expected to be different from time to time, as their meaning is context-dependent (Arnseth et al., 2018). For example, playing a game in class means something other than playing the game outside school. Similarly, a game played for a course in English would probably be framed and interpreted differently in the context of a science course. As such, games may be considered "flexible artifacts" with regard to their meaning (Arnseth et al., 2018, p. 124). From a dialogic point of view, players of a game can be understood to be in dialogue both among themselves and with the game. In this study, we explore the students' meaning making process surrounding gameplay through the uncertainties that they express in interaction with each other, in the context of sustainability education at secondary school.

Socio-cultural and socio-constructivist learning theories underscore the understanding of how students build knowledge together through conversation and practice within games. These theories posit that learning is inherently a social process, facilitated by dialogue and interaction between peers and with tools such as games. According to Roschelle (1992), collaborative learning involves the construction of shared meanings, where players engage with both the content and each other to co-construct knowledge. This process can be understood through the lens of convergent conceptual change, where collaboration aims to align players' individual interpretations towards a shared understanding. When students play climate change-related games, they not only grapple with in-game uncertainties but also engage in dialogue that fosters collective sense-making. This interaction can enhance critical thinking and problem-solving skills, as players articulate their thoughts, challenge each other's assumptions, and collaboratively generate solutions. By framing games as interactive learning environments, teachers can harness the dialogical process to promote a deeper understanding of complex issues like climate change within the classroom setting.

In considering the multifaceted nature of collaborative learning, it is essential to recognise the diverse instructional approaches that fall under its umbrella, ranging from cooperative learning and peer tutoring to problem-based learning and learning communities (Koschmann, 1996; Smith & MacGregor, 1992). While the boundaries between collaborative and cooperative learning can be blurred, with scholars viewing them as either synonymous, complementary, or distinct along a continuum of structure, both approaches harness the power of peer interactions to enhance learning (Bruffee, 1999). This interplay reflects an ongoing negotiation of power and authority within learning environments, where knowledge is co-constructed rather than transmitted (Yang, 2023).

By acknowledging the philosophical foundations that underpin collaborative learning, educators can create conditions where students negotiate the boundaries of diverse knowledge communities, promoting an educational practice that values dialogue, mutual engagement, and collective problem-solving (Bruffee, 1999; Roschelle & Teasley, 1995). This dialogic process requires a delicate balance between structure and freedom, allowing learners to navigate uncertainties while capitalizing on the strengths of their peers. As educators integrate games into the curriculum, leveraging these collaborative frameworks can transform classroom dynamics, encouraging active student participation in constructing shared understandings within complex, real-world contexts like climate change. Thus, games enriched by collaborative learning principles not only engage students in meaningful educational experiences but also prepare them for the complexities of contemporary challenges through the development of critical thinking, adaptability, and resilience (Yang, 2023).

Uncertainty is a broad term that describes several ways of not knowing. The term may be applied to refer to different sites (e.g. in reality, in a person's mind, as a social construct), different ideas of an absence of uncertainty (e.g. complete understanding, confidence, determinism), and different objects (Bevan, 2022). In this study, the different types of uncertainty are differentiated by object, based on the framework of Dewulf and Biesbroek (2018). This framework of uncertainty is developed to make decision-makers in environmental governance aware of the different types of uncertainty that they face, and the different strategies to deal with these uncertainties. Based on previous research in the field, Dewulf and Biesbroek (2018) distinguish between nine different types of uncertainty by referring to the nature and object of these uncertainties. The nature of an uncertainty relates to the reason for the uncertainty: a lack of knowledge, the nature of reality, or different perspectives and interpretations. Consequently, one can distinguish between epistemological uncertainty, ontological uncertainty, and ambiguity, respectively. The objects of uncertainty identified by Dewulf and Biesbroek (2018) give information about what the decision-maker is uncertain about. They differentiate between substantive uncertainty, strategic uncertainty, and institutional uncertainty: uncertainty about content, strategy and rules, respectively. Although the framework is meant to inform environmental decision-making, it can be transferred to other contexts. In a previous study, the framework was applied to identify different types of uncertainty in games (van Schaik, 2023). This study refers to the different objects of uncertainty, but not the different natures of uncertainty, because (a) epistemology and ontology are entangled (Dequech, 2004) and can be challenging to distinguish between; and (b) the objects of uncertainty are more easily relatable to curriculum content. As such, the study does not explore *in what way* the students are uncertain, but rather what the students express uncertainty *about*.

To truly address the issue of climate change in education, the uncertain dimensions of this issue (e.g., regarding how to respond) need to be acknowledged

(e.g., Stevenson et al., 2017). These uncertain dimensions extend beyond uncertainty about content (e.g., Dewulf & Biesbroek, 2018; Kirby & Webb, 2023; Stevenson et al., 2017), which indicates that uncertainty about strategy and rules could be of relevance to consider for climate change education, too.

Methods

For this study, we collaborated with a class of 14-year-olds and two lower secondary school teachers (L1 and L2) who wanted to try out games to address sustainable development. One teacher had a lot of experience using digital games in education. The teachers originally worked with the interdisciplinary theme with a class consisting of a mix of students from different classes, but COVID-19 measures limited them to one class. Consequently, the students had spent differing amounts of time on sustainable development that year. Nevertheless, all were familiar with the theme from previous education. We presented the research study to the students and distributed the consent forms two weeks prior to the study, held in December 2020. The students and their parents received information about the study, and the option to withdraw from the research at any time, in line with the guidelines of the Norwegian Agency for Shared Services in Education and Research (www.sikt.no/en). Seventeen of the 19 students (and their parents) consented and participated in the research. We used pseudonyms.

Materials

The students played two climate change-related games, which they had not played before. The teachers had played both. The board game, *Another Future* (Andthen, 2020; Harris, 2020),[1] is a pay as you please print-and-play board game in which four participants play different characters with different opinions on how to address the climate crisis and how the future should look. Together, the players shape the future by laying tiles on the game board with measures that correspond to some of the characters' views on climate solutions. The digital game, *Frostpunk* (11 Bit Studios, 2018), is a single-player game that had been on the schools' gaming computers for social science classes. The player leads a community that settles in an ice-cold environment, as the world has frozen over, and people struggle to survive. The game confronts the player with ethical dilemmas, such as whether to put children to work in these circumstances.

The two games differ in various ways. *Another Future* has a game board made of tiles, and cards with very abstract representations of reality in the form of words. In contrast, the elaborate computer graphics and simulations of *Frostpunk* are realistic and easily recognisable representations of an imagined reality. Furthermore, *Another Future* is a multiplayer game in which a player interacts

[1] The authors translated the game from English to Norwegian for this project.

with three other human participants, whereas *Frostpunk* is a single-player game, in which the player interacts with computer-generated characters.

Implementation

In cooperation with the two teachers, L1 and L2, a lesson with games was developed. The lesson started at 08:15 and consisted of 70 plus 70 minutes, with a 10-minute break in between. L1 presented the lesson plan, with the goal "to explore what games can tell us about sustainability". The first 70 minutes were used to introduce, play and discuss *Another Future* in groups of four. In the second set of 70 minutes, the students were introduced to, played and discussed *Frostpunk* in pairs. As *Frostpunk* is a single-player game, the students discussed what to do in the game and, every now and then, switched who was in control of the gaming computer. For both games, the students were asked to discuss a set of questions while playing (see Appendix 1 for *Another Future* and Appendix 2 for *Frostpunk*). The students noted their answers for *Frostpunk*, for which they had some extra time after gameplay. After each game, there was a short whole-class discussion that related to the set of questions and the overall goal of the lesson.

Data collection

This study focused *solely* on the students' group talk, conducted with groups of which all students and their parents consented. Gameplay was audio- and video-recorded and lasted for about 40 to 50 minutes for each game. Three groups of four students were recorded while playing *Another Future*. Six groups of two students were recorded while playing *Frostpunk*. We observed the lessons and conducted interviews with the teachers and three students to get an impression of their experiences with the lesson, but did not analyse these in this study due to the nature of the research question.

Analysis

The audio recordings of the group talk were transcribed and the files were transferred to NVivo (Lumivero, n.d.), software for qualitative data analysis. Initially, we identified uncertainties (e.g., questions, doubt, hesitation, not knowing, surprise) in the transcripts, after which we assigned a first, predefined code. As such, we primarily performed a directed content analysis to explore the objects of uncertainty that the students talked about. A directed content analysis is a qualitative analysis in which the data material is coded with initial codes that are predetermined, based on theory, and thus deductive (Hsieh & Shannon, 2005). However, we did look beyond these initial codes: Any uncertainties that did not fit into the predetermined categories received their own codes. The objects of uncertainty in the framework by Dewulf and Biesbroek (2018) informed our codes. Simplified to uncertainty about "content", "strategy", and "rules", we coded the transcribed group talk with reference to these three objects. After the coding in relation to these objects was performed, we applied more specific, data-

based codes to get more insight into the data. All codes and the total number of coding references for these codes are displayed in Appendix 3. An illustration of the coding process is shown in Appendix 4.

We operationalised the objects as uncertainty about the content of the game, uncertainty about the strategy of the students playing the game, and uncertainty about the rules of the game. Questions (or sequences of talk with underlying questions) focused on representations in the game and their meanings, were understood as uncertainty about content. Using the well-known game *Monopoly* (Charles Darrow, 1933) to illustrate, examples are "*Which chance card will I draw and what will its consequences be?"* or "*Where can I find that street?"* Uncertainty about strategy can be found in sequences of talk where explicit actions or plans for action are discussed, or where players are attempting to compare their scores with each other. In *Monopoly*, such sequences can be identified when people talk about questions such as "*Should I buy everything I come across?"*, *"What is my opponents' strategy?"* or "*How much money do I have?"* Uncertainty about rules is interpreted as uncertainty about possibilities in the game, options that players have and how these are limited through the game mechanics or rule sheet. Questions such as "*When do I win?"*, *"How can I get out of jail?"* or "*Can a player buy several hotels at once?*" reflect such uncertainty about rules in *Monopoly*.

The different objects of uncertainty aligned somewhat with the categories of uncertainty that motivate gameplay, which Kumari et al. (2019) identified: game, player, and outcome. For this study, we typically considered uncertainty about player and outcome as strategy-related uncertainty. Uncertainty about rules is not part of the framework by Kumari and colleagues, presumably because such uncertainty does not particularly encourage gameplay. As this study focused on the uncertainties that the students expressed, the object of rules was taken into consideration.

Initially, the main author coded the first transcript together with a colleague, which was helpful as we could discuss various considerations together. Such considerations pertained to the unit of analysis, double coding, and students' expressions related to turn-taking and scores (see Textbox 1). Other considerations were, for example, how to code rhetorical questions, unexpected results and implicit uncertainty. These considerations were written down in a memo file in NVivo throughout the coding process. After the whole dataset was coded, the main author presented subsets of the coded transcripts to the co-authors, and consequent discussions revealed strong agreement among the authors on the analysis.

Coding considerations

- The units of analysis were not individual utterances, as they were incomprehensible without the wider context of the conversation. Instead, sequences of student talk in which students seemed to discuss a certain topic were used. Only sequences that seemed to revolve around or contain some uncertainty were coded.
- Uncertainty underlying talk about scores was categorised as strategic, as it was used to see how well one does in comparison to others.
- Regarding turn-taking expressions, we discussed that the question "Is it my turn?" could, but need not, reflect uncertainty. Such turn-taking questions were coded as "turn-taking", but not related to one of the three objects of uncertainty, as they were typically used as discursive moves.
- Double coding occurred multiple times during the coding process, as some sequences could be about both rules and strategy, for example.
- Rhetorical questions were not coded as uncertainty.
- When a student expressed that something during the game was unexpected, this was coded as uncertainty, although this was not necessarily expressed explicitly and could also be explained as "the student was wrong, assuming that …".

Textbox 1. Considerations during the coding process. These and similar considerations were noted and used to decide on similar cases during the coding process.

Results

The students and their teachers liked working with the games, with the students preferring *Frostpunk*. During gameplay, the students expressed uncertainties that typically concerned the three objects of uncertainty analysed in this study: content, strategy, and rules. Roughly 55% of all transcribed words were expressed in relation to one or more uncertainties. The results are presented in Figure 1. Besides uncertainties about whose turn it was (see Textbox 1), we identified no other uncertainties. Turn-taking questions, expressed more than 20 times for *Another Future*, typically ended conversations in favour of continued gameplay. In general, when expressing uncertainty, the 14-year-olds talked a lot about the rules of the games, particularly for *Another Future*. While playing *Frostpunk*, student groups discussed mostly strategy and rules, sometimes simultaneously. For both games, content was the least discussed object of uncertainty.

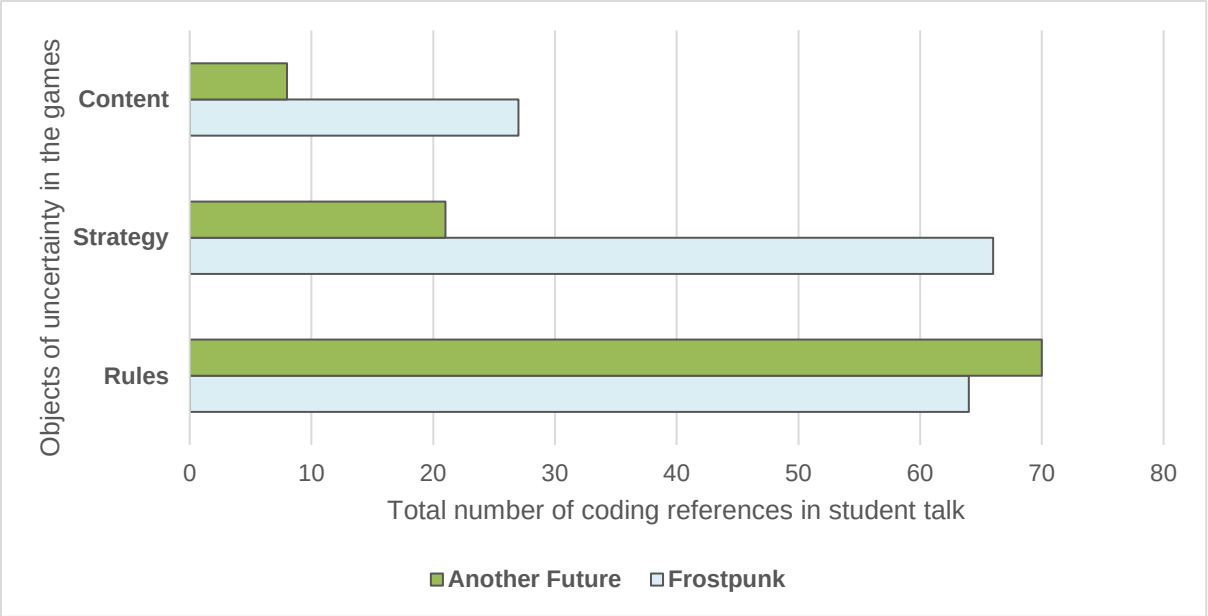

Figure 1. Total number of coding references to objects of uncertainty (content, strategy or rules) in games, identified from sequences of student group talk during or about games. This total number includes all groups (three of four students for Another Future and six of two students for Frostpunk).

Figure 2 and Figure 3 provide an overview of the objects of uncertainty identified in student talk for *Another Future* and *Frostpunk*, respectively. When the students talked about their uncertainty about content in *Another Future*, they mainly talked about the views of characters, events and the measures on the tiles in the game. In *Frostpunk*, such talk about content was about illness, the game scenario, and events and their consequences. For both games, uncertainty about strategy related to the students' uncertainties about their own actions, as well as the score or status quo that reflected how well they were doing in the game. For *Another Future*, they also talked about their uncertainties about others' actions, whereas previous actions and their consequences were the main topics of uncertainty expressed while playing *Frostpunk*. In talking about uncertainty concerning rules, the students often referred to tiles, events, and points when playing *Another Future*, and to actions, representations, checking status and possibilities when playing *Frostpunk*. The following sections address the results in more detail.

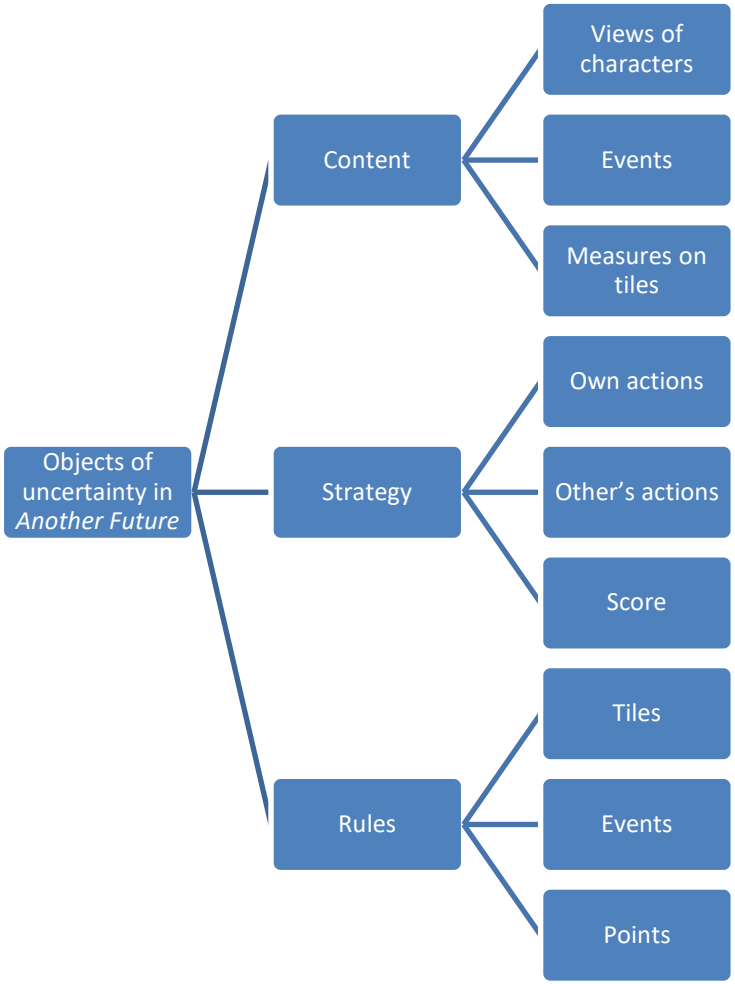

Figure 2. Objects of uncertainty in games, identified in talk of student groups playing Another Future. In relation to general objects such as content, strategy and rules, the Figure shows the main objects of uncertainty that the students in this study talked about during gameplay.

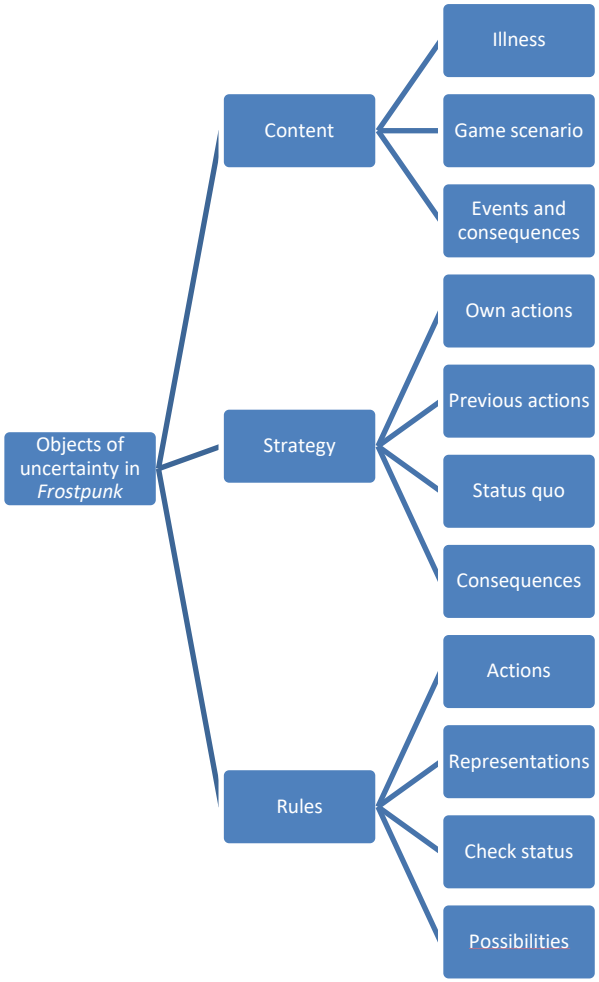

Figure 3. Objects of uncertainty in games, identified in talk of student groups playing Frostpunk. In relation to general objects such as content, strategy and rules, the Figure shows the main objects of uncertainty that the students in this study talked about during gameplay.

Uncertainty about content

Of all objects of uncertainty in the games discussed by the students, content was the least discussed, with a coverage of roughly 3% to 16% of all transcribed talk per group.

Few of the students' conversations regarding *Another Future* revolved around content-related uncertainty. These were for example about the measures on the tiles and the events in the game. In several cases, students reflected uncertainty about content when they expressed uncertainty about a character's viewpoint. Group 3 had a longer conversation about this, stimulated by the first of the set of questions that they received. Hanne led the conversation and started it by asking Jeanette what her character's viewpoints was. Jeanette read her card, Hal Bass:

Jeanette: "People are smart, and technology can reverse the climate catastrophe if we don't have too many rules. We have to take responsibility and do something. The earth is our planet, that we have shaped. We can develop new things, adapt and find new ways to live. With enough technological inventions, we soon won't have environmental problems."
Hanne: So, what does he stand for?
Sophia: Climate.
Jeanette: Yes, technology and such.
Hanne: Ok, how should we work for climate according to him? What do you all think?
Sophia: "People are smart, and technology can reverse…" [Sophia reads Jeanette's card]
Hanne: Yes, but the card doesn't give the answer. We just have to think here.
Hermann: You have to read what he thinks, and then you have to think from what he thinks.
Sophia: "… we can develop new things, adapt and find new ways to live". He wants us to live like … technological. Future. And that we should … "We have to take responsibility and do something. The earth is our planet that we have shaped." So…
Hanne: But how should we work for the climate according to him? It's a thinking exercise.
Sophia: He wants ... well … I don't know! It's a weird question.
Hanne: He wants to make technical things? So maybe he wants us to work for the climate in a way that we have more climate-friendly…
Hermann: We'll start the game and talk about this in the meantime.

The sequence shows a group that worked on their understanding. They were uncertain about how to interpret the viewpoint of Hal Bass. Hanne attempted to get Jeanette and Sophia to make sense of the viewpoint and relate it to the climate crisis. Sophia read the character card again but could not pinpoint Hal Bass' perspective. She expressed this uncertainty explicitly. Hanne, then, suggested that the character has a technology-focused perspective on climate solutions. Hermann concluded the conversation about the topic by proposing that they could start a new game and discuss the viewpoint while playing. Later, Hermann returned to the topic:

Hermann: We have to talk about how Hal Bass wants to work with climate.
Jeanette: Who are you talking to?
Hermann: Everyone. We have to talk about how Hal Bass wants climate things.
Jeanette: Hanne, you should say what he wants.
Hanne: I don't know.

Although Group 3 attempted to explore their uncertainty regarding Hal Bass' viewpoint several times, they did not resolve it. This contrasts with the other sequences in which groups expressed uncertainty about content. These sequences were typically short, about characters' viewpoints, the measures on the tiles, or events in the game. For example, the students in Group 1, who also discussed the question about characters' viewpoints, were satisfied with hearing the content of the character cards and did not attempt to interpret. Likewise, Group 2 merely briefly discussed an uncertainty about an event. Marlen asked a question about an event, but the other group members did not reply seriously:

Marlen: What does it mean that it is a long winter?
Bram: That it is a long winter.
Olaf: I'd think a long winter is a long winter.

For *Frostpunk*, most groups expressed uncertainties about content in relation to disease, the game's scenario, and the questions of what was happening in the game and what the consequences were. When discussing disease, the students wanted to know how sick the people were, what diseases they had and whether they could infect others. In the following sequence, Group 6 expressed such uncertainty:

Olaf: We have two sick people now! Four!
Hanne: How did they get sick so fast?
Olaf: This here is a new pandemic!

After this, Hanne repeatedly insisted on giving the people food ("Did they get food?") and suggested that a lack of food caused people's sickness: "It's probably why they are sick because they don't have food." Hanne suggested a resolution of the earlier uncertainty and used this in an attempt to solve the problem. Other groups also expressed such tentative suggestions as to why things in the game were as they were. For example, in Group 5, Finn said "They are upset about it, I think, about that kids can't do anything". When Finn and Hermann wondered why the people did not seem happy with eating soup, Finn mentioned: "I don't think there are that many soups they can eat." Besides such tentative explanations, some students expressed uncertainty about content in relation to the game scenario, typically within an explicit question. For example, Hermann wondered why the people in the game live down in a cave, and Finn suggested this is because there is less wind there. Hermann indicated that he did not think he would have thought to do the same. Another question regarding the game scenario is posed by Judith in Group 2, who, after the game, asked: "How can someone go out hunting for

raw meat if all animals are dead?" Besides laughing a little, the students in Group 2 did not discuss the question further.

Uncertainty about strategy

With a coverage ranging from 4% to 47% of all transcribed group talk, for both games the students expressed more uncertainty about strategy than about content. For *Frostpunk*, students talked slightly more about strategy than about rules, whereas uncertainty about rules dominated conversations during *Another Future*.

For *Another Future*, several categories of uncertainty about strategy could be distinguished. Most uncertainties were related to a student's own actions or others' actions, followed by uncertainty regarding collective actions and the score. Expressions reflecting strategic uncertainty regarding own actions included past actions. For example, Ivan, in Group 1, regretted that he had not saved a tile that would have fit in about any place, reflecting a strategic uncertainty of what to play at which time, an uncertainty of which Ivan might have become more aware. Ivan also reflected such strategic uncertainty regarding actions while they take place:

Ivan: I have a good idea. Can't I move this one?
Stig: But that one can't be moved unless you have a "sea levels rising".
Ivan: But then I can move it up there, because then Finn's point goes away.
Stig: But then my point goes away too.

The sequence also reveals Stig's uncertainty regarding others' strategy. Stig feared that Ivan would do something that would have affected his score negatively. Such uncertainty regarding the actions of others is expressed in all groups, and sometimes more neutral (Bram in Group 2: "Which one [tile with measure] will you put on [the board]?") or positive for the person expressing the uncertainty. Marlen, for example, was surprised. As the character indicated with blue in Group 2, she wondered, "Why are you building blue for me? Now I've got one more point". Uncertainty about collective actions was expressed twice, for example by Hermann in Group 3:

Hermann: What I don't get, is… I feel we help each other. If there were to be a war against each other… Well, but that is okay.

Furthermore, the students tried to find out how many points they had and compared these scores to each other.

For *Frostpunk*, the students also expressed uncertainty about strategy regarding their own actions. As they played in groups of two, they typically asked the other person in the group what to do. For example, during Marlen's turn to play in Group 3, she asked Bram multiple times what to do:

Marlen: And now, what do I do?

Finn and Hermann also discussed their in-game actions with each other, for example regarding resource management or technology for heating:

Finn: Do you want to pick that one [heaters] or do you want steam hub?
Hermann: Yeah, because we'll get it warmer.
Finn: Yeah.
Hermann: And it's better if it's warmer.
Finn: It's only that that one … Well, that one there is a heater. It's for workplaces, but this one is a steam hub. That takes a… Okay, if you are a steam hub and I am a heater, we'll do rock paper scissors.
Hermann: Ok, heaters it'll be.

In this sequence, the students resolved their uncertainty somewhat unconventionally. While they usually talked together to find out what they wanted to do, Finn and Hermann decided to resolve this strategic uncertainty with a game of rock paper scissors. Afterwards, Hermann justified this resolution: "It's almost the same thing anyway."

The students predominantly talked about what they should do when expressing some uncertainty about strategy during *Frostpunk*. However, in other instances, the students wanted to know the status quo. Groups 4, 5 and 6, who sat beside each other, occasionally talked together about the amount of homeless and sick in the different games. Guided by the set of questions, students also asked each other what they did, expressing uncertainty regarding past actions. For example, Hanne in Group 6 asked:

Hanne: What did we do on day 2?
Olaf: I don't remember.
Hanne: Wasn't it on day 3 that there was a crisis?
Olaf: Yeah, we got many sick.
Hanne: And more homeless?

Besides uncertainty about what to do, the status quo and what they did, the students expressed strategy-related uncertainty about the consequences of their actions. Recall Finn and Hermann, who implemented a law that the people have to eat soup, which ensured more food rations, but appeared to frustrate people:

Hermann: And that's what I don't … Soup is good. I would have been cheering! My hope would have been lifted, if I…
Finn: Just eating soup?
Hermann: Yes, there's fish… fish soup would …
Finn: I don't think there are that many soups they can eat.
Hermann: No.
Finn: But fortunately, there aren't any sick ones yet.

Prior to this sequence, Hermann and Finn discovered that the people disliked soup. This sequence confirmed their surprise at the reaction of the people in the

game, with Hermann saying that he would have responded differently. As such, the students expressed uncertainty regarding the consequences of their actions, also in advance of their actions. When Hermann and Finn switched on the generator, Finn said, "Now we will see if the temperature increases" and Hermann responded with "Let's hope so". As such, they indicated their own uncertainty regarding their strategy, more specifically regarding the consequences of their actions in the game.

Uncertainty about rules

The students expressed uncertainty as they were learning how to play the game. For *Another Future*, the coverage of uncertainty about rules ranged from 25% to 68% of all talk in the groups. This was 8% to 28% for *Frostpunk*.

Regarding *Another Future*, the students predominantly expressed such uncertainty about the games' rules in relation to the tiles with measures that they could play, but also in relation to the consequences of events in the game and how to get points. When referring to tiles with measures, the students usually expressed such uncertainty regarding whether they could place a tile at a particular place. "Can I do this?" Ivan asked his group when placing a tile on the board of *Another Future*. With regards to the events in *Another Future*, they for example posed questions about the purposes and consequences of event cards. Particularly Group 3 expressed uncertainty about when they would get events. Hermann repeatedly asked the group how they could get events. As a result of this uncertainty, the first game that Group 3 played was without these event cards. After the first game, they asked the teacher for clarification and played a new game, this time with the events. Other uncertainties regarding the rules about events were clarified faster, for example when Bram in Group 2 wanted to know what a heatwave entails:

Bram: Look at the rule sheet to see what a heatwave is.
Olaf: Each player chooses a tile they have and gives it to the player on their right side.

The students clarified who had to give a tile to whom and continued to play. The uncertainty regarding the rules about the heatwave event was resolved.

Uncertainty about the rules of *Frostpunk* usually concerned what certain representations were, or how to perform certain actions, followed by questions about the possibilities in the game and how to check the status in the game. Regarding the uncertainty about the representations in the game, the students posed questions such as: "Is that an oven?" (Judith, Group 2), "This is wood, right?" (Marlen, Group 3), and "What is that?" (Finn, Group 5). The uncertainty about how to do something was, for example, expressed by Ivan in Group 4, who asked a teacher how to turn on the generator, the source of heat in the settlement; and Hanne in Group 6, who expressed uncertainty about the possibilities of reducing the number of sick people in the game. The questions about how to

perform certain actions also related to uncertainty about strategy when deciding what to do: "What should I do?" contains elements of both possibility and strategy, where the strategy of the students was shaped by the possibilities in the game. The uncertainty regarding the possibilities in *Frostpunk* could be found in the tentative explanations described in Uncertainty about content, for example when Finn suggested that there are not many types of soup available. Group 6 found out that it was possible to rename game characters and spent a considerable amount of time doing this.

Discussion

When playing newly introduced games, the students in this study mostly expressed uncertainty about the rules of the game. The games' content, in contrast, was relatively little discussed. The students talked more about strategy-related uncertainties while playing *Frostpunk* than when playing *Another Future.* For both games, content-related uncertainties reflected how students attempted to make sense of the game, for example regarding what was happening and why. Strategy-related uncertainties were expressed when the students talked about their own and others' past and future actions and tried to gauge how well they were doing in the game. Rule-related uncertainties were about the space of possibilities in the game and its limitations.

In line with previous research on largely unguided student talk during gameplay performed at upper secondary schools in Norway (Sandberg, 2023; Sandberg & Silseth, 2021), the lower secondary school students' discussions in this study seemed mostly instrumental, regarding choices and possibilities for action. The 14-year-old students frequently expressed uncertainty while playing *Another Future* and *Frostpunk*. However, more content-oriented questions were relatively little addressed, particularly for *Another Future*. For *Frostpunk*, the motivational aspect of uncertainty about content in games as identified by Kumari et al. (2019) was clearer. In view of their recent experience with the COVID-19 pandemic, the students expressed particular concern about disease among the game characters. Other uncertainties about content that appeared to reflect engagement were found within the tentative explanations that students provided in response to what was happening within the game and the occasions when they questioned the game scenario.

Uncertainty about strategy was dominant in student talk during *Frostpunk,* but not for *Another Future*. This kind of uncertainty was mostly associated with decision-making, an important category of uncertainty for players' experience of digital games (Kumari et al., 2019; Power et al., 2019). The students seemed to place themselves more frequently in a position of agency in the digital game than in the board game. This is likely to be attributable to the differences between the games. As *Frostpunk* was a single-player game played in pairs, the students had

to decide on the in-game actions together, whereas in the multiplayer game, *Another Future*, they did not have to discuss their strategies. Indeed, players of *Another Future* may have avoided talking about strategy, as they could opt to compete against each other. Furthermore, the representations and gameplay mechanics in *Frostpunk* might have been easier to empathise with, as the digital game more realistically visualised the circumstances for the players. This is interesting, as *Frostpunk* is set in a dystopian, frozen world in an alternative past, whereas the *Another Future* scenario seeks to represent the current public climate change debate more closely. This study suggests that teachers may do well to start with a game such as *Frostpunk*, as meaningful dialogue about *what to do* may be easier to obtain using a digital, visually realistic, single-player game played in pairs. The qualities of a game like *Another Future*, on the other hand, may become successful as part of a well-planned educational programme.

The large proportion of uncertainty about rules in students' talk is unsurprising, considering that these games were new to the students. Rules are important for games (Stenros, 2017). According to Consalvo, the rules "keep a game distinct from other games as well as other parts of life. Paradoxically perhaps, it is the rules that make a game fun and entice an individual to play" (2007, p. 7). They add meaning through determining the actions that a player can and cannot perform, as well as the events that may occur (Juul, 2005). With only 40 to 50 minutes of gameplay, the students spent a large proportion of their time on negotiating their understanding of the rules of the game, towards a shared understanding (Roschelle, 1992). The abstract representations of reality in the board game *Another Future* appear to have required the students to discuss rules to a greater degree than in the digital game *Frostpunk*, where the representations of real life appear far less abstract and more realistic. This can be explained by the format of the game. Whereas digital games have incorporated the rules into the game mechanics, board games require players to familiarise themselves with the rules and apply them (Juul, 2005). As uncertainty about rules was often expressed during gameplay of both the digital and the board game, this study suggests that this category of uncertainty might be a useful addition to the frameworks of Costikyan (2013), Power et al. (2019) and, when expanded beyond motivational uncertainties, Kumari et al. (2019). With little time to spend on a game, teachers may expect their students' conversations to be about the rules of the game. This could give teachers the opportunity to draw the line between uncertainty about rules in the game and institutional uncertainties in reality, with the game having provided a concrete and shared experience (Roschelle, 1992; Yang, 2023) to which the topic can be related.

Students only related the games to real-life issues to a very limited degree, which is interesting when considering that these games may be understood to represent uncertainties of relevance to the issue of climate change (van Schaik, 2023). The students' discussions were primarily limited to the games themselves, although some references to reality might be found in students' concern for

disease and the few occasions that students placed themselves in the shoes of game characters. Although the students more easily related to the game scenario in *Frostpunk*, this did not seem to lead to more discussions about real-life issues. The students were probably preoccupied with playing, rather than voicing possible differences or similarities with reality.

Nevertheless, the identified objects of uncertainty can be related to themes such as climate change and sustainability. The three objects of uncertainty are derived from a framework for use in environmental governance (Dewulf & Biesbroek, 2018), indicating uncertainties of importance to decision-making situations, and, by extension, of potential relevance to education about issues like climate change. The students frequently posed the question of what to do, which is perhaps one of the most essential questions that people ask themselves regarding climate change. However, merely asking 14-year-olds to play a climate change-related game to consider how it can tell them something about sustainability does not suffice to support meaningful dialogue about climate change-related uncertainties. The teacher has an important role to play and may opt to guide the discussion through whole-class play (Sandberg, 2023), or with additional goals or tasks (van der Meij et al., 2020). In this study, the set of questions prompted some conversations, but these were typically short, and the students did not seem to refer to real life.

This study showed that students talk about many uncertainties during gameplay, yet does not provide any evidence whether potential follow-up discussions and activities offer meaningful contributions to climate change education. This remains to be seen. Future research could explore transitions between in-game talk and discussions on real-world situations. Is it useful for teachers to use uncertainties that their students encounter in games as a reference to proceed to discuss real-world situations of relevance to the curriculum? For example, to what extent are references to the game useful or distracting? We see possibilities for follow-up activities, but would they work? A game as *Frostpunk* could potentially be used to initiate a project about the connection between temperature and disease, and *Another Future* to reflect on the plurality of views on mitigating and adapting to climate change expressed by people in the media (e.g. politicians, company directors, scientists and influencers) (see Figure 4). Teachers can refer to the situation in the game during follow-up activities. While it might be more intuitive to relate in-game strategy and content to topics in climate change education, rules, both formal and informal, can also be identified in real-life situations, with relevant uncertainties.

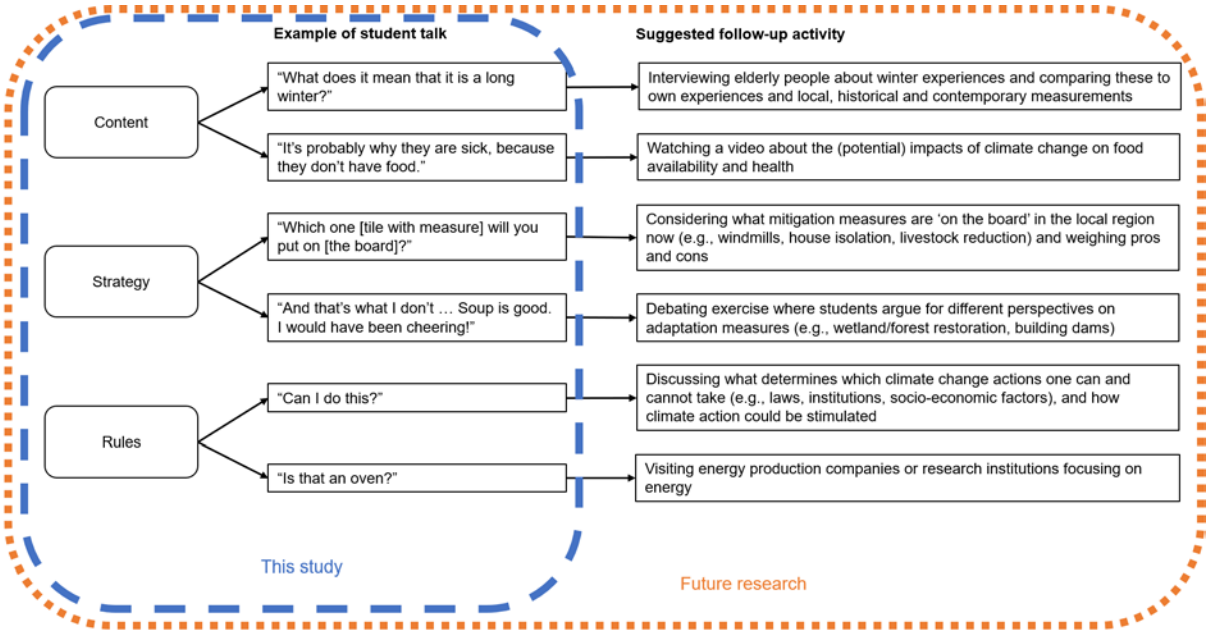

Figure 4. Examples of student talk during gameplay in which uncertainty is expressed from this study and suggested follow-up activities. The suggested follow-up activities are illustrative examples, that remain to be studied in this context. The examples are organised by the object of uncertainty that was identified in these examples. The figure shows examples from both Another Future and Frostpunk, respectively the first and second example for each object of uncertainty.

Limitations

The study was a small case study and did not have a representative, generalisable sample to substantiate claims on what uncertainties students express in similar settings. As the coding process was interpretative in nature, we found it helpful to use three broad categories. This may have limited our scope to focus more on the uncertainties' relation to these categories. However, as we first coded sequences as relating to an uncertainty, we kept a broader view and recognised the category of turn-taking. Some uncertainties could be coded into multiple categories, as these were not mutually exclusive. Nevertheless, the study provides insight into what kinds of uncertainties may be talked about when students play games. As mentioned, there are many topics that can be further investigated in this context, such as different teaching strategies, the role of the teacher, lesson and game design, the duration of gameplay, game-student interactions, and students' reflections. Future research could also explore the topic on a larger scale and evaluate the necessary follow-up activities (see Figure 4).

Conclusion

When playing climate change-related games, lower secondary school students primarily discussed uncertainties about rules and strategies rather than game content. The digital game, which was played in pairs, encouraged more strategic

discussion compared to the board game, where students could compete against each other.

The discussions among students often revolved around game mechanics, indicating a potential avenue for educators to introduce broader educational concepts. Teachers can use students' engagement with game rules and strategies as an opportunity to connect these to real-life decision-making processes relevant to climate change. By guiding discussions and drawing parallels between in-game decisions and real-world environmental scenarios, educators may foster a deeper understanding of complex issues. Game developers could aim to create scenarios that naturally bridge game mechanics with educational themes, encouraging players to reflect on real-world implications.

While students were engaged with the games, their in-game discussions did not directly address climate change educational content. This highlights a challenge for educators in ensuring that gameplay translates into educational value. Educators need to create post-game discussions or activities that tie game experiences to learning objectives, emphasizing reflection on game scenarios as analogies for real-world issues. Game developers could design supplementary materials or guides to help teachers navigate this transition, ensuring the educational potential of games is fully realized.

The brief encounters with these games offer valuable starting points but require follow-up to maximize educational benefits. Educators are encouraged to view these games as catalysts for dialogue and deeper exploration, building on the initial engagement to develop comprehensive lesson plans around climate change-related uncertainties.

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Appendices

Appendix 1 Questions for Another Future

(translated from Norwegian)

1. Play *Another Future.* Keep the board as it is when you are done playing.
2. In the game *Another Future*, you play a person who has a view on how we can get a more sustainable future, and how we can avoid the climate crisis.
    a. Talk about the viewpoint of Hal Bass.
        i. How should we work to prevent climate change, according to him?
        ii. On which tiles can you find measures that Hal Bass likes? Why are these tiles part of his view of a sustainable future?
        iii. *BONUS*: What kind of measures that you know from real life match Hal Bass' view? Why?
    b. Find the person who has a vision of the future that is furthest away from Hal Bass' vision of the future.
        i. Why do the views not match?
    c. Talk about what happened in the game. There are three possible outcomes: one person won, multiple persons/all won, or no one won.
        i. Who won and why?
3. If there is not enough time left to play once more, continue to point 4.a.ii and answer the questions from there.
   If there is enough time left, play once more. Attempt to get a future in which everyone wins. Again, keep the board as it is at the end.
4. Talk about what happened in the game.
    a. The goal was that everyone would win this time.
        i. What happened for your group? Did everyone win? Why?
        ii. What does it mean that 'everyone wins'? How would that look in the real world?
    b. There are several catastrophes in the game.
        i. Which catastrophes happened in your game? What was the result?
        ii. How can this game mirror what happens in the real world?
    c. Talk about the viewpoint of Rae Flounder.

   i. How does she think we should work to prevent climate change?
   ii. On which of the tiles can you find measures that Rae Flounder likes? Why?
   iii. Who does Rae Flounder like to work together with and why?
   iv. *BONUS*: What kind of measures from the real world fit the viewpoint of Rae Flounder? Why?
5. What are your viewpoints on a sustainable future? What kind of solutions are best?

Appendix 2 Exercises for Frostpunk

(Translated from Norwegian).

Learning goals

- **Be able to give examples of and to discuss current dilemmas in relation to the use of natural resources**
- **Be able to give examples of and to discuss current dilemmas in relation to the loss of biodiversity**
- **Discuss how energy use can affect the local environment**

The Exercises for this game consist of two parts. The first is to discuss all choices you make when you play with your group. It is necessary to give arguments for your choices and to reach agreement about what is smartest. Remember to write down the choices made and why. It is not the one who sits with the controls who has the last word; the majority wins if there is disagreement. Good communication and discussion are important because there will be many choices in the game. For each day within the game, you can change who is playing, so everyone can try and everyone can write.

The second part is to create a discussion after the game, for which there are some questions here to get you started. Here, you can write down the answers as some key terms in the same document that you used to create the timeline. Use the timeline actively to include all details and discussions you have had. If you have answered the questions, you can discuss the experiences you have had and the impressions these have left.

Exercises

1. Play through the game and manage your colony to your best of your ability. Discuss each choice with your group. It is not the case that the one who plays has the last word, as the majority decides. Take screenshots of choices and laws that you sign, so you can use this in the timeline and discussion part.
   If your colony gets lost, you can start again. Write down what you did differently this time and why.
2. Make a timeline for the game, and if you have to start over, make a new timeline for that/those sessions too. Make a table that looks like the one in the example below and fill it out.

Start on day one and write down the central events and what consequences they had for later in the game. Maximum three events a day.

a. **(Example)**

Day	**Event**	**Consequence**
1	Your citizens do not have a place to live. It is extremely cold.	People freeze and get sick.

b. Which days were most important and why?

c. Did something happen during the first days that still had effects much later in the game? (What should I have prioritised or done differently?)

3. Did you make choices that you regretted? Why? Choose a few examples.
4. Does it mean something that you cannot go back and change the choices that you made; that there is no save and reload function?
5. Can we use the game to reflect on how we are doing today?
6. How is sustainable development affected by your choices?
7. What sustainable development goal do you think it is important to focus on, so that the planet is a good place to be?
8. What do you do to prevent global warming?
9. Can we use the game to say something about the future?
10. What do you think is the cause of the new ice age in this game?
11. Did you make some sustainable choices in the game? (Explain how)

Appendix 3 All codes and the total number of coding references per game

Table 1. All codes and the total number of coding references for each code per game. Codes in bold are top-level codes, and show the initial coding for uncertainty. Underlined codes are the predefined codes that classify an uncertainty as institutional, strategic or substantial. The other codes are the more specific codes within these codes, and in some cases with even more specific sub-codes, with names based on the data material. Sub-codes are listed below the higher-level codes that they belong to.

Total number of coding references for each code, per game		
Codes	Another Future	Frostpunk
Turntaking	**35**	**6**
Uncertainty	**79**	**102**
Institutional uncertainty	71	65
What is that	0	23
Done	2	0
Events	20	0
Consequences	8	0
Take	1	0
Goal	3	0
How to check	0	8
How to do	0	24
Points	10	0
Tiles	21	0
Fit	35	0
Board direction	9	0
Number on hand	2	0
White tiles	1	0
What if you can't	2	0
What is possible	0	7
Strategic uncertainty	21	64
Collective action	2	0
Consequences	0	10
Did we	0	11
Do what	0	45
Other's action	10	0
Own action	6	0
Points	5	0
Status quo	0	11
Substantive uncertainty	8	29
Event	2	0
Explanation	0	4
Game scenario	0	3
Illness	0	6
Important days	0	1
Item in game	0	1
Kids grow up	0	2
Measure on tile	2	0
Names	0	1
Soup	0	1
Temperature	0	2
View character	4	0
What happens & consequences	0	8
Workers	0	3

Appendix 4 Coding the transcribed data material in Nvivo.

Figure 5. An excerpt of the coding process in Nvivo (Lumivero, n.d.), with the transcribed audio recordings (left) and codes (right). Uncertainty is shown in pink. The extract also shows institutional uncertainty in blue with sub-codes 'How to do' (purple) and 'What is possible' (yellow), strategic uncertainty in red, with sub-code 'Status quo' (green), and substantive uncertainty in purple with sub-codes 'Explanation' (yellow) and 'Game scenario' (red).