

# EXPERIMENTING WITH GAME-BASED LEARNING FOR A PLAYFUL UNDERSTANDING OF SYSTEMIC TRANSITIONS FOR IMPLEMENTING TRANSFORMATIVE INNOVATION POLICY

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## Keywords

game-based learning, sustainability transitions, transformative innovation policy, systemic change, x-curve

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## Abstract

Games are a known source of entertainment, especially for children. But games can also be effective learning tools for adults, especially in interdisciplinary education and policy spaces. In this paper, we argue that game-based learning can help the socio-cognitive and emotional understanding of the complexities of sociotechnical system change, as proposed in the sustainability transitions theory. Mobilising the x-curve framework for sociotechnical transitions, we have developed a fully functional game which helps to build transformative innovation capacity among policy practitioners through second-order learning during and after a game-play session. The game helps in unpacking the art of anticipation and negotiations between (roleplaying) actors, understanding the key role of context and requires reacting to landscape shocks to 'build' certain niche dimensions and 'destroy' regime dimensions by using and exchanging limited resources. Despite having 'hidden agendas', the players also learn about the importance of transdisciplinary collaboration to win the game. We argue that such approaches of game-based learning can help advance knowledge on transition dynamics and network building among transition actors, which is fundamental for enacting transformations. We hope that through this paper, our experience of developing and testing the game inspires others to develop similar tools for action-oriented transitions research that reimagines the relationships between actors, innovations, and contributions towards systemic change.

## 1. Introduction

How individuals learn is an interesting topic of research. Learning happens through cognitive development influenced by societal contexts, through and beyond institutionalised education. Learning continues throughout peoples' lifetimes, where individuals continue to unpack and change perceptions of complex and constantly evolving socio-economic-environmental factors. In a sociotechnical transition context, learning by doing, social learning, and policy learning are relevant concepts that illustrate different types and ways of learning and different processes and motivations for learning (Van Mierlo and Beers, 2020; Van Poeck et al., 2020; Boon and Bakker, 2016; Brown et al., 2003). It is now well understood that in order to enable Transformative Innovation Policy (TIP), researchers and practitioners need to work together in 'experimentation with policy that enables processes of social learning in order to develop alternative pathways and enact desirable futures' (Schot and Steinmueller, 2018; Ghosh et al., 2021). This is, however, easier said than done.

Multiple factors contribute to challenges in social learning when it comes to a clear understanding of change processes in complex socio-technical systems. First, there is often a lack of clarity among actors about the entangled nature of these systems and the multiple 'dimensions' and rules that constitute them; second, actors are often inclined to work in silos, overestimating their agency and power, avoiding conflict, confrontation and

negotiation (Wittmayer et al., 2017); third, the emphasis is often about acting, driving, steering and shaping transitions, instead of recognising the need for coordination, collaboration, trust, reflexivity and emotional connections to *navigate* ongoing transitions. To mitigate such challenges, we argue that game-based learning is a valuable approach to offer a simulated experience that enables individuals to perceive and realise the complexities of navigating systemic change. The benefits of using games in non-gaming contexts are that they can help create mental models, enhance emotional engagement with the game topic through experiential learning techniques, and help ensure active participation (Nacke & Deterding, 2017). In societal contexts, games have been introduced by teachers at various levels of education (Tsarava et al., 2018; Fotaris et al., 2016) as well as by learning professionals in organisations that strive to support knowledge sharing and improve participants' engagement (Patrício et al., 2018; Roth, 2015). These efforts have been proven to increase individuals' motivation and engagement with the learning process through a variety of playful activities such as board games, card games, simulations, roleplaying, Lego Serious Play, digital games like Minecraft Education, and gamified learning software like Classcraft (Shu & Liu, 2019). In policy contexts, games have been used to foster collaboration in public health policymaking (Spitters et al., 2017), to examine the learning potential of games for European climate policy (Haug et al., 2011) and as tools to boost social learning in the sustainable management of land and natural resources (den Haan & van der Voort, 2018).

In 2021, we developed the "Systemic Change" game for experiential learning about socio-technical system change within the Mobile Transformative Innovation Lab (MoTIL) of the Transformative Innovation Policy (TIP) Consortium. The game was developed by building on game-based learning literature and mobilising the fundamental and emerging theories of sustainability transitions and 'transformative outcomes' (Ghosh et al., 2021). The key objective of the game is to communicate the complexity of system change to interdisciplinary researchers and policy practitioners. The multi-level interaction between regimes and niches under landscape pressure characterises the complexity of systemic transitions (Geels, 2004). Systemic transitions are driven by multiple actors working simultaneously in policy, business, science, non-profit and other domains. These actors have limited resources, and they compete, coordinate, and negotiate with each other to maintain the regime. A game-based learning technique not only offers clarity about this theory, but also triggers emotions related to social behaviour (e.g. greed vs generosity), self-appraisal (e.g. embarrassment vs self-confidence) and appraisal of future transitions (e.g. fear vs hope) in role-playing a regime or a niche actor (Martiskainen and Sovacool, 2021). Ultimately, the game is a tool to be included in a collection of learning materials that exemplify the learnings and co-constructed methodologies of implementing TIP in diverse contexts.

This paper contributes to the academic debate on how a game-based technique to policy learning can contribute to sustainability transitions and innovations for transformative change. We will discuss the core motivation and theoretical basis for experimenting with a game-based learning technique, which could motivate transdisciplinary researchers to try such alternative action-oriented methodologies of transitions research. We will also explain how we developed this game - the processes we followed and the iterations that helped

improve the game prototype over eleven months. This paper makes a methodological contribution by showcasing how to develop a learning game and reflecting on how a game-based learning approach might have improved players' understanding of the complex socio-technical system change theory. This paper is for academics who are planning to experiment with a game-based learning technique in the creative space of their labs, as well as for practitioners who have been invited to play a game as part of a research project and are curious as to how their inputs can improve the game.

The rest of the paper is structured as follows: Section 2 presents a literature review on game-based learning and sustainability transitions. Section 3 outlines the methods we used to develop the systemic change game. Section 4 discusses the main concepts included, rationales and decision-making process, and how we included feedback from several testing sessions. Section 5 discusses the benefits, challenges, and opportunities around the development of the game, based on an analysis of play testing sessions and interviews. Section 6 presents our conclusions about the implications of game-based learning for transformations.

## 2. Literature review

### 2.1 Game-based learning

#### a. Socio-cognitive value of game-based learning

Game-based learning<sup>1</sup> can be defined as a type of game play that incorporates in its design specific learning outcomes that the game designers aim to achieve at the end of the playing session (Shaffer et al., 2005). The definition of game-based learning and the various debates in the literature reveals a tension between covering the subject matter and prioritising game play. A challenge for game designers is to balance both (Plass et al., 2010).

Games embody experiential learning theories. When participants engage with an activity that creates an experience, new knowledge is created following a learning-by-doing approach (Kolb, 1984). Games provide learners with interesting, novel challenges and problems to solve in a safe environment (Kirriemuir & McFarlane, 2004). Multi-sensory

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<sup>1</sup> A distinction needs to be made here between game-based learning and gamification. Gamification is defined as *"the use of game design elements in non-game contexts"* (Deterding et al., 2011). Gamification has been used in the literature as an all-encompassing term, which presents a difficulty for researchers outside the field. Gamification designs do not necessarily mean making a whole game but rather adding elements of games in non-game situations. These non-game situations can include various organisational, marketing, educational, or even advertising and health contexts. For example, Wang et al. (2015) discuss how gamification can be useful in different problem areas such as bringing in gamification rewards to encourage households to consume water more efficiently. We chose to align our paper with the game-based learning literature based on the fact that we have designed a whole game rather than used 'game design elements'. Moreover, our goal with this game was to improve learning whereas gamification is not focused solely on learning contexts.

settings like games encourage creativity and help learners develop problem-solving and communication skills among their peers and teachers (Ermi & Mäyrä, 2005).

Based on extensive research on the cognitive effects that games have on learners, the goal of game-based learning tools is to help learners construct mental models (Mayer, 2005, 2014). Learners start by perceiving the information presented in the game, then move to organising these stimuli as visual and verbal representations in their memory and finally combine the representations with existing knowledge (Mayer, 2014). In other words, irrespective of age, gender or background, games provide a unique socio-cognitive space for enhancing reflexivity, creativity, and problem-solving capacities.

According to theories examining the socio-cultural elements of learning, learning processes can be socially constructed and motivated (Bandura, 2002; Barab & Duffy, 2000; Wenger, 1998, 2000). Games can facilitate social interaction with other learners or groups of learners where such experiences have the potential of enhancing learning (Squire, 2006, 2011). Adopting a socio-cultural theory perspective allows game designers to create game-play elements focusing on motivating learners to collaborate in groups, exchange knowledge to solve in-game challenges, as well as create knowledge when combining their experiences and existing knowledge to better understand the subject matter (Gkogkidis & Dacre, 2020.). Consequently, learners deal more intensively with learning topics (Kapp 2012).

#### b. Learning among practitioners and organisations' stakeholder engagement

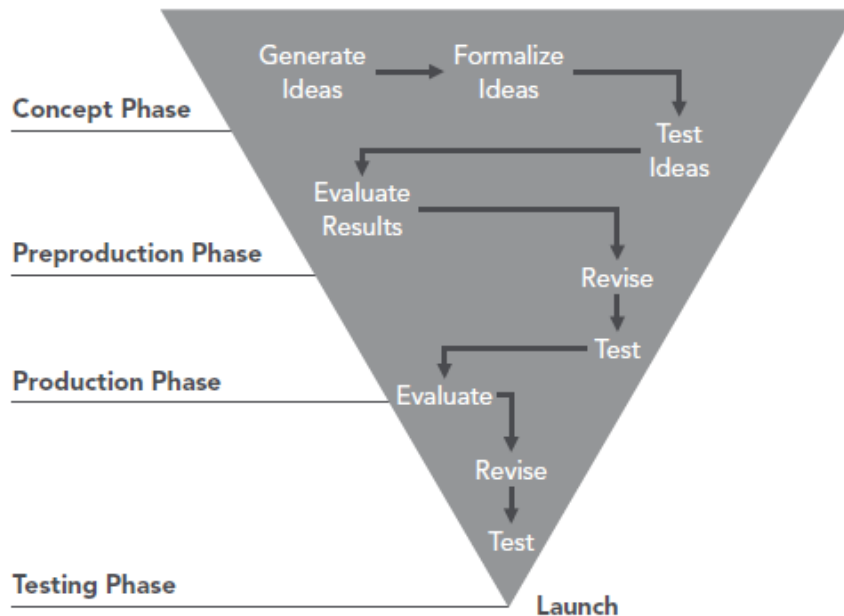
Games and other playful tools have been used by organisations and practitioners to foster creativity and knowledge exchange amongst practitioner groups with the end goal of enhancing innovation, communication among departments and strategy planning (Patrício et al., 2018; Roth, 2015; Roos, 2004). Leadership training and development is another area in organisations where game-based learning has shown some promise, results showing enhancement of coaching, communication and decision-making skills (Sousa & Rocha, 2019). The use of game design to foster stakeholder engagement has also been explored. For example, Marcucci et al. (2018) explored how to design solutions that engage users of urban transportation systems, suggesting designers should focus on user-centred approaches i.e., carefully research and consider the needs of end-users when designing the solution. Consequently, games may be effective tools for enabling coordination, cooperation, planning, partnership building and decision-making in contexts to advance 'collaborative governance' (Emerson et al., 2012).

#### c. How to make a game

The literature on games suggests iterative frameworks that can help organise the game design process in distinct stages. These stages typically include an initial brainstorming/ideation phase where many themes and ideas for the game are generated and discussed among stakeholders, followed by a prototyping phase where designers produce a low-cost paper prototype of the game that can be play-tested to identify

potential improvements (Figure 1). The process repeats itself, resulting in a better prototype until the production stage begins (Fullerton, 2019; Schell, 2008).

**Figure 1.** Iterative process in designing a game

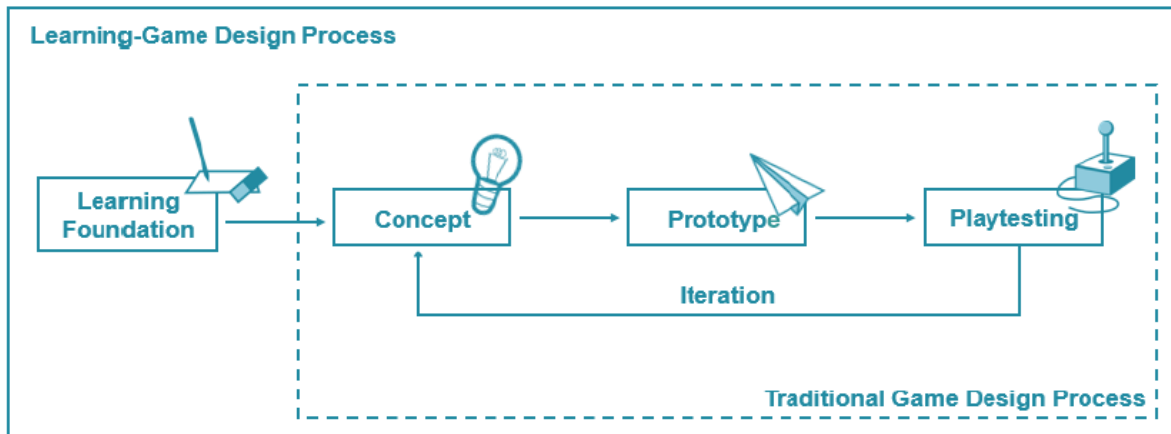


Source: Fullerton (2019).

Paper prototyping describes a design approach aiming to test designers' assumptions about how a game is perceived by the end-users - the players. A paper version of the game is created and then playtested with groups of stakeholders who are encouraged to give feedback. Incorporating this feedback helps to develop an improved version of the game (Snyder, 2003; Fullerton, 2019).

The literature suggests playtesting is one of the most valuable activities during a game development life cycle. It allows the team to gather insights about the user experience of game and determine whether or not the game needs further changes (Boller & Kapp 2017). This makes game design a non-linear and iterative process.

**Figure 2.** A game design process describing a framework that can assist designers in making learning games



Source: Eckardt et al (2018)

In this paper, the learning foundations are associated with sustainability transitions theory, which we will introduce in the next section.

## 2.2 Sustainability transitions

Our game is based on a specific theory of change (ToC) namely the Multi-Level Perspective (Geels, 2002; Rip and Kemp, 1998). In this ToC, the process of systemic change happens through complex interactions in three distinct yet interconnected levels: niches, regimes, and landscapes. Regimes are dominant configurations expressed in a series of stable practices, rules, and behaviours that define the dynamics of operation in any sociotechnical system such as energy, mobility or healthcare. Niches are alternative system practices that challenge the incumbent regime rules by nurturing alternative socio-technical innovations for that system. This process is influenced by the landscape, a series of exogenous events, shocks, and trends that pressurises the regimes to open up and/or niches to find maturity (Geels & Schot, 2007). For instance, we can consider climate change or the COVID-19 pandemic as landscape events that have opened up the existing healthcare and mobility practices and accelerated alternative innovations to emerge. Thus, sociotechnical transitions occur through a dynamic interaction between emerging niches, stable regimes and external pressures that co-evolve and create radically or incrementally new socio-technical configurations through a multi-actor led, highly political change process (Ghosh and Schot, 2019).

According to MLP, there are multiple pathways for systemic change depending on how locked in a regime is, how mature niches are, and the presence of landscape pressures. These pathways arise from shifts in values, norms, and preferences that guide the behaviour of agents in the system and, in turn, can destabilise the regime and open space for a niche to create new rules. The literature also suggests that not all changes are necessarily transformative. Unlocking transformative change in society can be guided by a set of Transformative Outcomes (TO) which signpost different processes that can contribute to destabilising an incumbent regime and opening space for a new one to emerge. TOs involve three main processes: (a) building and nurturing niches, (b) expanding and mainstreaming niches and (c) opening up and unlocking regimes (Ghosh et al, 2021).



Guiding interventions through these stages can lead to deeper changes in the rules that shape actors' behaviours.

This evolutionary process of transition involves multiple stakeholders constantly acting and reacting in response to each other and to landscape pressures. According to their individual interest and visions, actors in government, business, academia, and civil society actively engage in a process of negotiation that might create tensions and conflicts between the dominant regime actors and those in the niche (Raven et al., 2010). As transitions are about building sustainable pathways of change, such interactions also need to involve those marginalised groups whose voices are seldom heard.

Despite growing interest in further developing the research agenda (Köhler et al, 2019), the transitions literature does not adequately address how the concepts of STSs and MLP can be mobilised in practice, in different contexts such as rural and urban, the Global North, and the Global South. Applying these concepts usefully to enable policy action and contextualising them in different geographical and cultural settings remains a difficult endeavour for both scholars and practitioners. As academic abstractions, these concepts encompass numerous and heterogeneous elements that are deeply interrelated and in constant change, which increase the level of complexity and hinder the possibility of easy explanations and comprehension. For example, how systems (as phenotype) differ from regimes (genotype) remains a long-standing debate in the community. Even when regimes are well defined, which actors and rules constitute a regime and where to draw the boundary of a single regime remains ambiguous and dependent on units of analysis. Hence, there is real value in fostering an engaging space where different audiences can actively invest time and mental capacity to navigate these complexities and ambiguities. The ultimate goal is to provide the space for developing a course of action for changing such a complex system towards solving a particular sustainability challenge.

Drawing on the theory of sustainability transitions, specifically the multiplicity of actors, their capacities and strategies to utilise and exchange resources, together with understanding the tensions between the sociotechnical regime (status quo) and niches (alternatives), we constructed the learning game that we discuss in this paper.

### **2.3 Second order learning and examples of games in systems thinking**

We argue that transitions and transformations researchers, policy makers, and practitioners can gain several insights from game-based learning. The idea of second order learning provides a bridge between the literature on game-based learning and sustainability transitions because games embody experiential learning and aim to help people playing them (re)construct mental models and their socio-cognitive space, which is what second order learning is about and is important for how we interpret innovation.

Interpretations of second order learning are diverse in the sustainability transitions literature (Van Mierlo and Beers, 2018; Schot and Geels 2008, Geels 2002, Geels and Schot 2007, Schot and Steinmueller 2018). Mezirow's transformative learning is arguably one of the

most appropriate ways to understand transformative innovation policy. Mezirow developed and tested his theory in adult education, where they define Transformative learning as: “the process of effecting change [through]... a coherent body of experience — associations, concepts, values, feelings, conditioned responses - frames of reference [that] ...selectively shape and delimit expectations, perceptions, cognition, and feelings. (Mezirow, 1997:5-7)

Moreover, Mezirow also clarifies that transformative learning as frames of reference consists of habits of mind and points of view, with the latter being more malleable to change:

“A **frame of reference** encompasses cognitive, conative, and emotional components, and is composed of two dimensions: **habits of mind** and a **point of view** ... **Habits of mind** are broad, abstract, orienting, habitual ways of thinking, feeling, and acting influenced by assumptions that constitute a set of codes. Habits of mind are more durable than points of view. **Points of view are subject to continuing change** as we reflect on either the content or process by which we solve problems and identify the need to modify assumptions. This happens whenever we try to understand actions that do not work the way we anticipated.” (pp. 5-6)

If we reinterpret what TIPC proposes as second order learning, we can argue that the main goal of second order learning is transforming frames of reference that scaffold our interpretations of the directionality of innovation. This can be done through changes in habits of mind (harder to modify) and points of view (easier to change).

We argue that the ever-growing sustainability transitions literature as well as the literature on science and technology policy more broadly have not yet adequately explored the potential of games as effective learning tools. These literatures can learn from the insights of game-based learning in education and management about real-world complexity and the value of games for learning and reflexivity (see for example, Heinonen et al., 2017; Tsarava et al. 2018; Gkogkidis, 2020). At the same time, some games have been designed in recent years to communicate concepts and ideas around transition, transformation, and anticipating sustainable futures. The latter genre is quite common in several card-based games (Table 1).

**Table 1.** Variety of card-based games

Name of game	Brief description
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<p>“The Oracle for Transfeminist Technologies (Varon et al., 2019)</p>	<p>A card deck designed to collectively envision and share ideas for transfeminist tech in the future. This game is based on the assumption that people who are excluded by technology in today’s world are qualified to design future scenarios (Varon, 2020).</p>
<p>Flaws of the Smart City (Friction, 2016)</p>	<p>Card game explores smart city futures (that architects like Alexander might also enjoy playing). The co-founder of Design Friction explains how the game tries to make it easier for those outside the design community to easily use future scenarios and design fiction (Kerspern, 2019).</p>
<p>HEY! Imaginable Guidelines (SanalArc, 2018)</p>	<p>Another city-themed game in which participants use cards to discover how cities are designed by selecting topics that are necessary, desirable, or irrelevant to the urban design problem they are trying to solve (Hattam, 2019). The game provokes players to make changes and continue the conversation after the play has concluded.</p>
<p>Equitable Futures (Finlev et al., 2019)</p>	<p>a future-oriented game produced by the Institute For the Future. It is used to develop understandings of challenges to overcome as players try to find new ways to build a more equitable future and reimagine our worlds for 2030 (Puzio et al., 2020).</p>

Games are also gaining popularity in citizen science and public engagements in science (Millburn and Wills, 2021), smart city design (Cavada and Rogers, 2020), and collaborative city planning in general (Sousa, 2020).

### 3. Methods

#### 3.1 Data collection and analysis method

For this paper, we followed two methodological approaches to collect data. First, we maintained a diary and reflective note about our game development journey (detailed in section 3.2). Second, we carried out semi-structured interviews with players in the playtesting sessions. These interviews were held between 20-28 September 2021 and were carried out by one author. Interviews were recorded in Zoom with consent (see Appendix A).

While the diary helped us remember the sequence in which actions and decisions were taken, it also aided us in situating the logical steps of the game's iterative development. For this research, we analysed the feedback we received during the playtesting sessions (based on recordings of the sessions). However, these data were incomplete for a robust analysis about the challenges and opportunities. To mitigate this gap, we interviewed some of the players. Each interview lasted for about 30 minutes. The interview questions were:

1. What did you like in the game-play session? What did you dislike the most?
2. To what extent are games useful for understanding complex ideas like how socio-technical systems can change, and the role of different actors in these processes?
3. What did you gain, if anything, from playing the game with us?
4. We want to make the game available online (and eventually in an 'in-person' format) so more people can play it without anyone actively facilitating the game. Do you foresee the game being played without active facilitation? What are the advantages and risks according to you?
5. Do you think you would recommend your colleagues to play the game? What would be your main reason for the recommendation?

We interviewed five people who participated in at least one of our test game playing sessions. These included junior and senior researchers and practitioners. All of them were asked the same set of open-ended questions that we emailed to them ahead of the interview; in some cases, additional or follow-up questions were included to clarify or further address a topic. We also invited the interviewees to express any other thoughts or comments that they wanted to add. One possible limitation of our method was that we carried out the interviews about three months after the people participated in one of our play-testing sessions, so interviewees may not have remembered their experiences of playing the game very accurately. To mitigate this, we sent them a short written and visual reminder of the game before the interview.

Another limitation is that at the time of publishing this paper, we have not yet been able to test real-life applications that can lead to analysing second order learning about systemic change. Considering second order learning is a long-term process, it would take additional time and data collection for sufficient analysis. However, participants who playtested the game (mainly researchers and staff of national research agencies) mentioned they had a better understanding of the complexity of systemic change and how it unfolds.

### 3.2 Game development method

Understanding how systemic change unfolds is still a challenge for different audiences. Hence, we first defined the main objectives for developing the game: (a) to **improve understanding** of the key concepts of socio-technical transitions with non-academic stakeholders, (b) **building transformative capacity** among policy practitioners; and (c) **enabling second order learning** among practitioners about the complexity of systemic change.

Bearing these objectives in mind, we brainstormed an initial conceptualisation of the key ideas derived from the multi-level perspective, theory of change, and socio-technical systems that would be developed (Figure 3 below). We then portrayed our ideas into an online collaborative game with the support of a game development expert, who guided the methodology through game design principles and mathematical calculations for the limited resources system. As a result of this first stage, we created a first version on a virtual whiteboard platform under the logic of minimum viable product.

As game development is an iterative process, the next stage involved several play testing sessions. We first tested the game among ourselves to have a quick sense of the fundamental conceptual and layout adjustments that needed to be made before sharing it with an external audience. Once such adjustments were made, we ran four play testing sessions with a total of 28 participants from 7 countries and different backgrounds. The first sessions included participants with research and/or policymaking experience who had varying levels of knowledge about systemic change theory. The third play test session was open to anyone interested in the topic. This session included researchers, students, designers, and practitioners from international organisations and national research promotion agencies. The final playtesting was in March 2022 with a more stable and well-designed version of the game.

Participants were immersed in an online experience while playing the role of five transition actors who, under certain rules, cooperated with each other despite their self-interests by spending their allocated resources (money, knowledge, influence) and by performing certain actions every turn to win the game. At the end of every session, we had an open discussion in which participants reflected on the dynamics and learnings of the game, providing feedback and suggestions for further game development. This enabled us to revise the game rules and improve the prototype. We systematised all feedback and suggestions for further game development. Similarly, we maintained old game versions to track changes and contrast the advantages and disadvantages of different alternatives. Overall, the game was developed based on the inputs of users (play testers) who provided feedback around their playing experience. Such a collaborative process allowed us to refine the design of the game's board and rules.

The final stage involved in our methodology for creating this game involved engaging a graphic designer to professionally design the game board and its elements (cards, resources, rules etc.) to make it more intuitive and visually appealing. We also created a

manual to make the play instructions clearer to understand and so that ultimately, the game can be played online or in-person independently without any sort of facilitation.

**Figure 3.** Systemic Change game key method stages



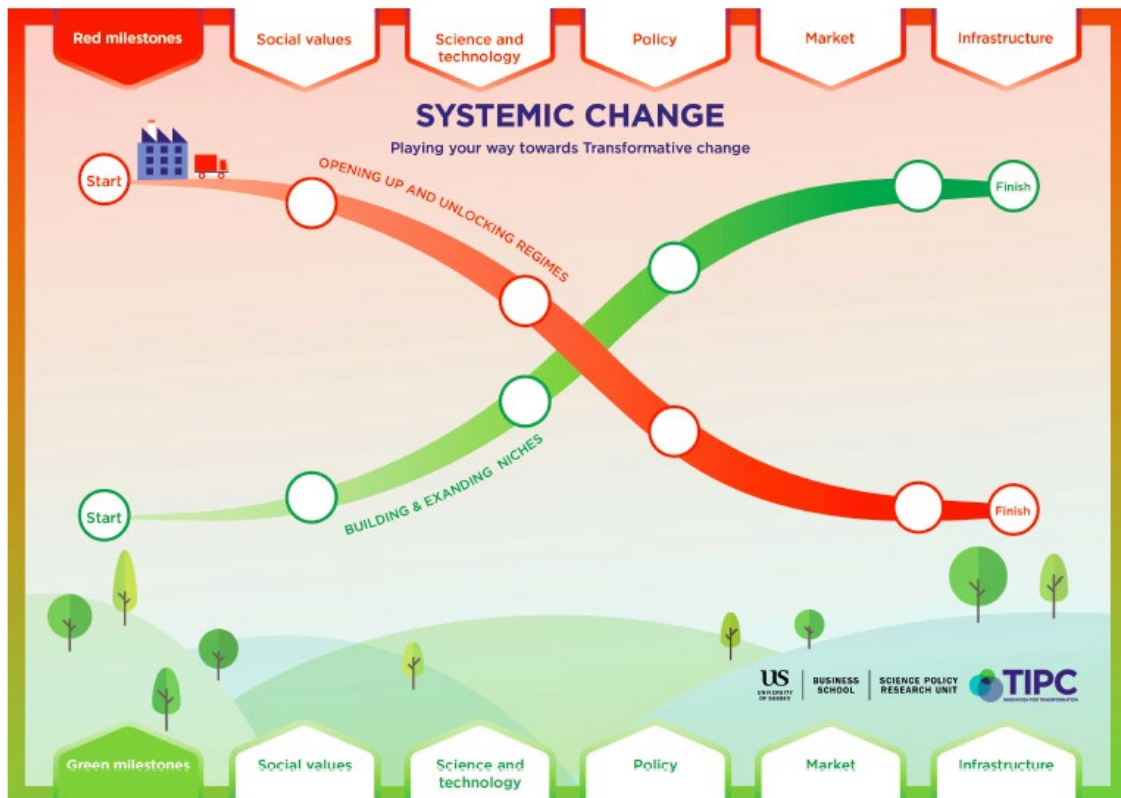
Source: Authors' elaboration

#### 4. The game

In this section, we present the System Change game. We discuss how we mobilised sustainability transition theory and concepts in the game and how we revised and improved the rules of the game through an iterative process of feedback and redesign.

The game board presents an X-curve following the logic of niche emergence and regime destabilisation, as articulated in Loorbach et al. (2017). The Board showcases (Figure 4 below) two cross-cutting lines - one running from the bottom left corner to the top right (green colour), which represents the emergence of niches, and the other line runs from the top left corner to the bottom right (red colour), which represents regime destabilisation.

**Figure 4.** Systemic Change game board



Source: Authors' elaboration based on Loorbach et al (2017)

There are five steps in-between the start and finish points of each line. Within the game, each of these steps represents achieving a milestone. In total, players achieve 10 milestone by building 5 green milestones and destroying 5 red milestones. Building green milestones and destroying red milestones goes along with the theory of building niches and destabilising socio-technical regimes. According to this theory of socio-technical change, each system comprises five dimensions, namely:

- 1) Social values
- 2) Science and Technology
- 3) Policy
- 4) Market
- 5) Infrastructure

Building a niche involves developing innovations along each of these five dimensions. Similarly, in order to destabilise an unsustainable regime, one must 'destroy' all five regime dimensions. This logic of simultaneous niche building and regime destabilisation forms the basic premise of winning the game. Two core ideas are conveyed here: First, it is insufficient just to build new technology (represented by the science and technology milestone). Building and destroying the market, social value are of equal weight in ultimately facilitating systemic change. Second, it is insufficient to just build a niche, without destroying the regime. Sustainability transitions is not be accomplished unless incumbent regime opens up. Therefore, destroying the red milestones forms a mandatory element of winning the game (i.e. achieving successful transition). Every time a red milestone is destroyed and a

green milestone is built, a red or green pawn can be moved to the next spot on the board. To win the game, players therefore need to build all green milestones and destroy all red ones, making it a 'collaborative' board game.

In a collaborative board game, players work together to beat the board. Strategies generally involve collaboration and coordination between multiple players to achieve the game's objective (in this case, reaching the finish points along both green and red lines). The possibility and necessity of multi-player coordination offered an ideal opportunity to introduce the theoretical idea of multi-actor transition in this game (Wittmayer et al, 2017; Avelino and Wittmayer, 2016). Systemic transition is a multi-actor process by nature, involving competition, negotiation and coordination in order to either innovate in niches or to maintain or give up status quo in the regimes. Traditionally, transitions can be visualised as a 'face-off' between niche actors (who are visionary frontrunners in the world, enthusiastic about alternatives to the current way of doing things) and regime actors (who are incumbents and often resistant to change in the existing way of doing things). However, often this distinction between niche and regime actors is blurry and stereotypical, which does not represent the complex reality. In the real world, under the right conditions, regime actors are also seen to be willing to open up to alternative approaches, unlearn their existing behaviours and strengthen their connection to niches (Ghosh et al., 2021). Therefore, the game doesn't mobilise the dichotomy between niche and regime actors, even though we acknowledge it is an important distinction in the transitions literature. The game introduces five key system actors, each with distinct beliefs, roles, and special powers emerging from their close connection with a specific system dimension (Table 2). This connection is further demonstrated through their ability to destroy a specific red milestone with one less resource and build a specific green milestone with one less resource if the corresponding red milestone has been destroyed (illustrated in the table below).

We have introduced three types of resources that each systemic actor will have access to at the start of the game: 1) Money; 2) Influence; 3) Knowledge. The board has 35 units<sup>2</sup> of each resource, divided unequally across the actors, according to their character descriptions. These resources also provide the necessary constraints to building or destroying a specific milestone. Therefore, the resources are 'endowments' for the players as well as 'costs' for achieving a milestone. Both the initial endowment and the amount of resources for the whole game were decided in a way that creates constraints for the exchange and negotiation process.

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<sup>2</sup> Based on a statistical calculation of the optimal number of resources needed for similar probability of winning and losing the game.

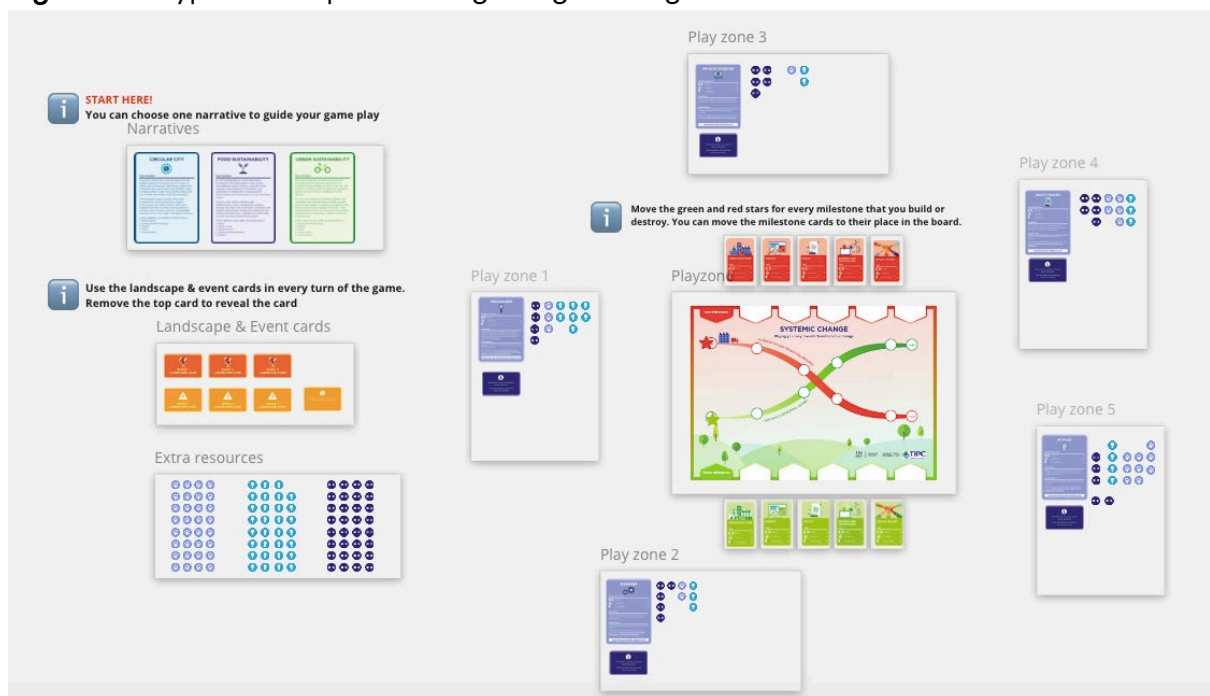


**Table 2.** Systemic Change Game Actors' roles and resource endowments

<b>Systemic actor</b>	<b>Belief</b>	<b>Special power</b>	<b>Starting resources</b>
<b>Private investor</b>	Believes in the market dynamics. Their goal is to scale up their solution. Is practical and innovative.	<p>Destroy the Market Milestone using one less unit.</p> <p>Build the Market Milestone using one less unit if the red Market milestone has been destroyed.</p>	<p>8 money units</p> <p>5 influence units</p> <p>4 knowledge units</p>
<b>Activist</b>	Believes in empowering the people and that change comes from the bottom up. Can mobilise other groups of people (transition actors) citizens	<p>Destroy the Social Value Milestone using one less unit.</p> <p>Build the Social Value Milestone using one less unit if the red Social Value milestone has been destroyed.</p>	<p>4 money units</p> <p>10 influence units</p> <p>4 knowledge units</p>
<b>Policymaker</b>	Is not too sure what is the right allocation of resources but is deeply concerned about finding solutions with the most public impact	<p>Destroy the Policy Milestone using one less resource.</p> <p>Build the Policy Milestone using one less unit if the red Policy milestone has been destroyed.</p>	<p>8 money units</p> <p>7 influence units</p> <p>4 knowledge units</p>

<p><b>Researcher</b></p>	<p>Concerned about the problems of the system. They want to make their ideas reality through their research. Optimistic about research that brings solutions to the problem.</p>	<p>Destroy the Science and Technology Milestone using one less unit.</p> <p>Build the Science and Technology Milestone using one less unit if the red Science and Technology milestone has been destroyed.</p>	<p>3 money units</p> <p>4 influence units</p> <p>9 knowledge units</p>
<p><b>Engineer</b></p>	<p>Passionate that infrastructure is the answer to the system's problems. Wants more investment on infrastructure</p>	<p>Destroy the Infrastructure Milestone using one less unit.</p> <p>Build the Infrastructure Milestone using one less unit, if the red Infrastructure milestone has been destroyed.</p>	<p>5 money units</p> <p>2 influence units</p> <p>3 knowledge units</p>

**Figure 5.** A typical set up at the beginning of the game



Source: Authors' elaboration

In this roleplaying game, each player takes the role of one systemic transition actor. While the fundamental logic of winning or losing the game mirrors the real-world success or failure in achieving sustainability transition, a core decision in developing a game is how to

operationalise the theory in creating rules and constraints within the simulation. Therefore, the game introduces some actions, incentives, secret goals and decision points for the players. Here are some features to operationalise the game, drawing on the transitions theory:

- 1) **Exchange of resources:** Transition actors in the real-world are in constant negotiation mainly due to lack of individual endowment of a specific resource and therefore trade what they have in exchange for what they need. To simulate such situations, we have created constraints in the initial endowment of resources for players that force negotiation during the game to exchange of resources and work out a 'win-win' situation. For example, in a situation where the activist is short of one unit of money for building the social value milestone, they may negotiate to get this unit of money from the investor who might be holding more units of money. We can imagine a scenario where the investor will offer the requested amount of money to the activist, probably in exchange for some units of influence which they might lack (and need) in order to build the market milestone. The underlying principle is that when all systemic actors are driven by the common goal of achieving a desirable transition, they will be willing to participate in the exchange of resources in order to collectively unlock transitions.

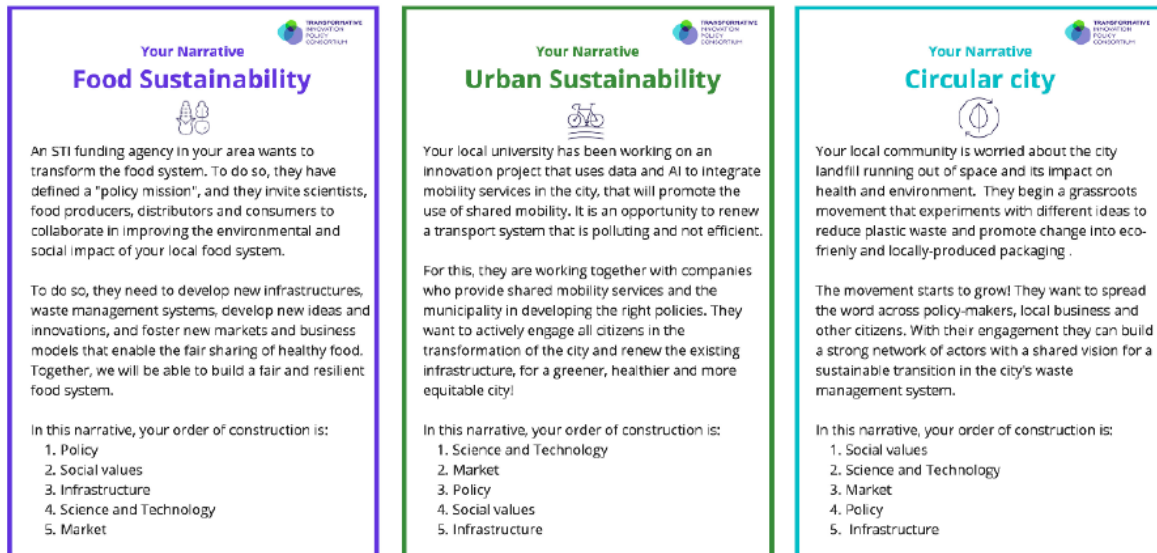
We decided to include three main types of resources in the game, namely influence, money and knowledge, because these elements are present in most social interactions, transcending cultural differences, beliefs or politics. Stakeholders often assess the relevance of each of these resources according to the individual and collective interests that they represent (Vestheim, 2012). For instance, influence (as form of power) is a fundamental element in negotiation. It affects social relations and the structure of networks among stakeholders. It influences transaction terms and bargaining processes and can lead to a negotiation that benefits the party with the most influence (Molm et al, 1999). Similarly, money is often used as the common measure of value in any transaction context, where needs, expectations and sense of reciprocity are at play (Larson, 1998). Lastly, with the increasing importance of information and skills, knowledge (both scientific and lay knowledge) plays often an implicit role in social negotiations (Elliot and Williams, 2008). For example, it can help entrepreneurs develop their careers; engineers build new artefacts, scientists make ground-breaking discoveries, and activists mobilise local and tacit knowledge. In the simulated environment of the game, these three types of resources in differentiated quantity offers the premise of coordination and cooperation required for transitions.

- 2) **Secret goals:** In real world transitions, actors are often motivated by self-interest in pursuing their own goals. This self-interest may range from profit-making incentive to having 'power over others'. These struggles between individual and systemic goals make transition an inherently political process. To reflect these politics, we introduced a special feature in the game called "secret goals", where each player is offered a goal to keep to themselves and not reveal until the end of the game. We have further introduced the rule that the team loses if all five players are able to achieve their secret goals. However, the winning state of the game requires any two of the five actors to be able to achieve their secret goal. This rule introduces tension in the game where all players act too altruistically and sacrifice their

secret missions for the collective win, which doesn't reflect the real-world situation. We also convey that a few actors' profit maximising behaviour or individualistic targets may not always be a barrier to a systemic transition as long as there is a mitigation strategy and ample coordinated action. The addition of the secret goals to the game's rules was a result of feedback during playtesting where some players expressed frustration that the game is 'too predictable' in the absence of uncertainty about individual behaviours.

- 3) **The effect of the landscape:** In transitions theory, landscape shocks and events have an essential role in niche building and regime destructions. Within the game, a landscape shock has negative consequences, mostly resulting in loss of resources. A landscape event is either positive or negative, resulting in loss or gain of resources. An example of an event is "Due to an economic crisis, there are funding cuts on scientific research. As a result, the Science and Technology milestone costs 2 more knowledge in this turn". Such an event card, when played, forces several decisions among the players. E.g. whether on not to build/destroy the science and technology milestone in that turn; who destroys (thereby bears the cost and/or needing to exchange). The game opens with a landscape shock depicting a crisis inducing the need for transition. An event card is opened after each round of the game and after three milestones are built or destroyed, resulting in a maximum of five times a landscape shock or event may unexpectedly affect the game.
- 4) **Storyline narratives and sequence:** Transitions are contextual. 'What drives transition' is often dependent on where the transition is happening, who are the actors involved, the economic and political circumstances, and what discourses are driving the processes. Therefore, we introduced three narratives in the form of a storyline that provide some grounding of the actions in context (Figure 5 below). The team picks one story to their liking to follow at the beginning of the game. This change was implemented in the game after a few playtesting sessions, where we observed that players are finding it difficult to justify their actions in the abstract world of niches and regimes without any real-world motivation to act. The storylines also served another purpose in operationalisation of the game. Each storyline offered a logical explanation for a specific sequence in which the green and red milestones are to be built or destroyed. Mobilising these storylines, we argue that in order to achieve sustainability transitions, niche and regime dimensions can be built or destroyed in a given sequence, depending on the contextual embedding of the transition. The team is then incentivised to follow this sequence through discounts (explained below).

**Figure 6.** Systemic Change game storyline narratives



Source: Authors' elaboration

- 5) **Discounts:** Within the game, discounts are essentially incentives for players to act in a certain way. Utilising the transitions theory and the power of storylines, we introduced three possibilities of getting a discount. As a first possibility, we introduced that destroying the red milestone before building the green milestone of the same system dimension offers a discount. E.g. a player gets a discount if they are building the policy green milestone when the red policy milestone has already been destroyed. This discount links the building with destroying and encourages the team to consider whether they should first destroy the red milestone before building the corresponding green one. As the building of the milestones can only happen during a particular player's turn (as each actor holds their corresponding green milestone), this discount results in a dilemma in the team dynamics on whether to destroy first in order to gain the discount or to let go of the discount and build anyway before it is too late. A second possibility of a discount arises from the sequence of building the green milestones as suggested in the storyline. This adds to the complexity of the decision making: whether to destroy first, follow the sequence and get a double discount or to find a compromise? A third possibility of discount is from the special power of the players who can use one less resource for destroying a specific milestone (see table 2). Each discount reduces the cost by 1 unit of any resource.
- 6) **Time is of essence:** We designed the game to last for 50minutes, across three rounds, 20 min first round, 15min each in second and final round. A landscape shock card opens if the team can't finish a round within time. The team loses if they are out of time in the final round. This rule reflects that time is of essence for sustainability transition in the face of rising global temperatures and climate emergency.
- 7) **Role of facilitation:** The role of facilitation in game-based learning is a debated topic as there are advantages and disadvantages of facilitated game-play (Table 3 below). So far, in all our playtesting sessions, a member of our game development team was actively present: S/he explained the rules of the game, reminded players of the time, additional rules during the game; actively mediated the negotiation during the game-play and resolved

doubts among players on ‘what to do next’. There are many advantages of having an active facilitator. They can support the players, clarify rules and possible misunderstandings to the participants as they play.

“Understanding the rules was not easy, so having the facilitators present they were able to clarify some of the questions in real time.” (I5)

Facilitated playful activities like Lego Serious Play have shown that facilitators can act as educators explaining the ‘theory behind’ during the session if needed and can help in better understanding of the concepts under discussion (Gkogkidis & Dacre, 2021). Interviewees also pointed out that the game is hardly self-explanatory and the knowledge of a facilitator regarding the theoretical underpinnings is essential for the learning experience.

“It might still need a couple of iterations to make it self-explanatory or create a very streamlined version, but for now it requires a knowledgeable facilitator.” (I3)

In certain cultural or policy contexts, the roleplaying element of the game might be less clear or approachable than others. Facilitators can help make the game more accessible, by suggesting ideas of what their personalities or behaviours could be like, by nudging them into protecting with their available resources and by appreciating their efforts to stay in character. However, there are some shortcomings of facilitated game-play. Game design literature mentions the importance of creating clear, succinct guidelines allowing players to discover games on their own, without facilitation or help from the game designers (Fullerton, 2014; Schell, 2008). Both in commercial and learning games, scaling up (making the game available to more people) is easier when the game can be played without facilitation. For this to happen, interviewees stressed on the importance of game design elements.

*“It [success of unfacilitated game-play] would highly depend on the quality of the written and video instructions, and whether you are able to develop a simplified version of the game.” (I4)*

An important consideration while facilitating a game-based learning session is to determine how much control one exerts over the negotiations and decisions taking place during game-play. The facilitator might either dominate the conversation; thus losing the opportunity to discover alternative dynamics, or lose control and let go of intervening in important decision points (Chee et al., 2014). A balance between these two extremes is not easy to strike.

**Table 3.** Pros and cons of facilitation

Pros of facilitation	Cons of facilitation
<ul style="list-style-type: none"> <li>● Facilitator can clarify the rules</li> <li>● Facilitator can explain the concepts if needed</li> <li>● Support players during game play</li> <li>● Encourage roleplaying, making it</li> </ul>	<ul style="list-style-type: none"> <li>● Difficult to have more people playing the game</li> <li>● Difficult to train many facilitators</li> <li>● Facilitator can dominate the conversation</li> </ul>

more fun and engaging; promotes inclusivity; makes it socially more difficult to leave the game early (I5)	<ul style="list-style-type: none"> <li>Facilitator can control negotiation</li> </ul>
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8) **Post gaming reflection sessions:** This is an important aspect of learning games. It facilitates reflections, as suggested in section 2.1 - deepen one's understanding of why the rules of the game are as they are; how the real-world transitions are similar or different from the simulated version presented in the game. We particularly emphasised discussing four questions:

- What were your 'aha- moments' while playing the game? (something surprising, a concept or idea that clicked in your mind)
- What can you reflect about the story narrative and the suggested sequencing order?
- How did landscape events impact the process of systemic change?
- How was the process of negotiation/coordination among players?

A typical output of this deliberation can be seen in Figure 7 below.

Figure 7. Post gaming reflection on 9<sup>th</sup> March 2022.



Source: Authors' elaboration

This session helps players self-reflect and compare their immersive game experience with the real world. Participants discovered many answers for themselves in silently reflecting and discussing the experience. They found that strategic planning is important for transitions; that planning may not always work due to landscape shocks; that change can be initiated from the bottom up building of new social values, as depicted in one of the storylines. These lessons led the participants to question their existing understanding and assumptions about what a system is and how to change it. This is where we found evidence of the game fostering and encouraging second order learning (see section 2.3 above).

The session was also used to gather feedback on the rules of the game during playtesting.

- 9) **Role of playtesting:** Following the literature on the importance of playtesting during game development, we have tested this game in at least 5 occasions. Playtesting offers the opportunity to identify elements of the game that need further improvements and at the same time validate the changes that were made in the previous iteration (Fullerton, 2019; Schell, 2008). In Table 4 below, we set out four instances where we acted on constructive feedback by players at the end of playtesting, with rationales to either accept and modify the game or defer suggested changes.

**Table 4.** Rationales behind iterative game design process

Suggestions received during playtesting	Decisions made	Rationales for the decisions
There is lack of clarity on how each player should behave in the game, in order to play the role adequately	We added a description of each player characteristics in terms of their values and beliefs in the cards.	We wanted to promote better roleplaying so that motivations and interests reflect real world transition actors. The descriptions also helped in immersing oneself in character.
Game could reflect the possibility of following different pathways for achieving systemic change	Three storyline narratives were added to guide the course of the game	We wanted to spark imagination about different regimes and different transition pathways in different parts of the world that may not necessarily require policy led change
The instructions of the game-play are too complicated and hard to follow	An informational sheet was developed and designed, including the set up, winning state, losing state and other rules of the game <sup>3</sup>	We wanted to make the instructions clear and accessible so that it is self-explanatory even without the active facilitation by a member of the game

<sup>3</sup> Supplied as supplementary material



		development team
Include citizens as actor	We didn't alter the 5 player cards based on this suggestion	We argue that the 'activist' player card represent citizens' voices

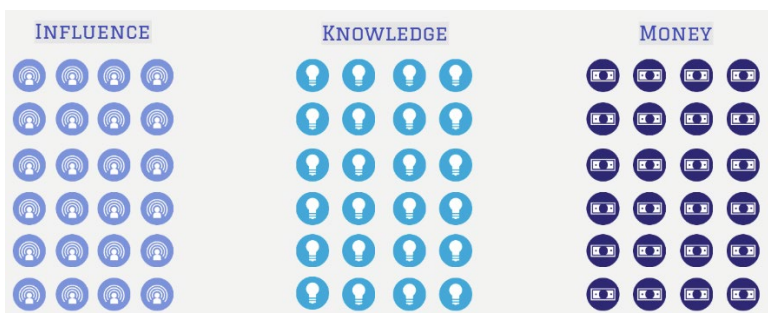
10) **Graphic designing of the game:** Incorporating aesthetic design supports players' engagement in game-based learning (Plass et al, 2015). When people play a game, they want to get immersed in the narrative and dynamic that the game presents. In that sense, graphic design has the potential of attracting players and of evoking certain emotional responses or behaviours from players (Dickey, 2015). This is why we used a professional graphic design team to make the game more accessible and visually appealing for participants. The teams emphasised colour-coding for the different types of cards, adjusting font sizes for easy reading, and adding visual icons to identify the resources. They also supported the graphic design of the informational sheet, adding artwork to illustrate the components and instructions of the game. All these elements can act as enablers for game immersion and have a significant impact on the game experience.

Figure 8. Example of a player card



Source: Authors' elaboration

Figure 9. Movable icons for resources



Source: Authors' elaboration

## 5. Analysis of game based learning for Transformative Innovation Policy (TIP)

### 5.1 Considerations for game design

*“TIP is a concept that is easy to understand on a high level, but operationalising it is hard. So a game is a nice idea to do so and help people grasp it.” (I5)* One of the TIP Consortium members who played the game in a playtesting session articulated the nuance of the challenge of communicating TIP theory. On one hand, it is a highly intuitive theory of change that sits well with policymakers. On the other hand, “What can I do” to enable this theory of change is often the struggle policymakers struggle with. This understanding motivated the game design.

During playtesting, players mentioned that roles offered in the game was difficult for players who do not know the theory and are unfamiliar with what, traditionally, each actor strives to achieve in the system, showcasing how prior knowledge influences player’s behaviours when playing. *“Role playing is challenging because people might not know a lot about the new role they are playing.” (I3)*. Prompted by this feedback, we created some descriptions that would invite players to ‘get into their characters’.

One of the key challenges in designing a game is to ensure that the players are motivated to *continue* playing the game, that they see the value of playing the game as they play. Therefore we needed to consider the difficulty level of the game, how many theoretical concepts to use, how to keep it engaging and how to enable association with the real world during play. At the end of the first game play session in May 2021, one participant commented: *“There are too many random things at the moment e.g., who starts the game, who has which green milestone, order of destroying red milestones etc.”* Indeed, in the initial conception of the game, we had many open-ended rules. Over the course of iterations, we reduced the randomness by allocating the “right” green cards to the appropriate actors, e.g. at the beginning of the game, the policy maker would hold the policy green card, and the researcher would hold the science and technology green card. This was an attempt at simplification, removing the complexity of “exchange of cards” required in initial iterations of the game. Over six months between March and September 2021, we experimented with several permutations and combinations of endowments, exchange rules, discounts, and incentives to make the game engaging and an effective learning space.

While playtesting the game, we observed that players play too altruistically when it comes to exchanging resources (this is also confirmed by the interviews: see I3, I4). They were often willing to offer their last remaining resource to someone without considering that this action would have negative consequences (e.g., they would not subsequently be able to build or destroy a milestone in their own turn). In further playtesting with secret goals incorporated in the game, we observed players anticipated what the other players’ secret goal was and acted accordingly to jeopardise such goals. These observations make game design a learning journey by itself.

There were considerable challenges in navigating the complexity of the game rules during playtesting sessions at the beginning of play. *"It took a good amount of time to get the game going at first, because it is not a particularly easy game."* (I2) Over time, this challenge was addressed by 1) streamlining the instructions in a detailed facilitation guide; 2) designing an infosheet for the game; 3) training and improving skills of facilitation.

In designing certain rules, we faced the dilemma of for whom is this game most suitable. Participants of our play testing sessions tended to agree that games are valuable for learning, yet the challenge has been to choose the right audience for the level of complexity of the game. Another feedback we received concerns the linearity versus allowing players to choose from different options. One interviewee suggested that *"[The] game is deterministic and rather constrained. Because it leads to constructing and deconstructing in a particular way.."* (I1). These feedback makes us consider making simpler and more advanced versions of the game, which can cater for different audiences (students, practitioners, and policy makers with varying levels of familiarity with transitions theory).

## 5.2 Value of game-play for teaching and learning TIP

The value of the systemic change game for TIP community can be argued in the following ways: i) immersion in a roleplay game enables players to reframe their perceptions about the complexity and dynamics of actor interactions in the systemic change process (Heinonen et al. 2017); ii) an interactive game is a good way to deeply learn as well as to unlearn; and iii) the game highlights the importance of cooperation in spite of personal objectives to fulfil, hence unlock social learning.

Social learning is a key feature of Systemic Change game. During the playtesting sessions, groups of TIP practitioners and researchers exchanged knowledge with each other to try and collectively win the game. While interdisciplinary researchers are more well-versed with the social, environmental, and cultural aspects of system change, the game also exposed practitioners from disciplinary backgrounds (e.g., in natural science and engineering) to understand the complexity of systems and the value of transdisciplinary collaboration for transformative innovation. The game enabled network building – one where interpersonal relationships were strengthened through vibrant exchanges (such as roleplaying a conversation between a policymaker and activist) that helped 'break to ice' between people even in online settings during the pandemic. The game, while bringing people out of their comfort zone, created a new space of ease and comfort for discovering own's emotions and communicating them. The game-play nurtured a mutual trust, connection and better understanding each other, which is highly valuable for co-creating knowledge for transformative change.

Most interviewees enjoyed the cooperative nature of the game (I1, I3, I4). They were curious to see how collaboration would play out between them as a group. *"[the] opportunity to interact with different team members and other people. This was not a one-sided thing, but a collective, collaborative task or activity."* (I3) Some players also highlighted the tension over individual secret goals and tensions between different actors as a realistic attribute of the game, something which creates undercurrents of competition. *"The tension between*

*collaborative and competitive forms. Although the collaboration was stronger ... It was good to have fun while also helping each other out.*" (I4). However, the extent to which players found the game 'fun' heavily depended on the group dynamics, interpersonal characteristics and a certain level of capacity of all players to match each other's speed and rhythm of thinking, analysing and decision-making. *"The game lacked an intrinsic element of fun; the enjoyment aspect was dependent on players' personalities. As a purpose-driven game, some extra elements could make the game more entertaining."* (I1).

While learning and having fun could sit in parallel, the objective of our game design was to prioritise learning and make the game interesting to play. Therefore the game design focussed on offering systemic change as a learning tool, which provokes curiosity about the practicalities and complexities of systemic change. For one interviewee, the game made them *"... reflect on what it takes to really understand the dynamics of change and whether or not this is something that could be simplified."* (I4) This begs the question to what extent the nature of interactions among players mirror those in the real world. Interviewees agreed that while some of the rule looks a bit 'superficial' and 'imposed' upon, other rules provide appropriate essence of a theory of change that can be applied for TIP practice (I1,I2,I4).

Several interviewees (I1, I4) reflected on the idea that the game is more focused on second order learning for those with a basic understanding of transitions theory. They mentioned how the game helped them to rethink their understandings, values, and norms. The game was an experimental space where players felt comfortable to speak and act according to their personalities. They also gained more clarity about the value of coordination as opposed to working in separate projects and policy programmes. Therefore, we argue that the experience of playing the systemic change game triggered learning and unlearning. The experiential element of game-based learning (Kolb, 1984) was also mentioned by participants of our play testing sessions. Several stated that the game was an opportunity for them and their teammates to put themselves in the shoes of different actors in a safe or experimental environment. For some, the game gave them *"an insight into how people behaved in that kind of setting when doing something experimental or outside their comfort zones."* (I2).

A reason why the game brought people outside of their comfort zone is illustrated in quotes about diversity. At least two interviewees stressed the importance of appreciating diversity of understanding and communicating with people from different educational backgrounds and cultural contexts. *"Interesting to see how people with different backgrounds interpreted the concepts of the game."* (I2). Another interviewee noted that *"Diversity in people's backgrounds in the session were [sic] very interesting for playing in a team ... Meeting people from different backgrounds. Heterogeneous groups where you learn from them because the discussions were richer, diverse ideas and experiences and not only the same type of people talking about the same."* (I3) This shows that the game stimulated players to realise that 'others have different perspectives and ways of understanding the world'. Such understanding encourages actors to act empathetically in a transdisciplinary context like TIP.

Games can also develop participants' cognitive abilities about perceiving and analysing transition processes. Games can encourage abstraction, analysis and problem-solving. They provide ways to navigate common challenges and solve visibly complex issues, using available resources, utilising the logical and analytical power of the human brain. As transitions are often about navigating uncertainty, a game-based learning space potentially drives the participants to enhance their analytical and problem-solving capacity through smart negotiations and maximising the use of social and communication skills. Such situations in a game teach the transition actor that solutions to complex problems are often solved politically through empathy, mutual respect, openness and cooperation, instead of technocratic solutions.

## 5.6 Future avenues for game development and dissemination

Future work involves further playtesting, developing more sophisticated application software for game-play and wider dissemination of the game for game-based learning across multiple policy and practice contexts. As Heinonen et al. (2017, p.110) note, "gaming-based social learning" can motivate participants to reframe perceptions about the complex dynamics of system change as well as appreciate the nuances of negotiation, argumentation, and reasoning. In this line, one senior researcher we interviewed suggested that a future iteration could include adding in regime actors to be characters resistant to, and even acting against systemic change. Adding new players e.g those who are resistant to change as well as other aspects such as incorporating spatial sensitivities and introducing uncertainties to the game would be options to extend the game. However, this will require a complete rethinking of rules, logics and flow of the game.

From a pedagogical perspective, the Systemic Change game is designed as an alternative tool for communicating about systemic transformations. One interviewee noted that the game is "*useful as a fresh participatory format that allowed people to learn the concepts by "osmosis". (I2)*. Another interviewee also said that the game is recommended for "*students who are just being introduced to Transitions, for them to interact with the basic concepts and ideas.*" (I1). As a future initiative, one might consider playing systemic change game in undergraduate and postgraduate classrooms as an effective method for teaching sociotechnical transitions and TIP theory.

The game in its current format is not suitable for players who are completely unaware of sociotechnical systems theories. "*The game works not as an introduction to a topic, but rather as putting in practice concepts that have already been introduced. For instance, it can be part of a learning package where you first are introduced to the concepts (by reading a paper), then discuss them, and then play the game and apply them. What you get from the game is that it is a different immersion to reading or talking about it, you can play with the concepts.*" (I2). These useful comments prompted us to think of a future package of learning materials that include the game-play as an activity following an introductory presentation on key theories and concepts of transitions. How to combine this innovative approach of knowledge co-creation with more conventional approaches of teaching and learning is an ongoing debate in the TIP community.

More immediately, we plan to play to game in the current format, in person and observe any changes in the dynamics and learning in the post-pandemic world. We envision that the game could be used at local policy levels, for engaging across local government, business, and communities to identify priorities for a just transition.

## 6. Conclusions

Games can be effective learning tools in transdisciplinary science-policy environments. Our experience of developing the “Systemic change” collaborative roleplaying game is grounded in the scientific literature on socio-cognitive and emotional impact of games in creating mental models of theories and concepts that are otherwise difficult to grasp and mobilise. Through developing and playing the game over the last eleven months, we have experienced effective social learning in a simulated environment, among policy actors and organisations in the TIPC Consortium, about how transformative change happens and the importance of context, collaboration, and timely action for enabling systemic change. A successful game-play session involves a playful learning experience among the participants, who would actively engage in roleplaying one of the five transition actors, negotiate with one another to exchange (limited) resources, and make collective decisions about destroying regime dimensions and building niche dimensions, given the existing constraints, incentives and secret objectives. A post gaming reflection session offers the space for sharing the experience and compare the simulation with realities of system change.

The game offers lessons for new ways of policymaking for system change in ‘post-normal times’, underlined by complexity, chaos and contradictions (Sardar 2010). The feedback we received from the participants in the four game-play sessions illustrate that the game offered hope that systemic change is possible, but also induced fear about lack of collaboration and adverse strategies hindering change. It allows participants to immerse in a setting where they realise that having simultaneous control over or accounting for all ‘rules of game’ is difficult - if not impossible, which installs a sense of humility for some and pro-activeness in others. Thus, policymaking for Transformative Innovation Policy can benefit from embracing uncertainty, reflexivity, learning from failure, incorporating values of modesty and accountability (Fuller, 2017).

This paper makes a methodological contribution by showcasing how to develop a learning game through a co-creational and iterative process and reflecting on how a game-based learning approach might improve players’ understanding of complex system change theory. This paper serves as an additional resource for those who are interested in playing the game and are curious about the logic and justifications of some of the game’s rules. We also hope that it may inspire game developers to develop more game-based learning tools for transformative action research community.

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## Appendix A - Interviews Summary

Interviewee No.	Organisation	Role	Interview Date
1	University of Sussex (UK)	Senior Researcher	September 20, 2021
2	Transformative Innovation Policy Consortium	Senior Practitioner	September 23, 2021
3	Ashoka University (India)	Junior Researcher	September 23, 2021
4	Utrecht University (Netherlands)	Junior Researcher	September 24, 2021
5	Research Promotion National Agency	Senior Practitioner	September 28, 2021