The Good, the Bad, and the Divergent in Game-based Learning: Player Experiences of a Serious Game for Climate Change Engagement

Daniel Fernández Galeote
daniel.fernandezgaleote@tuni.fi
Tampere University
Tampere, Finland

Chubo Zeko
chubozeko@gmail.com
University of Oulu
Oulu, Finland

Kristofers Volkovs
kristofers.volkovs@gmail.com
University of Oulu
Oulu, Finland

Marius Diamant
marius.diamant@orange.fr
University of Oulu
Oulu, Finland

Mattia Thibault
mattia.thibault@tuni.fi
Tampere University
Tampere, Finland

Nikoletta-Zampeta Legaki
zampeta.legaki@tuni.fi
Tampere University
Tampere, Finland

Dorina Rajanen
dorina.rajanen@oulu.fi
University of Oulu
Oulu, Finland

Mikko Rajanen
mikko.rajanen@oulu.fi
University of Oulu
Oulu, Finland

Juho Hamari
juho.hamari@tuni.fi
Tampere University
Tampere, Finland

ABSTRACT

Engaging citizens with climate change is an urgent and complex issue. Gamified initiatives such as game-based learning are used to promote awareness, emotional connection, and action, but we would benefit from more examples of how players truly play serious games and learn through them, especially regarding climate change, which presents unique characteristics as a learning topic. Thus, we developed a digital game about climate change and pandemics and thematically analyzed 12 players' experiences with it, including their relationship with the designed path, their possible deviations, and their engagement with the topic. Among our findings, we observe that progressing does not always involve interacting exactly as designed, and that game features that would be problematic otherwise can be accepted in the context of education. We also found that players may resist engaging in morally controversial in-game actions, give up in advance, or progress without understanding their actions' meaning. They also take actions diverging from a purely learning-oriented purpose, such as talking to and trying to interact with characters. Furthermore, game-based climate change engagement is complex and transcends learning new information. The results imply that game-based learning experiences cannot be completely guided, but designers are encouraged to clarify instructions to avoid moments of confused progress. In addition, players can frame educational games as different from entertainment ones in, e.g., their acceptable text amount, but not necessarily in terms of playful affordances. Accessibility and transparency should be addressed too. Importantly, the pedagogical and engaging value of adding playful interactions allowing for player autonomy, surprise, and character attachment should be considered. These can support player engagement and therefore maximize the educational value of games. Regarding climate change, we provide cognitive, affective and behavioral implications, including a call for designs that consider player agency and context.

CCS CONCEPTS

• **Applied computing** → **Interactive learning environments**; **Computer games**; • **Human-centered computing** → **User studies**.

KEYWORDS

game-based learning, serious games, gamification, player experience, climate change engagement, sustainability

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1 INTRODUCTION

Gamification, or the intentional transformation of activities and systems to afford game-like experiences [21], has permeated for over a decade multiple areas of society, predominantly education and health [26]. Game-based learning, a form of educational gamification, involves activities where players are expected to attain learning outcomes through game play [38].

One domain in which gamification has grown during the last decade is climate change engagement, where games have been explored and often shown to be successful in cognitively, affectively, and behaviorally connecting diverse players with the issue [17].

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Dozens of computer games about climate change exist, and most of them are designed with the purpose to engage players with the topic [13] through multiple identities and actions [14]. However, multiple gaps have been identified in existing interventions both in researching the issue and in the games' design [17]. One game design challenge is to provide experiences that elicit effective user engagement with the topic on all levels, namely cognitive, affective, and behavioral [39]. Therefore, we created a digital game to research how game design can engage players, and how they react to the game's design. Informed by the literature on games for climate change engagement [13, 14, 17], the game includes features such as a focus on health as a climate change impact, a complex view of the citizen as an actor beyond consumer behavior, and prompting real-world player action.

Next, we conducted a study to explore how players truly engage with serious games and how they experience game elements introduced to elicit engagement. This is because gamification aims to engage players with a real-world topic and pursues outcomes, such as education or attitude and behavior change, but players may have other interests besides being persuaded. While some gamification typologies acknowledge that players motivated by change and disruption exist [49], serious game design frameworks focus on crafting experiences that support pedagogical goals but require players to behave as designers expect. This is potentially problematic, and not only given the importance of intrinsic motivation for learning [26, 38] and autonomy for enjoyment and effectiveness [11, 23]. If gamification design and analysis remain ignorant of gameplay events that do not strictly follow the designed path, such as acting before reading, greeting a character, mocking an element in the environment, or problematizing the game's content, these occurrences may counteract the designers' intentions. For this reason, our study aims to holistically answer the following research question: *How do players experience and interact with a serious game about climate change, including their relationship with the designed path, their possible deviations, and their engagement with the topic?*

2 BACKGROUND

2.1 Games and gamification

Although multitude of game definitions have been proposed [44], one of the most common used in games scholarship is Salen Tekinbaş and Zimmerman's "system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome." [46, p. 81]. Gamification, which can be used as an umbrella term encompassing concepts such as serious games and game-based learning [21], often uses principles of game design to transform activities so that they result in game-like experiences that support behavioral and cognitive changes [21]. Hence, intentional gamification shares techniques and principles with the discipline of game design, but departs from it by commonly seeking a utilitarian result beyond entertainment. In particular, game-based learning consists of using games, not always digital [38] and not always designed for educational purposes [37], to engage players in learning activities where an educational topic is not treated as content to be delivered but rather as part of a game system (i.e., an artificial conflict with rules and outcomes) that players engage with through a role and enacted (consequential) choices [37].

Broadly speaking, a game designer's role is to author a gameplay experience that hooks the player [16]. This is typically expressed as attempting to keep the player in a state of flow through a balance of challenge and ability [16]. In simple terms, then, a priority of game designers is to maximize moments of continuity, where players are actively using their skills to overcome challenging activities, and minimize discontinuity, or moments in which disruptions of this balance may make players bored or frustrated.

Gamification designers must commonly add the attainment of behavioral or cognitive outcomes to the provision of a satisfactory gameplay experience [21]. For this reason, they will typically focus on indicators, such as player engagement with the topic, that general methods of game design evaluation will not cover. Hence, specific frameworks exist to support serious games and game-based learning design. While the elements and categories considered vary among proponents (e.g., [2, 42]), a common assumption is that the player experience should be meticulously crafted [36], including their emotions [4] and forms of enjoyment [9]. In formal education particularly, curriculum demands may significantly shape the game content and structure (see, e.g., [22]). Where design frameworks have been proposed to be used as analytical tools, their goal is to understand how game design elements promote learning [5, 6, 8] or, more broadly, "productive" engagement with the topic. In summary, methodologies aimed at supporting game-based learning design focus primarily on how learning occurs, leaving out of the picture other aspects of the player experience.

More broadly, gamified systems aim to change behaviors and cognition, so they will work at their best when players are receptive to their messages; in other words, their implied player [1] is one who collaborates in being persuaded by the game and its message. However, players may want and attempt to engage with them in unexpected, messy, divergent and essentially playful ways. After all, games and play are becoming central and even ubiquitous in modern societies [21], so many players are used to freely play within structures fundamentally similar to those of serious games (e.g., digital commercial games for entertainment). Given that activities framed as games tend to prompt playful behaviors [11], it is only expected that players will want to do more than just play to learn exactly in the intended way. In this way, a tension exists between the educational frame and the play frame, and more specifically, between the designer's goal and the player's.

The fact that serious game play is often prompted by authorities such as teachers and employers, rather than the players themselves, may lead to issues. Forceful play can reduce the sense of autonomy and enjoyment and harm effectiveness [23]. However, if game play fits what players spontaneously feel inclined to do, or simply turn out to be enjoyable, these negative effects may be countered [12].

2.2 Supporting gamified autonomous learning

Given the importance of supporting player autonomy, multiple proposals of how to design for it have been offered. Even outside of games, designers have proposed encouraging free creation and communication, and using ambiguous design to support the user's autonomous meaning-making [18]. In game design, the core of the gameplay experience has been defined as making meaningful choices [46]. Choices may be meaningful, for example, given the

possibility of failure, which in game-based learning may even be an integral part of the learning experience [38]. In this way, having the freedom to fail is not understood as a form of discontinuity, but rather as designed and expected. Other proposals to support player agency in game-based learning include promoting player freedom, e.g., via systems that permit exploration and system restructuring, and accommodating multiple play styles and approaches to problems [10]. In gamification, this would include those users who are motivated by change and disruption of the designed experience [49]. A broad reading of how designers direct freedom in games includes four types of limits: the possible (what can be done but is not necessary), the impossible (what cannot be done), the mandatory (what must be done), and the forbidden (what can be done but has negative consequences) [33]. Therefore, managing freedom includes not only imperatives, but also possibilities and discouragement. Players with a mental model of video games including these affordances will likely expect them in the context of gamification too, as occurs in design interaction broadly [35].

In fact, player agency goes beyond openness or meaning "by design." Especially in narrative games, agency need not involve choice, but a commitment to meaning in an interaction, that is, expressing intent and it being positively received [45]. More broadly, eudaimonic agency would not be only about affecting the game's system or narrative, but also interpreting one's own actions and reflecting upon the game's fictional elements [7]. A concept from the field of education relevant to game-based learning, agentic engagement, is defined as learners' "constructive contribution into the flow of the instruction they receive" [40, p. 258]. Agentic engagement is about personalizing the learning activity, making it more enjoyable and relevant to oneself, bringing new perspectives and asking for more content, among other things [40]. These perspectives shift the initiative and creativity from the designer-instructor to the player-learner. Indeed, it has been suggested that gamification should move away from a focus on the artifact towards a focus on experiences supporting eudaimonia, or a good life [11], and from extrinsically motivating mechanisms to enjoyable experiences of play as the core of game-based learning [43]. Designers have been encouraged to provide open spaces where players may find their own path, rather than determining a solution for players to discover [47], i.e., enabling rather than controlling [48]. These recommendations fit well with the characteristics of climate change as an engagement problem, described next.

2.3 Gamified climate change engagement

Beyond the general issues mentioned above, specific principles should be taken into account when attempting to engage players with a topic such as climate change. Unlike other challenges, climate change has been termed a wicked problem: it is physically and socially complex, large-scale, long-term, and solutions cannot be single, definitive, and satisfactory to the diversity of actors involved [25]. Furthermore, others have termed it a "super wicked" problem given that time is of the essence, those with the most power to address it also cause it, action is irrationally delayed, and its reach is larger than the legal and institutional frameworks in place [28]. Climate change is publicly discussed and players are likely to have some knowledge and opinion about it. In fact, public engagement with climate change can be seen as broader than scientific understanding: the engaged person will manifest a cognitive, and affective, and a behavioral connection to the issue [30], which complicates both the idea of the learner as a blank slate who either knows or does not know, and that of the serious game as a simple transmitter of knowledge.

While cognition, emotion and behavior have been long recognized as relevant components of student engagement [15], these are further complicated when learning about and/or gamifying climate change, given the complex psychosocial factors affecting climate change engagement [19, 34, 52]. Given the difficulty to promote deep and lasting engagement with climate change, experts have proposed replacing top-down approaches, which assume that the main issue is a deficit of information, with dialogic strategies that consider the public's personal circumstances [53]. In this vein, methods promoting interactivity and engagement have been deemed effective [32, 39].

In particular, gamification has been found to be effective across the climate change engagement spectrum while providing enjoyable and meaningful gameplay experiences, but challenges and gaps still exist and need to be studied [17]. This is not limited to intentional gamification; both games for entertainment and serious games show climate change engagement potential according to expert criteria [13]. In addition, games have been found to provide a diversity of identities for players to embody and explore [14] which is positive given the multiplicity of actors involved in climate change action and the need to rethink and expand the role of citizens in it [53]. The game used in this study was designed to provide information about a largely unknown topic, the connections between climate change and infectious diseases [51], but switches to an emergent dialog model when considering climate action [3]. Thus, despite its didactic structure, where interaction largely supports information, the game applies at various times guidelines proposed for emergent dialog in games [3], e.g., showing causes and consequences rather than right and wrong; providing mechanisms to support discussion about content; and allowing players to autonomously set their own goals. This dialogic approach is in line with agentic engagement [40] and, while limited by various constraints, it aims to merge traditional, teaching-like experiences with more player-driven ones. The game is described in detail next.

3 METHODS

To answer our research question, we conducted an exploratory study to observe how players experience the game, including their relationship with the designed path and the possible deviations from it, and their engagement with the topic. For the study, we recruited 12 participants who played the game to completion. Qualitative data was collected in the form of observational notes and interview responses. Thematic analysis has been used to analyze the collected data. Next, we describe three methodological perspectives of the study: a description of the game system used, the data collection context, and the data analysis process.

3.1 Game system description

This study employs a serious game for climate change engagement, *Climate Connected: Outbreak*. The game has been designed and

developed by the first author. Similar versions of the game exist for VR systems and regular computer screens. The game is designed to be played and completed in a single session of one hour or less.

The game discusses the topic of pandemics and other health issues that can be worsened by degrading environmental conditions. Its central message is that environmental, animal and human health are interlinked, and that climate change worsens all of them [50]. In this way, the game connects climate change with quotidian issues and propose action at the root of the problem (i.e., greenhouse gas emissions reduction). The game presents a linear narrative where players solve riddles, find objects, complete minigames, and answer questions.

In the game, the player travels to the year 2050. The game story is structured into **four chapters** (see Figure 1 for details). In the **first chapter**, the player is presented with an optimistic version of the future, which is soon substituted by a more likely one where the world is living a global pandemic as the environmental situation continues to degrade. Soon, the player is acquainted with a spirit of nature who invites them to explore the connections between climate change and the pandemic through day-to-day objects that can be found in their virtual apartment.

In the **second chapter**, a basic game loop repeats several times. First, the spirit of nature proposes a riddle pointing to an object representing an element of the climate-health system. Once the player finds it, they must complete a minigame. The game has 14 different objects to find (two in the first chapter and 12 in the second one), each one with its corresponding minigame featuring a unique mechanic and goal (e.g., extinguishing a wildfire or switching a console to renewable energy). With each new object found and minigame completed, a conceptual flowchart grows progressively from impacts to causes of climate change.

The **third chapter** starts once the flowchart is complete. In it, the spirit of nature quizzes the player about topics ranging from the causes of climate change to its various impacts for human and ecosystem health. Thus, the inverse path is followed, this time from causes to consequences.

The **fourth chapter** introduces climate action as a deeper way of facing pandemics given that it can prevent them by acting on their root causes. Players are asked about how they feel about the topic (e.g., alarmed, concerned, unsure, skeptic), and the game provides feedback based on their responses. Motivation and amotivation are addressed, as well as additional pedagogy and acknowledgment of personal and environmental barriers to action. Then, they are invited to commit to one climate action. If they agree, they are proposed different possibilities, including acquiring more knowledge, individual and collective action, and artistic creation related to environmental issues. Once they select a general category, they are sent an email with more specific actions that they may take.

In this way, the game is a combination of a top-down approach aiming to educate players, given the apparent lack of public knowledge about the link between climate change and infectious diseases [51], and a bottom-up one, which is appropriate for climate change engagement given the ineffectiveness of prescribing actions instead of taking into account the player's situation and preferences. In general, the health implications of climate change are rarely addressed in previous gamification studies [17].

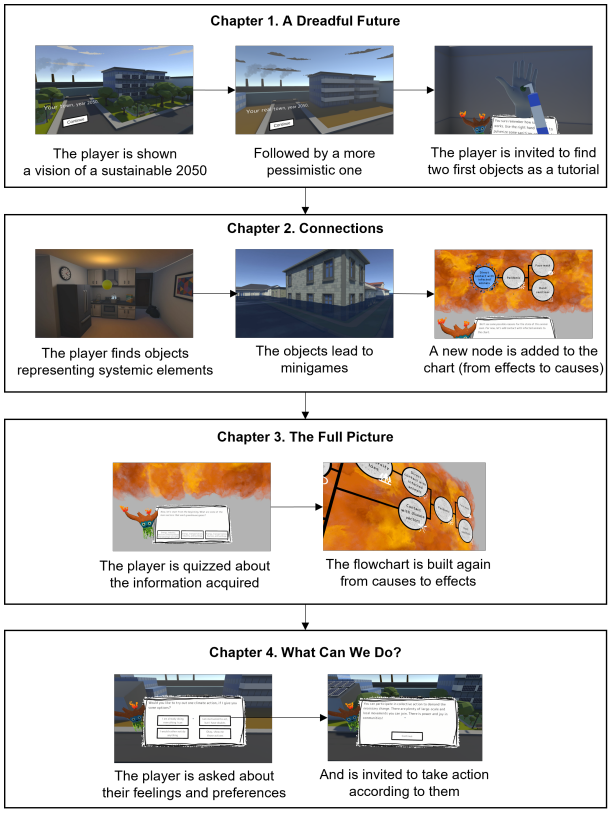

Figure 1: The game's structure.

In this study we used a beta version of the game where some aspects were provisional. For example, it featured the intended colorful low-poly graphics but some objects did not have their final appearance. The game included various sound effects, but not music. Elements such as graphics and audio can have an effect on engagement and immersion, and can facilitate comprehension of the content and gameplay. Nonetheless, the informational content and structure of the game were almost final. From the design and development perspective, this study covers one iteration of the game design according to the user centered design process [20].

3.2 Data collection

For the data collection, we conducted individual tests in a computer with 12 players (6 female, 5 male, 1 did not say). The participants were recruited through an open call for volunteers sent to the local network of the authors who collected the data, chiefly from their academic environment, irrespective of study subject. Players had different degrees of self-assessed video gaming experience and environmental knowledge, resulting in four groups of three participants according to their combined gaming experience (high/low) and environmental knowledge (high/low). The selection of a diverse sample aims to support the findings' generalization. The ages of 11 participants (one preferred not to say) were between 20 and 35, with a median of 24.

The average completion time was 47 minutes (min. 32, max. 64). Although the game was played from start to end, the participants of this study did not receive an email with specific climate actions at the end of their gameplay. They did have the choice to select a general category of action that they were interested in pursuing, but the follow-up email was not part of this study as we were interested in how players experience the game in situ.

Data were collected during April of 2022. Each data collection session followed the same procedure. Participants declared their experience with games and knowledge of environmental issues as high or low; read the information sheet and data privacy statement and signed the informed consent; completed a climate change concept map; played and completed the game; and revised their concept map. During gameplay, authors 2 and 3 took written notes of players' actions and comments. After playing, the researchers also interviewed the participants regarding usability (issues, discomfort), playability (enjoyment, dislikes, improvements), and engagement with the game and climate change, including cognitive (learning), emotional (feelings during play), and behavioral (effect on their view of their own life and actions). In this paper, the analyzed data consists of observational notes of gameplay and interview answers. As recommended [41], we use multiple data sources to support the study's validity.

3.3 Data analysis

To analyze the data, we followed a thematic analysis process [41]. consisting of two phases: (a) data management and (b) data abstraction and interpretation [41]. The first step in data management is familiarization. Here, authors 1, 5, and 6 read the data and independently listed subjects of interest relevant to our research question.

The second step, constructing an initial thematic framework, comprises the creation of themes and subthemes to organize the data. In this step, the three researchers created between 5 and 7 themes linking particular items, with as many subthemes as needed, based on the data. Next, the researchers met and created a common framework, which would be used to tag the data, every theme and subtheme being a code. The framework consisted of six themes: (1) continuity, or forms of progress according to the game's design; (2) discontinuity, or moments where advancement is frustrated; (3) divergence, or events where players depart from the intended path without causing discontinuity, that is, without blocking progress; (4) topic engagement, or events where players engage (or not) with climate-related topics; (5) representation and mediation, including ways in which players engage with core elements of the game; and (6) emotions, or moments where players showed or described a particular feeling.

For the third step, indexing and sorting the data, we used ATLAS.ti. This step consisted of annotating the data according to their belonging to the themes and subthemes proposed. The three researchers tagged in this manner the data from two participants and met to compare their notes. The involvement of various analysts aims to support validity through triangulation [41]. After various limitations were pointed out, some subthemes were slightly modified and/or clarified and two researchers proceeded to independently code all the data. Then, following a process of consensual coding ([24], cited in [27]), the two researchers met and discussed until a consensus was reached for all chunks of data.

In the fourth step, reviewing data extracts, one researcher used ATLAS.ti to re-read the data once again, this time according to their labels. This step was done closely with the fifth step, data summary and display, where a spreadsheet was created for each theme containing all of its associated data, with the subthemes as columns and the participants as rows. During this time, the data was refined further and the two last themes were reorganized as subthemes.

After the data management phase, abstraction and interpretation steps were undertaken. This involved using spreadsheets and text documents. First, the same researcher who summarized the data developed categories from it. These categories aim to capture the range of ways in which a theme or subtheme manifests. This process included finding elements, or distinct types of response, in the themes and subthemes. Next, they were sorted according to key dimensions of the players' experience and behavior, and finally these dimensions formed more abstract categories. The aim of categories is to label the data in a more interpretive way so that the research question can be addressed through a more meaningful understanding of data and the phenomena that it points towards [41]. Finally, we report some links among the data and explanations for phenomena, mainly in the form of explicit reasons given by participants.

4 RESULTS

The data analysis resulted in four large themes (continuity, discontinuity, divergence, and topic engagement) that also constituted the thematic framework for identifying and grouping lower-level subthemes and categories. The continuity theme includes aspects in the game experience that indicate that the player proceeds according to the game design. Discontinuity refers to moments when the advancement is interrupted or frustrated. Divergence refers to events and behavior that departs from the intended path, but without causing discontinuity. Finally, topic engagement consists of indications that players engage with climate change and how it is represented in-game. The themes also include aspects related to other two themes initially present, namely representation and mediation and emotion, which have been incorporated according to their fitness (e.g., representation elements that favor continuity; emotions felt in relation to discontinuity). For each theme, various subthemes were identified (shown in bold below), 15 in total, representing relevant aspects of each theme. Furthermore, multiple categories (in italics below), 43 in total, summarize and abstract how particular subthemes (bolded) occurred in the data, pointing at particular player behaviors, emotions and cognition. For a summary of all themes, subthemes and categories, see Table 1.

4.1 Continuity

The continuity theme includes four subthemes and 10 categories. The first subtheme is **goal preparation**, which describes the actions performed before achieving a goal. Three categories of actions were observed in this subtheme. First, players prepared for their goals by *reading instructions*, which occurred primarily when facing a new situation, task, or challenge, and as a means to recover

Table 1: Results of the thematic analysis, including themes, subthemes, and categories

Theme	Subtheme	Categories
Continuity	Goal preparation	Reading instructions; Methodical exploration; Reasoned or clearly prompted exploration
	Goal attainment	Purposeful but spontaneous goal attainment; Purposeful and reflective goal attainment; Excess in goal attainment
	Design-enabled player failure	Failure due to lack of attention; Failure due to lack of knowledge
	Evaluations and emotions supporting continuity	Evaluations of representation contributing to continuity; Emotional continuity
Discontinuity	Limited goal preparation	Lack of visual guidance; Lack of textual guidance; Missing information with a negative experience impact; Missing information with no serious consequence; Aimless exploration after lacking information; Aimless exploration despite a reasoned or clearly prompted task; Aimless exploration that gets resolved by chance
	Goal-related discontinuities	Failed premature goal-directed action; Unsupported goal-directed action; Accidental or thoughtless goal achievement
	Unintended failure	Technical failures; Anticipating failure
	Psychological and physical resistance	Resistance to engage; Player limitations affecting game reception
	Evaluations and emotions related to discontinuity	Evaluations of representation contributing to discontinuity; Emotional discontinuity
Divergence	Divergent behavior	Divergence with creatures and characters; Environmental divergence; Failing on purpose to see the consequences
	Humorous comments	Humorous comments about the environment; Humorous comments about creatures and characters; Humorous comments about information
Topic engagement	Engaging with new information	Learning; Doubts and misunderstandings
	Connecting information to the past and future	Limited learning; Knowledge of oneself and one's action; Knowledge and perception of the world; Effect on intention and future ideas; No change in intention
	Teaching the game	Criticism of the content; Criticism of the medium
	Topic-related evaluations and emotions	Evaluations of representation strengthening topic engagement; Emotional topic engagement

from failure or being stuck. Second, players engaged in *methodical exploration* by looking and moving around, which would typically end with finding the right object, whether by intention or chance. The data depict ambiguous moments when it is not clear whether the player is exploring in search of something they have an approximate idea about, or just aimlessly drifting. As the gameplay data is based on observation, we had to rely on behavioral cues. Thus, we considered the absence of clicking as methodical exploration due to players abstaining from taking the action that signals identification (i.e., clicking an object) until they are reasonably sure. Third, players prepared to achieve the goal via *reasoned or clearly prompted exploration* by looking for an explicitly described element or engaging in actions to support their search. Players explored the environment under correct premises, for example expressing a reasoning or reading or recalling past findings, or incorrect ones, for example based on wrong expectations (e.g., expecting to see a rat after a clue refers to "smaller animals") or searching in the wrong place (e.g., looking for an object within a virtual screen instead of the 3D environment). Even if guessing under correct premises, it was possible to fail because the game did not support their action, which is a form of discontinuity that will be explained in section 4.2.

The second subtheme is **goal attainment**, which describes how goals were attained in ways that supported continuity. Three categories were observed. First, players engaged in *purposeful but spontaneous goal attainment* by achieving the goal without careful thought. This is the case with tasks that were simple and repetitive, therefore they could be completed via experimentation (e.g., applying sanitizer and rubbing hands together), or through casual exploration (e.g., finding mosquito breeding grounds in a small environment). Second, players engaged in *purposeful and reflective goal attainment*, which is directly connected to the forms of goal preparation above. This included times in which they succeeded after reading attentively task instructions and information, but also after failing and seriously reconsidering the information. This form of goal attainment also followed discontinuity, e.g., lack of game responsiveness when similar attempts did not work (e.g., the player is selecting an object that makes sense but is not the one that the game wants) or after a very different action did not yield any result

(e.g., watering a tree before seeing that the top is on fire). Interestingly, players also engaged with purposeful goal attainment that had a personal meaning, which was observed during gameplay via explicit comments (e.g., "I hate mosquitoes") or uttered emotional exclamations (e.g., "Nooo, not the trees!" or "Oh, my God!" as the sea level rises). Third, players enacted *excess in goal attainment* by repeating an action that could have been performed just once. This includes excessive clicking (e.g., putting out a wildfire) which was sometimes joined by an emotional comment ("Nooo, not the trees!") but may have been due to slow game feedback. Players also repeated entire processes, for example boxing multiple items in a single box when only one would have been enough, which may not have been clearly communicated by the game. Players occasionally went too far by engaging in unnecessary extra actions such as moving plants to dry land instead of just uprooting them. This may also be due to lack of guidance and feedback, but could indicate that players had the capacity and wished to solve more and harder challenges.

The third subtheme, **design-enabled player failure**, includes moments in which players fail in a way that is supported by the game. Two categories were identified: *failure due to lack of attention*, that is, not reading attentively, and *failure due to lack of knowledge*, especially when answering the quiz. In one case, this led to player frustration.

The fourth subtheme, **evaluations and emotions supporting continuity**, includes two categories. First, opinions and appraisals of game aspects such as the game's environment, characters, audiovisuals, information, options, controls, and mechanics-dynamics. These *representational aspects contributing to continuity* include players being amused or sad about characters (e.g., a dead bird), which left some players wanting more. We considered that liking the game's chart, finding the writing funny, or considering the amount of textual information as adequate supported continuity, as did liking the choices offered by the game. Players also manifested that they found the exploration fun, the game easy in a positive way or that they were stuck "but not for too long." Some evaluations were idiosyncratic of serious games or a testing session, for example one player manifesting that there was a large amount of text but that this was expected from an educational game or that the game lacks polish but it is "okay." Second, various forms of *emotional continuity* were observed, which we clustered around enjoyment-related continuity, including most of the elements described in the category above, and relief and relaxation-based continuity, for example relief when a new object is found after aimless exploration or feeling relaxed at the end of the game.

4.2 Discontinuity

The discontinuity theme includes five subthemes and 16 categories. The first subtheme is **limited goal preparation**, defining moments in which players face tasks with insufficient or inadequate means. This subtheme includes seven categories. Two similar ones are *lack of visual guidance* and *lack of textual guidance*. Lack of visual guidance occurs when a lack of visual elaboration renders interactions too abstract (e.g., the player is asked to put glue but has no glue in their hand) or when inconsistent animation leaves players confused about what is a relevant element and what is not (i.e., some objects are animated, some are static). It also happens when objects appear unremarkable but are in fact what the player should find, which may lead to players completing a segment of the game without having understood the meaning of their actions, and when objects are too hard to find. Textual guidance is lacking when instructions are unclear or cannot be reread, but also when many objects could reasonably be the solution but the game will only accept one (e.g., a console and a computer consume energy, but the right answer is one of them) or when the player chooses an option in the game expecting it to mean something different. Lack of guidance can result in aimless exploration, although players may add ambiguity to this by stating that "maybe [they] didn't read everything clearly," therefore suggesting a fault on their part.

A third form of limited preparation occurs as *the player misses information with a negative impact on their experience*, either being lost or taking unsuccessful actions, even needing to retry. Fourth, it may also be that *the player missed information but the game continues almost the same*, when the goal is obvious enough or when advancement is nonetheless permitted, e.g., skimming the text while answering a quiz.

The previous issues will often result in the fifth category, *aimless exploration originated in lack of information*, which may be ended sometimes by seeking more information (e.g., rereading). Sixth, the player may engage in *aimless exploration despite a reasoned or clearly prompted task*, for example when they explicitly recall their task but that is not enough to put them on the right track, or straightforward information is not enough (e.g., the instructions say that an object is to the player's right but they still look around, confused). This sometimes culminates in the seventh category of limited goal preparation, *aimless exploration that gets resolved by chance*. This includes processes which the note-takers deemed "random clicking," "clicking around," and "pixel hunting," or players aimlessly clicking everywhere when trying to find an object. Sometimes this aimless exploration leads to frustration, and sometimes the player vocalizes their issue (e.g., "I don't know what I'm searching for" or "there is too little information on what I'm looking for"). Typically, aimless exploration will result in an accidental goal attainment, described in the following subtheme.

Goal-related discontinuities include moments in which players interact with goals in ways that are not ideal from the design standpoint. This includes three categories. First, *failed premature goal-directed action*, when the player tries to complete a goal but is missing a previous step (e.g., trying to put a mosquito net before applying glue to the door frame). Second, *unsupported goal-directed action*, when players engage in a form of interaction or select an object that is unsupported or incorrect. Third, in other cases, *the goal is accidentally or thoughtlessly achieved*, which, despite moving the game forward, is a failure as the player does not advance consciously. For example, they may accidentally interact with the right element as part of aimless exploration or select an object without knowing what it is, especially if the visual guidance is limited. They may also achieve the goal having understood the required interaction but not its meaning. They may also experience a happy coincidence, when they find the right object purely because it is new or animated, or when a technical bug allows task completion in an unconventional manner, or even when the player selects an object "as a joke" and it surprisingly works.

The third discontinuity subtheme, **unintended failure**, includes both *technical failures*, which are common bugs such as a scene not loading or inconsistent collision detection, and *anticipating failure*, or players thinking that they will not be capable of recalling the provided information (i.e., "This is a very big chart, I don't know if I have to remember everything because I won't"). Meanwhile, the fourth subtheme, **psychological and physical resistance**, includes two categories where players refuse to act, rather than the game failing. In *resisting to engage*, players declare discomfort with a task due to, e.g., having to enact violence or cause environmental damage, even if the task is framed in the game as damaging. Resistance can also occur when *player limitations affect game reception*, either because the game makes them physically ill due to motion sickness or because they were already sick, which can result in tiredness.

Finally, the data shows **evaluations and emotions related to discontinuity**, including two categories. First *representational issues contributing to discontinuity*, for example the environment being visually confusing, the characters being not liked because of their personality or looks, the language containing difficult words (e.g., quotidian, pulverize), players wanting hints to mitigate discontinuities, excessive difficulty, unclear controls, and other issues mentioned above as part of other subthemes. Second, *emotional discontinuity*, with two clusters observed: anger and frustration-related discontinuity, and confusion and surprise-related discontinuity. Anger follows being stuck, while frustration derives from various features (e.g., throw sensitivity, aimless exploration, own failures, lack of options). Meanwhile, confusion and surprise occur during exploratory behavior or when providing an answer.

4.3 Divergence

The divergence theme includes two subthemes and six categories. The first subtheme is **divergent behavior**, or moments in which players took actions in the game that were not apparently aimed at progressing. Three categories were built here. First, *divergence with creatures and characters*, that is, trying to use a tool on a character. Players engaged in this way with the two main creatures in the game. This includes a cow, to which they threw water, possibly to prevent it from eating crops, and the game's guiding character, whom they tried to mask, spray with water, and shoot at. Some players expressed wanting more mechanics for character interaction, such as spraying water, which signals a will for the game to acknowledge their divergent behavior; in other words, divergent interaction. A second form of divergent behavior is *divergence with the environment*, or players trying to affect elements in the game unprompted and wishing for more interactions (i.e., "it's not the point of the game but I'd like to be able to spray the whole thing"). Sometimes these environment-directed actions were ambiguous, given that players may be trying to select environmental elements just because they want to advance in the game and don't know how to. Utterances such as "can I open things?" can be interpreted both as a desire to explore for exploration's sake or as asking for clarification when being goal-oriented. On other occasions, players may engage in non-prompted actions such as watering tree roots before noticing that their tops are on fire, but this may also be because they think that is what they should do to progress. Third, *failing on purpose to see the consequences* was also divergent behavior, e.g., waiting for a while before completing a task to see if something will happen, or choosing an incorrect answer because it sounds amusing.

The second subtheme, **humorous comments**, includes player utterances about the environment, characters, and the presented information. Three categories were formed. First, *humorous comments about the environment* consisted of comparisons between game elements and similar outside elements, such as a minigame looking "like CS:GO," plants looking "like weed," a planet covered in pollution looking "like the coronavirus," and a wooden toy looking "like its from a ritual." Other comments may have been also divergent, such as saying that "there is a lot of toilet paper" in the bathroom, but these were put already by design to express a humorous truth (people hoarding toilet paper during emergency situations such as pandemics). Second, players also expressed *humorous comments about creatures and characters*, including their appearance ("The character is cute but it's staring into my soul") and, ambiguously, about the avatar itself ("Where is my shadow?," "I have no feet?"). Players also interacted with characters by greeting them aloud when they first met them. Third, players made *humorous comments about information* given, including sarcasm and dark humor about the writing ("I would love to eat cardboard for sure") or the goal ("looking for a nice place to die"), and commenting on the options given (i.e., the game allows players to express that climate change is a lie, which one participant found funny).

4.4 Engagement with the topic

This theme includes four subthemes and 11 categories. The first subtheme, **engaging with new information**, includes two categories, the first of which is *learning*. Players learned connections that were previously unknown, especially the connection between climate change and pandemics, and that climate change is pervasive, including its causes but also individual and collective responsibility (e.g., "[the game] put things into a bigger perspective, we are a small piece in the whole ... individuals can do a lot but it's mostly about the bigger institutions"). They also learned new pieces of information, including causes (e.g., "There are greenhouse gases in the AC?"), mechanisms (e.g., the fact that a warmer ocean will expand and thus rise), impacts (sea level rise, animal well-being), solutions (reducing meat consumption, sustainable production of toys), and concepts (zoonosis). One emerging issue was that players could give too much importance to elements provided just as examples of larger sectors (e.g., toys for industrial production, video games for energy consumption) to the point that they would refer only to the example. Of course, engagement with new information may come with *doubts and misunderstandings*, either because an element's presence is unclear ("Why was a dead bird in my bathroom? It doesn't make sense!") or because the information given is misunderstood ("Not sure if the pandemic caused drastic climate change, or partially contributed to it").

The second subtheme reflects ways in which players were **connecting information to the past and future**. This is linked to five categories. First, *limited learning*, when players expressed that they already knew most of what was being shown in the game. Second, *knowledge of oneself and one's action* such as the participant's

personal circumstances affected topic interpretation, including comments about barbecues in their country of residence not being sustainable, the fact that the participant is more climate-conscious at home than in their Erasmus, and one participant saying "I have contributed to this a lot recently" referring to flights. Players also expressed their personal preferences in connection to in-game topics ("I hate mosquitoes") and connected their present life to the future depicted in the game (e.g., the player "[feeling] sad because it's going to be bad in 30 years, will we be able to do things as we are doing them now?"). In addition, personal awareness and action may limit the game's influence. Participants stated that their behavior would not change because they were already aware of environmental problems and behaved in a responsible way, so the game could be seen as a reminder. Participants may have even tried to tell others about these topics, but found that their effort did not yield the expected result.

Third, players also connected the topic to their *knowledge and perception of the world*, which affected their expectations of the game (e.g., the player already expected the future to look grim). Existing environmental knowledge and perceptions resulted in players connecting game events with aspects not mentioned there, such as saying "poor Netherlands" when shown sea level rise, or even proposing their own solutions (e.g., "you can make food for cattle with insects, which produces fewer emissions"). Existing knowledge and perception of society were also relevant, with participants saying that "it's all around us but we don't care", or expressing disappointment or "frustration that we know it all but we still need things like [this game]."

Fourth, the game had an *effect on intention and future ideas*, either general (declaring that they will remember the game when "an opportunity to do things" arises) or more specific, including personal consumption (eating less meat, reducing airplane travel, buying less fast fashion, eating insects, taking shorter showers, not using plastic-packaged goods) or becoming more influential (i.e., "go into politics and try to be a good politician"). However, and as the fifth category, the game also resulted in *no change in intention*, sometimes due to lack of perceived new ideas (e.g., "I'm more educated but I don't know what to do with it"; "[The game is] informative but [provides] no suggestions on how to decrease the crisis"). Other reasons included psychological barriers, such as temporal distance ("it has not happened yet so [I am] just mainly ignoring it") and individual action being inconvenient.

The third subtheme, **teaching the game**, includes moments in which players criticized the content or the medium. First, *criticism of the content* were directed at depictions of wasted resources that the game did not acknowledge (i.e., boiling water wastes energy, the packaging in a minigame was excessive, and closing a door with water is a waste). Second, *criticism of the medium* refers to commenting on the game as a video game that tells players that video games are bad for the environment. While this may have been said with the intention to signal hypocrisy, this was not clear from the participant's comment.

The fourth subtheme, **topic-related evaluations and emotions**, contains two categories about player engagement with different elements in the game and expressed or observed emotions. First, *representational aspects strengthening topic engagement* were found, specifically in the environment and the information. Environmental topic engagement included, e.g., expectations of the future prompted by the game's environment and care for sea level rise, as well as emotions such as worry, surprise, confusion, and sadness. Information-based topic engagement included the game showing consequences in a way that "increases concern," but also the opposite: one participant stated that the information is not emotional enough ("giving information just to read will not change my outlook on life, it would be better if there would be some stronger turning points ... if the information was more emotional then it would be better"). This leads to the second category, *emotional topic engagement*, which was clustered around three ideas. First, frustration and disappointment because of lack of real-world action, which is a form of engagement but may become apathy. Second, sadness, concern, and overwhelm when considering the consequences of climate change and the future, including negative feelings prompted by enacting unsustainable behaviors in the game as part of the gameplay. Third, surprise and curiosity from information and environments shown in the game, including utterances such as "Oh my God!" and "that is too much" when shown future sea level rise.

5 DISCUSSION

In this study, we have devised a thematic analysis framework to show ways in which players engage with a serious game and its topic. Answering our research question, *How do players experience and interact with a serious game about climate change, including their relationship with the designed path, their possible deviations, and their engagement with the topic?*, we have uncovered various ways in which continuity, discontinuity, divergence and topic engagement occur. While existing frameworks tend to focus on game elements supporting learning, we extended our observations beyond such elements to focus on players' behavior, experiences and engagement as observed during the gameplay and based on after-game impressions and reflections. These were later organized into subthemes and categories. This approach allowed us to show the nuance of game elements' effects; for example, a particular beat of the game such as exploration can lead to continuity and desired topic engagement once, but may lead to discontinuity and confusion at a later time, or with a different player. Because game mechanics and features are complex, interact with multiple other elements, and underpin different moments in games, nuanced and varied interactions are likely to occur.

The designer's goal is to author a desired player experience [16], which we call here facilitating continuity. In game-based learning, this is no different [36]. In our study, we found that continuity was supported in multiple ways. In behavioral terms, some actions advanced the game, but players wasted effort in unnecessary repetition due to misunderstandings. Sometimes, design-enabled failure occurred, but in this game it was not due to lack of a particular skill, but rather because instructions were ignored or misread or players failed to remember a given fact. This form of continuity-related failure often prompted players to do better the second time around, which is different from the feeling of discontinuity that follows a design's fault. However, some potentially problematic game characteristics were accepted in the context of it being a serious game

for research, used in a test session, rather than a game for entertainment or one that is commercially available, namely the large amount of text and the lack of polish. This suggests that players see serious games as learning experiences, and thus educational features like long texts to read are often expected and accepted as such. This is a promising finding as it has been previously observed that students prefer learning about climate change through games over other instruction methods [17].

This study found forms of discontinuity that are rarely considered in gamification scholarship, such as players' resistance to play for moral reasons or the impact that illness and physical discomfort can have in the gameplay experience. We also found that players may anticipate their own failure if they start to feel overwhelmed by the content, even if the intention of the designer is not total recall. In a similar vein, it was pointed out that complicated words stop the flow. Using everyday language rather than technicalities will usually provide a net benefit [31]. But most importantly, it was observed that players may advance without understanding the meaning behind their actions. This is crucial because forms of gameplay such as procedural rhetoric [3] rely on interaction to convey meaning; designers may want to reinforce such core ideas to make sure that they are understood, as game progress does not automatically imply learning [29]. Finally, ambiguities were observed once again, this time between what constitutes genuine lack of guidance, and what is lack of attention by the player.

This study also uncovered ways in which the experience is not, and cannot be, completely designed and guided, especially in terms of divergence and topic engagement. Our divergence-related findings support the idea that players wanted to do more than learn in the game. They did not only engage in actions that were not directly designed nor were obviously aimed at learning the content, but they explicitly communicated a want for more divergent interaction, that is, a desire to horse around and engage in free-spirited exploration [49]. Of course, the context of the study mattered, since the participants were personally recruited by the researchers present in the testing, which may have prompted them to be relaxed and playful. However, the same may occur in any other context, for example when students are in class surrounded by friends, or even alone at home. Although the well-known player divergent behavior of attempting to break the game and disrupt the system [49] was not observed, it does occur and designers should take it into account.

Finally, the pedagogical aspect of the game did not always have the expected impact. Climate change engagement involves cognition, affect, and behavior [30]. In cognitive terms, the game did show new connections to players, but the basic aspects of climate change were generally well-known. Thus, players engaged with the information in their own terms, and it was difficult to surprise them or even teach them something new. Interestingly, players sometimes reached conclusions that were not prompted by the game, making use of their previous ideas. A clear example was a participant who proposed eating insects as a less carbon-intensive dietary option. Furthermore, players may even teach the game when they see something that counters the pro-environmental message. Like moral choices, players may take these seriously even in a fictional frame. These examples and divergent behavior in the game can be associated with agentic engagement with the game and topic (see [40]). Conversely, designers should be careful with the examples that they set for larger issues, since players can assume that these have been chosen because they are the most relevant ones.

In affective terms, complex emotional relationships with the topic were observed. Players did not only relate to events in the game both positively and negatively, but they talked about their feelings towards the topic and how playing the game had reminded them of the state of the present. Even through a serious game, the complex emotional dimension of engagement [19, 34, 52] were experienced and discussed.

As previously outlined [3, 52], the didactic approach was limited in supporting behavior change. Participants often claimed to already do things for the environment and complained that the game did not give them new ideas. While this aspect will be reinforced in future iterations of the game, various actions were already communicated throughout the game. This suggests that even if designers think that clear action is suggested, players may not view it as such unless it is explicit and personalized. This game tackled the challenge to communicate a topic that players generally know about (climate change) in a new way (its connections with pandemics), but this new angle will not necessarily spur players to act. At this point, a priority should be made of identifying the main factors preventing the necessary scale of climate action, the role of citizens in it, and how games can support them while providing holistic opportunities for engagement and respecting player autonomy.

In summary, our method of inquiry and its results extend existing game-based learning frameworks in two general directions. First, beyond design. While frameworks advocate for a meticulous craft of the player's experience [36], including their emotions [4] and enjoyment [9], we observed ways in which designers cannot anticipate and adapt to every player's thought, feeling, action, and personal baggage. A telling example is the difference between designers' understanding of enjoyment as flow [9, 16] and players' self-directed exploration and humor. This should be examined further in terms of learning impact, since unexpected learner contributions can lead to pedagogically valuable moments [40], perhaps even for game-based learning designers. Thus, we propose to complement design prescription [2] and the study of intra-design tensions [42] with further experience description and design-experience tensions.

Second, beyond learning. While analytical frameworks aim to understand the relationship between design elements and learning [5, 6, 8], our observations yielded not only surprising examples of continuity, but also highlight the value of looking beyond "productive" motivation, engagement, and learning. Furthermore, we focused our observations on climate change to study what game-based learning looks like for such a complex topic. In a further expansion of learning, we inquired about the game's implications in the learner's life beyond "performance improvement."

5.1 Limitations and future research

This article has aimed to support the study's reliability by communicating with transparency and detail the processes followed, data collected, and analysis made. Two data sources and direct examples were used to strengthen measurement validity, rigorous data collection and analysis processes were followed to support internal validity, and a diverse sample was sought for external validity. However, the study presents limitations that should be mitigated

in future studies. First, the sample, although adequate in number for a qualitative study and varied in terms of self-declared game expertise and environmental knowledge, was contextually homogeneous, since participants were recruited around the same university. Future studies should explore how different players interact with gamification in other contexts.

Similarly, this study has used a particular game with characteristics that not all serious games will share: a linear, narrative experience lasting under an hour and focusing on climate change. While some of the findings from this study may be found in other serious games, others may be specific, such as the forms of continuity based on exploration and finding objects. In addition, the players were not exposed to the last step of the game experience, where they receive an email suggesting specific climate actions. Future studies with this game should focus on evaluating the complete experience, especially given player comments that it did not provide new ideas; observe longer term effects [17]; and compare game versions to understand the impact of, e.g., introducing more opportunities for divergence.

Future studies are encouraged to use the basic concepts of continuity, discontinuity, divergence and topic engagement to examine the relationship between players and serious games, and more broadly to update their implied player [1] to one who expects a more open management of their freedom [33]. They may also choose to focus in more detail on a particular theme of interest and probe participants about the reasons behind their comments and actions, especially the more ambiguous ones, while asking what players think of particularly unusual forms of divergence and topic engagement. For example, the gameplay notes analyzed here contained ambiguous data that we could not be sure to interpret correctly. In the future, this data may be triangulated with sources such as video, psychophysiological measurements or questioning about interesting or unclear events, although this would increase the data to analyze.

6 CONCLUSION

The urgency and complexity of climate change have led to the use of gamified initiatives aiming to engage players with it. However, the ways in which players truly play serious games and learn through them deserves scrutiny with real examples. We developed a digital game about climate change and pandemics and took notes from the experiences of 12 players with it. Then, we explored the data using a qualitative thematic analysis method, which reveals the multiple ways in which players enact continuity, endure discontinuity, express divergence, and engage with the topic. To promote continuity, designers should clarify what is expected of players and be aware that quirks and imperfections may be expected and forgiven due to expectations of educational games. To reduce discontinuity, designers should consider the accessibility issues that may arise from their games, and try to make interactions and metaphors as transparent as possible if they are supposed to convey a single meaning. The findings also include players enacting, and expressing a desire of, divergence. Designers should consider and further study the pedagogical and engaging value of adding playful interactions that support player autonomy, surprise, and character attachment. This can support player engagement and thus increase the educational value of games. Finally, it was observed that players engage with the topical content in complex ways beyond assimilating new information. Designers in this area are encouraged to consider the cognitive, affective and behavioral implications of climate change engagement, and to design games in a way that supports their desired outcomes effectively, that is, considering who players are, where they come from, and what they want.

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