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Authors:	Michalina Kułakowska, Aleksandra Solińska-Nowak
Document description:	This document translates the simulation models created as part of O4 to game elements, mechanics and potential playing scenarios. The book aims at showing how abstract notions can be translated to game elements without losing their meaning. Furthermore, it provides a state-of-the-art on overview of board games that deal with sustainability issues, focusing on their advantages and disadvantage sthat were identified based on the past research on serious games.

Disclaimer
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Table of Contents

Table of figures

List of tables

1. Link with SUSTAIN project & other outputs

Urban sustainability is a complex concept that is composed of many elements, which are difficult to comprehend and understand without a wider perspective on the whole urban system. The game will give the participants of the SUSTAIN course a chance to experience the components of the urban sustainability described in the Intellectual Outputs (1, 2, 3, 4). It will also provide them with the environment for facing the challenges and trade-offs existing in every city. This document will translate the topics from the previous outputs into potential game elements and mechanics, which will be further developed by the Ergo Ludo Editions and incorporated into the game used for the course. This "translation" will be supplemented with propositions of the accompanying materials and a list of resources for further reading.

2. Serious Games & Social Simulations - philosophy, implementation, experiential learning

2.1What is a serious game?

A *serious game* is an activity that combines game elements with a serious goal and as such may be used to, e.g., guide skill or knowledge development (Djaouti *et al.* 2011). In its contemporary use, the term is commonly attributed to Abt who used it in his book "Serious games" to refer to activities that "are not intended to be played primarily for amusement". He also provided several examples of such games, which included both digital and "pen-and-paper" games, such as simple activities that enhance mathematical skills development (Abt 1970).

A special type of serious game is a *social simulation*. Unlike other serious games that may be played alone (e.g. single-player computer game or quiz), social simulations always entail lively interactions with other players. In this type of activity, participants gather in one room and enter a special place in time and space, a *magic circle* (Huizinga 1955) that is governed by simulation-specific rules and players' individual or collective goals. Immersed in the simulation, participants become meaningfully engaged in something that could be described as creative group scenario building, storytelling or role-playing (Geurts *et al.* 2007). In this different reality, players discard their regular social roles and assume new identities. Liberated from their daily obligations, they may freely exploit their creativity and come up with completely new solutions to the emerging dilemmas (Geurts *et al.* 2007). Importantly enough, unlike regular purely entertaining games, social simulations are predominantly focused on cooperative or collaborative interactions rather than rivalry. Through sharing new problem perspectives and different kinds of knowledge and expertise, diverse people can observe, understood or even inspire each other to develop new mindsets and modify their behaviors through a collective process, referred to as *social learning* (Bouwen and Taillieu 2004).

2.2 Why serious games? Learning through serious games

How can this learning occur? The time and space in social simulations are compressed – an hour may correspond to a year or decade, a small board or map may represent the whole region, city or country. Yet, the basic mechanisms and challenges presented and played out by participants correspond to real processes and situations. The immersion in a simplified yet realistic simulation world may help players obtain the "gestalt," "the big picture" (Duke 1974) of a specific problem, discover the interrelationship between their decisions, the decisions of other players and their emerging consequences. This capacity of social simulations (and other serious games) to reveal "how things work" is referred to as *procedural rhetoric* - "the practice of using processes persuasively" or "authoring arguments through processes" (Bogost 2008). In procedural rhetoric, arguments about "how things work" are made implicitly rather than explicitly, not through actual warnings, advising or recommendations, but through being actively engaged in a dynamic model and exploring its boundaries to figure it out. For example, a flight simulator models how the mechanical and professional rules of aviation work (Bogost 2008). Social simulations, on the other hand, may model complex challenges, such as energy transition, social conflicts or policy-making.

Learning through social simulation and serious games differs thus significantly from traditional knowledge acquisition, like that based on textbooks and lectures. Learners (or players, to be more precise) in social simulations are not passively exposed to lectures, diagrams or figures but are engaged in collective problem-solving, directly testing and verifying different strategies. In other words, games and social simulations naturally follow Experiential Learning Cycle, based on a "trial and error" process by which experience is turned into knowledge (Kolb 1984).

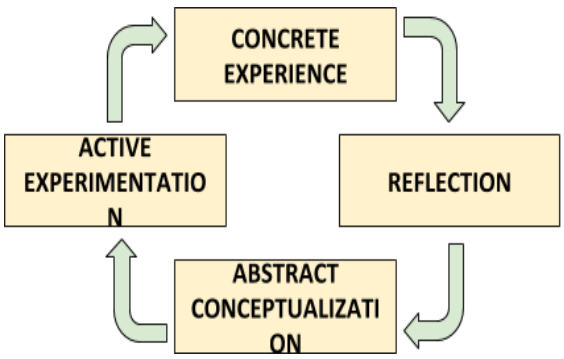

Figure 1. Experiential learning

According to experiential learning theory, knowledge is acquired in four sequential stages: 1) a concrete experience (what we see, feel or touch), 2) reflective observation (what we think about it and how we relate it to what we already know), 3) abstract conceptualization (making sense of the information available and drawing conclusions or developing theories.), and 4) active experimentation via applying new or modified ideas into the world to check what happens (figure1) (Kolb 1984). When faced with a dilemma in a simulation (concrete experience), players use critical

thinking and their ability to exploit their existing knowledge to deal with a new situation. Almost immediately after their decision, a result phase reveals its consequences. It may bring about, for example, a financial gain/loss or an unexpected natural disaster. It may also unlock new possibilities or, on the contrary, leave a player penniless and dependent on others.

When faced by frustrating or unexpected outcomes, players may easily modify their assumptions and base their subsequent decisions (in the following rounds) on a more sound recognition of a problem. Experiencing this decision-feedback cycle several times during one game session helps with verification of ineffective mental models and consolidation of new, more adequate strategies towards optimal solutions. As a result, players may develop self-reflection and undertake corrective action, fostering what is referred to as *double loop learning* (Argyris 1976).

Such active experimentation with solutions is very natural, rooted in intrinsic human curiosity and our willingness to try things out. For this reason, serious games and simulations are gaining recognition as a tool for addressing problems that require strategic thinking and collective decision-making. They are also often used in education, healthcare, defence, advertising, environmental awareness and sustainability, communication, politics, etc. (Djaouti 2011).

3. Serious Games - good practices

With the contemporary socio-economic issues (McAuley, 2018) and climate crisis (Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems, IPPC, 2019) becoming more visible for average people, a need has appeared for new tools to talk about and engage the public in solving the biggest challenges of our times.

A number of board games have been developed in recent years to address sustainability issues, including *The World's Future*, *Ruritania Game* (Anthony, 2019), *Nexus Game (*Mochizuki, et al, 2017*)*, *World Climate* (Sterman, et al., 2015), *Flood Resilience Game* (Keating, 2016) and more (Solińska-Nowak, et al., 2018). Those games, which include elements of or introduce the sustainability-related topics and themes, will be hereinafter referred to as *the sustainability games*.

Many of those games try to translate urban environment components into elements of playable game that would be both entertaining and educational, with varied levels of success. In this chapter we present the examples of several sustainability games (table 1), together with a summary of observed good practices, which could be adopted in the design of the Sustain board game.

3.1 Serious games for sustainability

With the resurgence of topics related to the sustainability and adoption of the Sustainable Development Goals, also known as the Global Goals, many organizations and companies started to use and develop games, ranging from workshop-based role-plays to commercially published board games that could be used at home with friends and families (table 1).

Most of the examined games are multiplayer games, designed for 2-30 participants (although the *Game of Urban Renewal* may also be played by one person), which adds to a lively atmosphere and spurs creative exchange of thoughts, especially in larger groups where several perspectives may be represented.

The majority of games require forethought and strategic thinking, as participants have to carefully weigh their actions against the decisions of other players and the resulting consequences. In *The World's Future*, players have to literally think about the world's future where their country's supply is constantly challenged by the demands of the growing population. In a different game, *Suburbia*, each player is developing their own neighborhood from available building tiles. Each tile is different, and while proper placement can generate significant profits, unfortunate one may radically reduce the tile's value (Smith 2015). Strategic planning is also at the core of the *Let's Make a Bus Route* game, as players (acting as bus drivers) cannot drop their passengers off randomly but rather carefully think about the order they let them out (for example, if a player stops by the shrine and allows a tourist to get off the bus too soon, he or she won't score many points in the end). Route planning gets even more complicated in the course of playing because players are not allowed to cross back over an intersection they have been to previously. As a result, "[y]ou need to think ahead as you plan out your map to make sure you get the stuff you need, while also making sure don't accidentally trap yourself on one side of the board" (SGL 2018).
An additional advantage of the games described is the fact that they encourage creativity and self-expression. In *Let's Make a Bus Route*, players are given markers and dry erase boards to plan their routes, predict hot spots and avoid potential traffic jams. Creative expanding of their neighbors or all cities is included in *Suburbia* (where players can choose from among a variety of buildings, including drive-throughs and casinos, homeowners associations and lakes and everything in between) and *Solar City* (in which players become the inhabitants of the future and try to rebuild their world after the eco-apocalypse). In the *Game of Urban Renewal* players can even enliven gameplay by introducing new buildings from bottle caps, pebbles, dried pasta, crystals, small candies, etc.

Although creative and enjoyable, not many of the existing board games meet all the criteria of comprehensive simulations. First of all, only some of them apply any realistic systemic model. There are, of course, board games that are based on existing case studies, such as social simulations *Nexus Game* (Mochizuki et al, 2016), *The World's Future*, and some computer-based games (e.g. MIT LAB tools). Those which very closely relate to the research data, like *Sustainable Urban Heating*

Simulation (Solinska-Nowak, et al., 2019), tend to be very complex and targeted at professionals and stakeholders who use them as a sandbox to test ideas and experiment with new solutions. Most of the analyzed board games (especially those linked directly with the urban sustainability) are either set in a completely fictitious setting or only loosely inspired by real places. For example, in *Solar City,* a science-fiction genre is exploited to set the context of the game. Players imagine that it is 2035 and huge corporations destroyed natural environment, leading to depletion of resources and millions of starving people. Trying to reverse these impacts, participants strive to repopulate the world and redesign the deteriorated city infrastructure. Even in *Let's Make a Bus Route,* which, in theory, takes place in Kyoto, the reference to the real city is in fact purely symbolic. Players move around a board to deliver tourists, commuters, students, and the elderly to selected destinations. While doing that, they have to be careful and avoid traffic jams. The city-specific transportation challenges are, however, not significant because the main goal for a player is to score as many points as possible (each passenger type is scored differently, for example tourists are most profitable as they may generate 42 points vs. 24 from students). Additionally, placing checks for passengers and areas (sightseeing spots, stations, universities) before other players can earn you extra bonus points, and so can elderly passengers or specific destinations (such as shrines or pagodas).

Such immediate gratification in the form of scores or bonuses is a common strategy used in these games. For example, in *Solar City*, introducing infrastructure activates a part of the city on a player's board, generating profits to the player who performed the action. More importantly, the action blocks the possibility of activating this part of the city for other players. Similarly, in *Suburbia*, correctly planned placement of a building may significantly raise a player's reputation and in consequence increase population (and the winner at the end of the game is the player with the largest population).

On one hand, this reward mechanism may force players to strategically plan each of their decisions. On the other, however, it may hamper their motivation and negatively affect their problem-solving skills. For example, studies on 51 children interested in drawing proved that the *expected* reward had decreased the amount of spontaneous interest the children took in what was perceived as their hobby before the study (Lepper et al., 1973). Similar results were obtained in adults. Reviewing 128 studies on the effects of rewards Deci et al. (1999, p. 658) concluded that:

> "Tangible rewards tend to have a substantially negative effect on intrinsic motivation (…) Even when tangible rewards are offered as indicators of good performance, they typically decrease intrinsic motivation for interesting activities."

Rewards can even make people less creative and thus less willing to look for effective solutions to problems. Why? The key to understanding this phenomenon lies in the difference between intrinsic and extrinsic motivation. When people do something because they like it or truly believe this is important, they are intrinsically motivated. They will willingly invest time and money to, for example, act towards sustainability; segregate rubbish, choose public transport rather than commuting by car

or support energy transition. However, when they do something because they expect a reward for it (e.g. money, reputation or winning the game), they are driven by extrinsic motivation. Extrinsic motivation may be misleading, as it does not stem from one's true propensity or desire but is conditioned by a reward. Such external motivation is fragile and may be easily undermined. It does not provide real impetus or inspiration to act and as such does not render into any significant long-term engagement (Ryan and Deci 2000).

Furthermore, rewarding spurs rivalry rather than collaboration. For example, in *Suburbia* or *Solar City* players may intentionally act against other players because they are afraid that their "opponents" will block their moves or gain more points. Also, although the majority of the games are multiplayer, the extent to which joint decision making can occur is limited. In most of the games, social interactions are not really encouraged and players are foremost pursuing their individual goals rather than working together for the common good. In most cases, players are either preoccupied with developing their own neighbourhood (*Suburbia*) or blocking investments possibilities available to other players (*Solar City*). Such decision making is not only inefficient (it does not lead to increased sustainability) but also rather simplified, as real decision-making in urban contexts has to be based on the collective wisdom of many actors (including public authorities, engineers, architects, planners, transport managers, activists or citizens), rooted in thorough analysis of potential trade-offs and synergies, and jointly negotiated.

What is more, players' actions are often guided by luck rather than a conscious decision-making process. For example, in *TheGame of Urban Renewal,* players spin a *Decision Engine Wheel* to check what move can be made (building, demolishing or drawing a card from the Planning Directive Cards). Also in *Let's Make a Bus Route*, participants draw cards to see where they can move their bus. Though it is intended to simulate uncertainty, it often deviates too much from the real-life situation, where uncertainty comes from the places where people naturally cannot make any decisions (disaster risk, weather) (CDKN Action Lab report, 2014). It limits players from making informed decisions and can lead to the frustration and negative emotions that may be directed towards the game itself.

The analyzed games have been created for specific groups, including sustainability professionals (*The World's Future*) and children and youth (*New Shores*; *Go Goals).* They are more often focused on a specific element of the system e.g., water-food-energy nexus (*Nexus Game*), disaster risk management *(Flood Resilience Game, Hazagora*). Some of the games specifically target urban sustainability (*The Game of Urban Renewal*, *Suburbia*, *Let's Make a Bus Route* or *Solar City*).

To address the gaps and combine them with positive aspects of existing board games, SUSTAIN was designed.

Sustainability	**Description**	**Advantages**	**Disadvantages**	**Link**

game				
Game of Urban Renewal	In the Game of Urban Renewal, players take one of the following roles: City Councilor, Developer, Community Activist, City Planning Employee, Man-On-The-Street, Academic Urban Theorist, Resident of Existing Development to be Demolished, Mayor, Random Federal Politician, Skyscraper Enthusiast, Garbage Man. From this perspective, they jointly try to manage the city. Each of them takes turn in spinning the Decision Engine Wheel to guide their action: build something (condominium, commercial building, public house, school or park) on a selected space on the board, demolish a building using.	No losers, no winners (the game lasts until all players have left the game in pursuit of other interests) Creativity: Players can add variety and enliven gameplay by introducing new buildings from bottle caps, pebbles, dried pasta, crystals, small candies.	The game spurs creativity and interest in architecture, land-use and urban planning but does not really highlight the sustainability aspect.	http://flaviotrevisan.com/2011/the-game-of-urban-renewal/
The World's Future	The World's Future is a social simulation that enables players to steer the future of the fictional countries that they become the leaders of. As the simulation progresses, they experience the pressure of making tradeoffs and the thrill of finding synergies involved in pursuing sustainable development.	Based on a systems model. Motivates through intrinsic motivation. Sandbox for testing ideas.	Very broad subject. Long (around 5-6 hours). Because it is targeted at professionals, it can be seen as very complex and difficult to play for other groups. Requires at least two moderators to facilitate the game	https://worldsfuture.socialsimulations.org/#about
Suburbia City Building Board Game	Suburbia is a tile-laying game that allows players	Fun, lively, realistic (a lot of different types of buildings	Triggers rivalry rather than cooperation (everyone is	https://www.theg

	to build and expand their neighborhoods. Participants are encouraged to invest in infrastructure that in the course of time will encourage population growth. As the town grows, players may increase their income and their reputation.	from drive-thrus and casinos to homeowners associations and lakes and everything in between).	developing their own suburb, often players weight up how much they are willing to buy a tile vs. the risk of another player buying it)	uardian.com/technology/2015/sep/05/suburbia-review-ballardian-town-planning-on-your-dinner-table
Let's Make a Bus Route	In Let's Make a Bus Route, players become the employees of a bus company in Kyoto. Their task is to create new bus routes that will respond to the needs of locals and tourists.	The game highlights the importance of efficient traffic management.	Many elements on the boards, long instructions	http://sgl.la/blog/letsmakeabusroute-review
Solar City	Solar City is a board game that applies build-and-block mechanics. Players imagine that it is 2035 and the world has been destroyed by the biggest corporations Their task is to restore the ecological balance and turn cities into "liveable places overflowing with lush greenery and powered by the energy of the sun."		The game triggers competition rather than cooperation, it is based on the extrinsic motivation to gain a reward (to win the game) rather than on intrinsic one.	http://www.gamesforcities.com/database/
New Shores	New Shores – a Game for Democracy is a multiplayer online game in which players are striving to develop a thriving society on a small fictional island. To do so, they may use the island's natural resources, earn money	Teaches about complex system in an easy way. Adapted to the use during limited time. Supplemented by the free teaching materials.	Players are expected to have at least basic digital skills and use mobile devices.It may be thus less accessible to the elderly or to players from poorer countries. Requires connection to the Internet.	https://newshores.crs.org.pl/#game

	and invest it in new facilities, both private and public. At the same time, they have to be careful not to upset the ecological balance of the island and avoid potential disasters.			
Go Goals	Go Goals is a game targeted children aged 8 to 10. Players move their tokens along the board and answer questions. The right answer is rewarded by the additional roll of a dice.	Very short and easy for all groups of players. Prepared for the self-print, which makes the game easily available through the Internet. Does not require a moderator.	Too simple to be engaging for older audiences. Only relays facts, does not use any procedural representation to represent processes and interconnections. Lacks elements that would engage players in social interactions. The game may trigger competition rather than cooperation, it is based on the extrinsic motivation to gain a reward (to win the game) rather than on intrinsic one.	https://go-goals.org/
Nexus Game	Nexus Game offers an opportunity to explore the challenges of water management for energy and food production. Participants are put into the roles of key ministries of two countries sharing the same river. From this perspective, they may brainstorm and collaborate to creatively form and verify a number of policies. As they try to meet the growing water demands, they still have to consider ecological and economical balance within and across the borders.	Uses procedural rhetoric to relay the processes. The simulation lets players observe a cause-effect in a very linear way. Motivates cooperation.	Requires a moderator. The simulation may be very long, even up to 4 hours.	https://nexus.socialsimulations.org/#applications

Flood Resilience Game	Flood Resilience Game allows players to experience and learn about the flood risk and resilience of communities in river valleys. Players become members of a community living in a flood-exposed area and are expected to come up with and implement effective flood-resilience strategies and policies.	Supplemented by a set of material for moderator to support the workshop.	Can be long and requires a moderator. Very focused on the resilience, does not allow creation of transformative strategies.	https://floodresilience.socialsimulations.org/#about-the-game
Sustainable Urban Heating Simulation	Sustainable Urban Heating Simulation enables participants to experience and identify specific opportunities, challenges and risks of transition towards low or zero emission heating options. The simulation enables participants to practice decision-making, negotiation and consensus building under uncertainty, triggering creative thinking and inspiring them to seek more realistic heating solutions for their homes and cities.	Includes real data and numbers. Lets players make both individual decisions (which impact only them), and decisions that directly impact the city's policies as a whole. Can be seen as a sandbox to test new ideas and create strategies.	Because of the real data and numbers included, it is quite complex and requires mathematical skills to play. Requires computer and spreadsheet for the calculations, which is quite limited. Can be quite long, requires at least 3 hours. Requires 2 moderators.	https://iiasa.ac.at/web/home/research/researchPrograms/RISK/190306-socialsimulation.html

Table 1. Sustainability Games and their characteristics.

4. Designing SUSTAIN the board game

Designing the game-based learning tool requires translating the concrete system into the game mechanics and game elements. For this reason, the approach is similar, with exceptions, to the design thinking theory.

4.1 Design thinking

4.1.1 Definition and characteristics

Design thinking is commonly defined as "an analytic and creative process that engages a person in opportunities to experiment, create and prototype models, gather feedback, and redesign". The final result of design comprises design concepts (proposals for new products, buildings, machines or programs). Design thinking has become an integral part of design, engineering, business or education. It usually starts with dissatisfaction with some existing solutions and determination to take action to solve the problem (Razzouk and Shute 2012).

At its core, design thinking refers to how designers *see* and how they consequently *think* (Liu, 1996). It is an iterative and interactive process where a designer or (preferably) a team of designers analyzes some representation of problem-solving concepts/ideas, finds correlations between them to solve the problem, and observes the result to inform further design efforts (Do & Gross, 2001; Lloyd & Scott, 1995).

According to Braha and Reich (2003), the design process is iterative, exploratory, and sometimes chaotic. It often starts with a diagrammatic representation that is transformed to more complex visual depiction by adding detail. The objective of using the visual "prompts" is to spur reflection, discussion, and self-critique and therefore test the idea. The ongoing process of modification of the idea/concept is supposed to remove "discrepancies and establish a fit between the problem space […] and the proposed design solution" (Razzouk and Shute 2012).

4.1.2 Forms of thinking in design thinking

Several forms of thinking can be observed in designing (Dorner, 1999):

- Design begins as a vague idea about what the design/product should look like and how it should work.
- In the course of time, sketches and models help transform the vague idea into a clearer and more concrete form. They also clarify the characteristics of the product and help to form a specific line of thought that facilitates the development process.
- The third form of design thinking consists of "picture-word cycle," that is, putting ideas into words that help the designer specify and work on details of the idea.

4.1.3 Design-thinker characteristics

Design thinkers should not only display creativity but a range of other characteristics (Owen 2007):

- Human- and environment-centered concern: Designers must keep in mind how the final product will address human needs. They should also consider environmental interests.

- Ability to visualize: Designers should be able to work visually (i.e., apply depiction of ideas).
- Predisposition toward multifunctionality: Designers should look at a range of possible solutions to a problem and keep „the big picture" of the problem in mind.
- Systemic vision: Designers should consider a problem from a systemic approach and apply systemic solutions (involving different procedures and concepts to create a holistic solution).
- Ability to use language as a tool: Designers should be able to explain their process not only visually but also verbally.
- Affinity for teamwork: Designers should develop interpersonal skills to be able to communicate with a wide range of across disciplines and work with other people.
- Avoiding the necessity of choice: Designers should look for competing alternatives before moving to choice making or decision making. They try to find a solution that avoids decision and combines the best possible choices.

4.1.4 Processes in design thinking

During the design process, designers are engaged in a number of cognitive processes (Kolodner and Wills 1996):

- **Preparation:** In this process, designers have to decide what to focus on. Therefore, this phase includes specifications and constraints of the problem, reinterpretation of ideas, visualization, problem reformulation, situation assessment and elaboration.
- **Assimilation:** In this process, designers make sense of the proposed solution, data, and observations coming from the design environment, such as feedback from experiments with prototypes.
- **Strategic control:** In this phase, designers must make many decisions over the course of a design (e.g., which idea to elaborate or adapt next, which constraints to relax, how to set priorities). They also move among various tasks, subproblems, and design processes in a flexible and highly opportunistic manner.

The basic elements of design thinking include generation, exploration, comparison, and selection. The generation and exploration widen a problem space, while the comparison and selection narrow a problem space:

> "When widening a problem, solutions are generated and then examined in relation to the goal. Then, in an iterative process, solutions may be modified or new solutions may be developed until an optimal solution is found. Narrowing a problem entails comparing two or more ideas and then selecting the solutions based on specific and relevant goal criteria." (Razzouk and Shute 2012)

4.1.5 What is the problem, objective and target groups?

The concept of a tool should be based on the problem, target groups' needs, and if possible, research in existing games focused on similar themes (Chapter 3). In the first phase of game design, it is good to learn from the mistakes and successes of others rather than our own.
The main problem, or in this case, the main assumption is that a group of people wants to use the potential of game-based learning as a support tool for the course that includes elements of urban metabolism, sustainable transportation, decision-making and the basic systems thinking. Some of the objectives of the game will thus coincide with the objectives of the course, namely:

Introducing the topics of sustainable transportation and urban metabolism.
Supporting the understanding of a complex system.
Providing a safe (and playful) environment for learning.
Promoting a sustainable way of living.
Learning about and experiencing sustainability related issues.

Table 2. Goals of the Sustain board game.

Other objectives, on the other hand, will focus on improving interpersonal skills through the play.

Communication: Good communication consists in collecting insights and perspectives from many different people and plays a key role in any decision-making process. A playful environment of games is perfect for triggering the exchange of opinions and experiences and joint decision-making in safe and respectful way (Geurts, et al, 2007).
Creativity: In the game, players assume fake roles and are thus encouraged to move away from their habitual thinking. As a result, they may be more creative and find the courage to think outside the box, explore and test innovative solutions to the emerging problems (Geurts, et al, 2007).
Consensus: Unless they realize that some of the goals they pursue are shared with others, people tend to be focused predominantly on their own interests. Games make use of this tension between individual and collective priorities, triggering rivalry but at the same time leaving enough room for collaboration. Sometimes, a decision to cooperate calls for personal sacrifice and thus offers a valuable lesson for students to overcome their "greedy" instincts and practice mutual understanding (Geurts, et al, 2007).

Table 3. Interpersonal objectives.

After the problem and objectives have been set, we can think of target groups. In the case of the SUSTAIN board game, we can identify 2 target groups: 1) students and 2) university, and high school teachers. The game is expected to serve as support material supplementing the final output of the Erasmus + SUSTAIN course.

Target group	**University students, university lecturers**
Problem/main objective	Experience, learn and understand the key concepts of urban sustainability, such as societal metabolism and urban transportation.
Other objectives	● Players practice decision-making, in particular decision-making under stress and uncertainty. ● Players learn how to communicate and collaborate more effectively. ● Players develop negotiation skills. ● Players face the complexity of the real world and explore solutions of the real-life problems in a safe environment. ● Players diagnose organizational challenges of city management. ● Players experience challenges connected with transitions in complex systems where multiple stakeholders' interests collide. ● Players learn how they can affect the urban system in the real world. ● Players develop critical thinking.

Table 4. Target groups.

After the target groups are established, some assumptions about them can be made (preferably based on interviews or other interactions with the target groups' representatives, table 5). In this case, the expertise was supplemented by the expert partners of the Sustain project.

	University students	**University lecturers**
What we know about target group and their environment?	may be familiar with commercial board games	may not be familiar with game-based learning
	may have varied speed of learning	have to be able to facilitate the game by themselves
	the number of students in class can change	
	the class is confined to the room	
	the class is limited by the time	

Table 5. Target group characteristics.

Based on our knowledge of the target group, it is possible to make general assumptions about the game (table 6).

What do we know about target groups and their environment?	**Assumptions**
may not be familiar with game-based learning	Easy to moderate, if possible no moderation
has to be able to facilitate the game by herself/himself	1 moderator
may be familiar with commercial board games	The game could be self-facilitated, the students may understand the mechanics quicker than the moderator
may have varied speed of learning	Everyone should be engaged in the learning of the mechanics process, peer-based support is recommended
the number of students in class can change	The game should be scalable to accommodate more or less players depending on the game session.
the class is confined to the room	The game should not include too many elements. Moderator should be able to set it up in the classroom.
the class is limited by the time	The game should be introduced, played and debriefed in the span of 1-3 h.

Table 6. General game assumptions.

Additional game assumptions can be inferred from the project-specific limitations, such as budget constraints and possibility to offer downloadable and self-printable materials. The SUSTAIN project assumes that the game will be available for self-print. As a result, the format of materials should ensure easy printing and cutting. Moreover, the project accounts for participants with disabilities, thus the game materials should be accessible or adaptable in terms of text size, materials, and other accommodations that would enable it to be used in an inclusive environment. Knowing the general game assumptions is a first step in the game creation process. The assumptions can change during the ideation, iteration and prototyping. However, they can provide a framework and let designers limit their ideas and find specific solutions that address the target groups' needs.

4.2 Real-life analysis and game components

To achieve the tool's objectives and successfully support learning through the game, game designers should identify important and relevant real-life elements (infrastructure); trade-offs, threats, shocks and time scales and incorporate them into the game.

In the case of the SUSTAIN board game, the real-life analysis and the identification of key elements are introduced in Intellectual Outputs 1 & 2. Additional links between said elements are introduced through Intellectual Output 4. Intellectual Output 3 focuses on useful tools for both game design, and, to be explained in the further chapters, for feedback and deepening the reflection.

4.2.1 System

The model created by the Italian Chapter of the System Dynamics Society, one of the partners in the SUSTAIN project, became the basis of the simplified model that could be used in the game (figure 2).

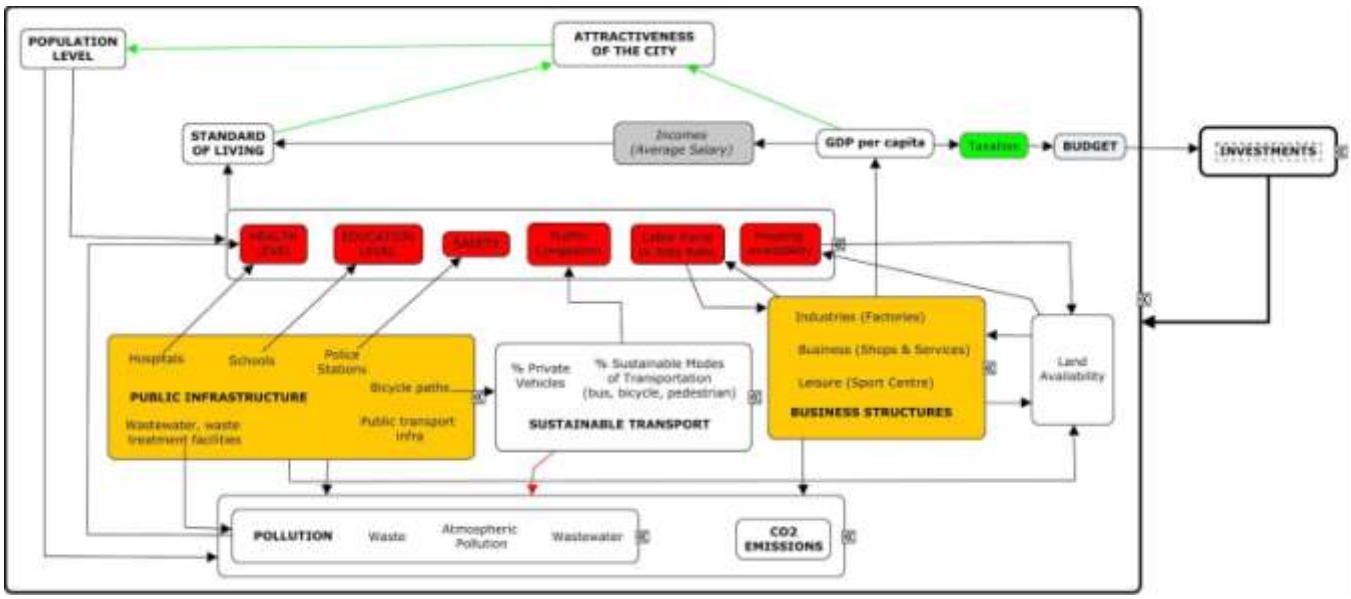

Figure 2. Simplified model used in the prototype of Sustain board game.

When creating a simplified model, authors took into consideration the elements underlined by the Intellectual Output 1 and 2 of the Erasmus + SUSTAIN project, and those elements that could affect the said elements directly. Besides the elements of the system, it was important to understand what threats and shocks can be observed within the system represented in the SUSTAIN board game. This data was also provided by the model prepared by Erasmus + SUSTAIN project partner System Dynamics Italian Chapter. Thus, the simplified model focuses on Pollution flows, understood as air pollution, waste, and wastewater, as well as CO_2 emissions. All greatly affect the urban environment and can be used as an example of the urban metabolism in the game.

Another very important element from the standpoint of the course is highlighting the topics and concepts related to sustainable transport.

Element	**Description**
Attractiveness of the city	defined as a final and most important indicator e. It is directly affected by the Population level, Standard of Living and GDP per capita, and indirectly by Pollution, Sustainable transport and land availability (and also by the existing infrastructure).
Standard of living	defined as a collection of indicators related to the wellbeing of the citizens. This indicator is directly related to the Attractiveness of the city.
GDP per capita	defined as a monetary measure of economic wellbeing of the citizens. It will directly affect the Attractiveness of the city (through an average salary) and all the departments' budgets (through taxes).
Population level	is defined as the number of people living in the city. This indicator is linked with the Attractiveness of the city (through migration - a direct link). It will also affect the Standard of living (through the housing availability and the Labor force to jobs ratio - through events) and Pollution and CO_2 emissions.
Sustainable transport	defined as % of private vehicles and % of sustainable modes of transportation. Players will be able to influence this indicator by investing in Sustainable means of transportation (e.g in bicycle paths, new bus stops, various campaigns) or in programmes and policies that would discourage the use of private vehicles (high cost of parking, zones limited only to public transport) or encourage the use of public transport (various campaigns, lower prices for the public transit).
Pollution (air pollution, waste, wastewater) accumulation	defined as an accumulation of air pollution, waste and wastewater produced each round. The tangible infrastructure in the city (residential areas, hospitals, schools, industry and more) will have a specific set pollution production. Using public infrastructure such as the Wastewater Treatment plant, players will have to deal with the existing pollution. Otherwise, the Pollution accumulation level will increase. Players can lower the accumulation level by investing in pollution treatment facilities and programmes or by working on lowering the pollution emissions (energy efficiency technologies, pro-renewables campaigns and subsidies, water efficiency, promotion of bio products and more). Population level might additionally affect the pollution produced.

CO_2 emissions	defined as the city's emissions of CO_2 (from population, industry, business, etc.).
Land availability	defined as the number of plots in the city available for a new use, development or investment.

Table 7. Main indicators for the city.

4.2.2 Stakeholders - what roles to put into the game?

A big challenge for the game design was to identify the stakeholders whose voice should be heard and who should be represented by the in-game roles. Systemic models more than often do not include the human element and focus solely on stocks and flows (Sterman 2013).

The decision making process is a key element of the whole SUSTAIN project and as such, it had to be taken into consideration in the design process. Therefore, it was decided that the players should learn about the system from the point of view of the city-level decision-makers, namely, the local administration representatives.

This choice has many advantages. First of all, the players can make city-wide decisions and experience their results, not only related to their immediate environment but also to the whole urban system. When playing the game with many rounds, players have a chance to repeat the experiential learning circle (figure 1) until they find solutions that fit their purposes. Another advantage is to give players who normally do not have such competencies in real life an opportunity to engage in large-scale decision making (Kolb 1984). It can potentially not only let them learn about the relations and trade-offs that affect the system on the biggest scale but also show the everyday struggles and goals of various interest groups that try to lobby the local governments.

But to achieve this, the specifics of the real-life actors have to be determined. The challenge in the design of this element lies in diversified administration structures and priorities that can be found throughout European cities. After analyzing the city departments of several cities, including Wroclaw, Warsaw, Athens, and London, a few interesting things came to the game designers' attention. The city departments from different cities, even within the borders of the same country, bear various names and have often overlapping responsibilities. Furthermore, there are many discrepancies between their responsibilities and actions.

It would be impossible to place all of the actors in the game, which is why the roles were generalized and their responsibilities were limited to the indicators, so it would be instinctual for players during the game.

Role	Tasks & Responsibilities	Description
All	Attractiveness of the City	
All	Reputation for department	
Department of Infrastructure	Public Infrastructure Energy distribution Revitalization & development of the new infrastructure Indicators: GDP PER CAPITA STANDARD OF LIVING ATTRACTIVENESS OF THE CITY	Congratulations! You have just been nominated as the head of the Infrastructure Department. You are partially responsible for keeping the GDP per capita at a high level. You should also keep an eye on the location of new buildings in the city. The most important buildings shouldn't be too far from residential areas, otherwise it could negatively affect the standard of living. Another important thing that you should monitor is the attractiveness of the city! It's the ultimate indicator of your city;s awesomeness. The residents will judge your every move and express their confidence in your actions.
Department of Environment & Sustainability	Level of pollution Level of emissions Promoting sustainable solutions Waste management Indicators: CO_2 EMISSIONS POLLUTION ACCUMULATION & PRODUCTION ATTRACTIVENESS OF THE CITY	Congratulations! You have just been nominated as the head of the Environment & Sustainability Department. Your task will be to promote sustainable solutions for waste and pollution management. You are responsible for lowering the CO_2 emissions and keeping the city's pollution levels at a minimum. Another important thing that you should monitor is the attractiveness of the city! It's the ultimate indicator of your city's awesomeness. The residents will judge your every move and express their confidence in your actions.
Department of Transportation	Efficient transportation within the city Public transportation Streets and sanitation Indicators: SUSTAINABLE TRANSPORT ATTRACTIVENESS OF THE CITY	Congratulations! You have just been nominated as the head of the Department of Transport. As such you will be responsible for efficient transport within the city. Try to address any problems connected sustainable transport. The most important buildings should be well connected to residential areas. Another important thing that you should monitor is the attractiveness of the city! It's the ultimate indicator of your city's awesomeness. The residents will judge your every move and express their confidence in your actions.
Department of	Welfare of the community	Congratulations!

Welfare	Health Contacts with NGOs Awareness campaigns Indicators: STANDARD OF LIVING ATTRACTIVENESS OF THE CITY	You have just been nominated as the head of the welfare department. therefore, the standard of living (health, safety, education, culture and more) of the city residents is in your hands. Ensure your people have access to educational facilities and jobs. Another important thing that you should monitor is the attractiveness of the city! It's the ultimate indicator of your city's awesomeness. The residents will judge your every move and express their confidence in your actions.
Department of Law & Public Services	Law enforcement Public safety Disaster preparedness & response Indicators: STANDARD OF LIVING ATTRACTIVENESS OF THE CITY	Congratulations! You have just been nominated as the head of the public services department. As such you are responsible for the standard of living of the residents. Make sure that the city is well protected against crime and unexpected events. Another important thing that you should monitor is the attractiveness of the city! It's the ultimate indicator of your city's awesomeness. The residents will judge your every move and express their confidence in your actions.
Department of Culture, Sport & Education	Cultural projects & festivals Sport facilities Educational projects Awareness Campaign Indicators: STANDARD OF LIVING ATTRACTIVENESS OF THE CITY	Congratulations! You have just been nominated as the head of the culture, sport & education department. Your task is to ensure the residents equal and open access to cultural, educational and leisure activities, so the standard of living of the city's residents. make sure that the offer is affordable and matches the needs of all age and social groups. Another important thing that you should monitor is the attractiveness of the city! it's the ultimate indicator of your city's awesomeness. The residents will judge your each move and express their confidence in your actions.

Table 8. A proposition of description of the roles which could be used as an introduction for the players.

4.2.3 Elements and their representations - prototyping the game

Another challenge of designing the SUSTAIN board game was identifying which of the elements of the system could be translated into concrete objects in the game and which should be represented by the rules or mechanics. The representation of the system element is never random. Game designer has to examine the role of the element in the system and its importance in achieving the game's objectives. In other words, each physical element of the game must have a specific function connected to the real-life system elements, trade-offs or shocks.

The city's current status in the game is symbolically represented by a number of indicators. Their changing values are reflected by progress tracks. Additionally, the city's plan and infrastructure, which

also play an important role in the game, are represented on the board by a limited number of tiles. The game materials include also different types of cards. Firstly, Role cards represent the roles in the game. They provide players with basic information about their tasks and responsibilities (indicators/KPIs), and the allocated budget and current reputation. The number of Role cards corresponds to the number of players. The next type of cards - Event cards, sets up the events for the round. Cards that belong to this category have a big impact on the whole city, e.g., a new nationwide policy that city has adapted to. Those cards must be sorted before each session according to the specific scenario. Additional scenarios would add a replay ability factor to this version of the game. More cards can be added to highlight the uncertainty (for example, natural disasters, change of political parties and more). Event cards can also be used to facilitate the game - Event cards with instructions can replace the facilitator during the game but at the same time ensure the just-in-time information and the understanding of all rules by all of the participants.
Each Role starts with a separate deck of possible investments (Solutions). Each solution has a specific name (i.e., Build a new school); description, which doesn't have to be included directly on the card, but can be added as a supportive material; effect on one or more indicators, and level of public confidence in department; requirements to implement the action on a card and cost. The description can be omitted on the card but should be added to the game/course materials. Additional materials can still add to the learning objectives without being disruptive for more advanced students. Each department has to consider the trade-offs, as not all of the solutions have only positive impacts on the city. Solutions can be infrastructure-based (i.e., facilities, residential buildings, bicycle paths, parks, business and entertainment facilities) or policy-based (i.e.m subsidies, campaigns and more). The Solutions could be permanent (e.g., new schools/hospitals but also lasting policies) or last only for one round. Only a few Solutions are available for each department at the beginning of the simulation. The rest of the cards will be drawn in the next rounds by departments, according to the scenario and in relation to citizen requests. Additional Solutions could also be attained in relation to the events. Another deck of cards - Request cards - furthers the narration for the gameplay. Request cards represent both requests and complaints from various interest groups in the city and can touch on different topics. For example, the request can involve the food/water/energy nexus, issues connected to public transport or urban greenery, facilities within the city and many more. The Request cards may ask players for investments that are not quite necessary or welcomed in the city but represent the need to "respond to the citizens' requests." It may be that investing in some solutions may bring very positive individual outcomes for the player, i.e., doubling the public confidence in the player. Requests that have not been addressed will bring negative effects, e.g., change in the governance or the lowering of some city indicators.

Requests are common for the whole city and can have a negative effect on public confidence in all departments if not solved. The faster they are answered, the bigger increase in the public confidence in the department that invests in the requested Solution. Requests and Solutions should be, at least partially, based on the good and bad practices described in the other outputs and observed in European cities.

The state of the city and players' actions (some of the solutions) may affect the outside world by increasing the concentration of CO_2. It is possible to add some linkages to the relevant SDGs both through cards or even on a more practical level. For example, inequalities can be represented by different departments having different budgets - thanks to the immersion; the players will consider it on a more personal level.

The game ends after a specific number of rounds or after specific indicators reach certain levels, either desired (e.g., the attractiveness of the city) or undesired (e.g. pollution accumulation and production or CO_2 emissions). The results are summarized by comparing different indicators to represent the effectiveness of each department and the city as a whole. Despite these indicators, there is no clear winner or loser of the game and players will be free to interpret the results, though some explanations and examples from the real world should be prepared to reflect on the linkages to the current world problems.

The identified indicators could be represented by the paper tracks or cards with points. The model and e-books 1 & 2 identified some infrastructure and projects that could be represented in the game as specific game elements. For example, facilities connected to the waste flows were taken directly from the model. So was transport infrastructure - both sustainable and unsustainable, i.e., roads or bicycle paths.

The players will receive feedback on a few levels. First, when investing in Solutions, departments will receive reputation points (individual feedback) and check the effects their actions have had on the city's indicators (state of the city). Secondly, some of the indicators, such as pollution/waste, wellbeing and more, will affect each other through synergies and event cards. Both the players' actions and the levels of indicators will affect the outside world, which will be represented by the CO_2 emissions indicator.

After making assumptions about the physical representation of the systems elements, it's time to prepare a prototype and test it.

4.2.4 Further development and iterations

The prototyping is very important in the process of iteration. The prototype should be easy to modify and flexible. The first prototype hardly ever becomes the final version of the game. It is especially true in the case of serious games, where the user's context may be dramatically different from the context in which the tool has been developed (R. Dörner et al.). Before reaching its final form, the game has to be tested many times, ideally with varied groups or, if there is any - a specific target group. Each iteration of the prototype removes elements of systems that are unneeded or too complex and adds elements that were missing. It might happen that the physical representation of the elements could completely change to accommodate problems observed during the test. Each text, instruction or icon should be user tested in terms of inclusivity. To this end, tests should gather

as many people with limitations and special needs as possible. Their inclusion often leads to change in the color palette, type and size of the font.

The SUSTAIN board game was tested with representatives of various groups with different backgrounds, such as high school students, PhD students, policy experts and game designers, aged 17 to 40+ (figure3). The tests were facilitated simultaneously in Poland by the Centre for Systems Solutions, and in Italy by Ergo Ludo. The version of the game used in the lead course at the Macedonia University will be much different than the initial prototype prepared for the first tests (figure 4).

Figure 3. One of the tests conducted in Wroclaw, Poland.

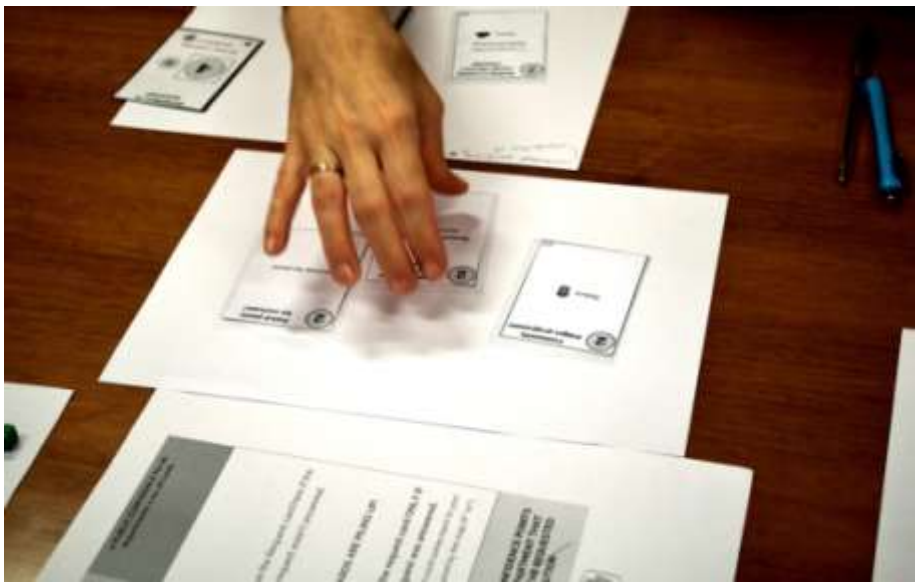

Figure 4. Photo from the test led by Ergo Ludo during the transnational meeting in Rome, Italy.

This is not to say that the development of the game will end with the course. Our objective is to further develop the game, even after the project's completion. To this end, we will gather the feedback from all players (including you, the reader) and use it later to improve the product. Taking into account the notion of generational learning, we aim to make use of solutions and projects conceived by the students during the course and either add them to the game or develop them into alternative scenarios.

5. Moderating and a deeper reflection

5.1 The role of the moderator

The Moderator's role during the game should be minimal. The Moderator should lead the intro to the game and facilitate the debriefing. During the game, the rules and gameflow will be explained through game elements. The Moderator keeps an eye on the players and reacts when ground rules are broken.

5.2 Intro

5.2.1 Explaining about social simulations & games

At least a short explanation of social simulation & serious games is necessary. During the course, one of the weeks will be dedicated to providing players with background information on games & social simulations.

5.2.2 Basic rules

At least short introduction of the basic rules is necessary in the form of a short presentation.

What should be explained?

- General introduction to the city
- General introduction to the roles
- Different types of cards
- Number of rounds & time
- No winners, no losers
- Your own goal

5.2.3 Magic circle

Introduce the concept of a magic circle:

> *In the simulation we are within the magic circle. Upon entering it, we start to identify with the adopted roles. Remember that these are only roles and they should be separated from the actual people playing them. What happens in the circle - all your actions and interactions - should stay in the circle. If you experience any discomfort during the simulation, please let us know, we can stop it at any moment.*

5.2.4 Ground rules

Some ground rules you might propose:

- One person speaks at a time;
- Questions may be asked to clarify ideas;
- Criticizing others must always occur in a careful, respectful and constructive manner;
- Feelings may be expressed; they are not to be suppressed or denied;
- If anyone feels uncomfortable, you can stop the game.

5.3 Debriefing

A summary discussion is a key element of a game-based workshop. It is usually referred to as "debriefing" and defined as "the occasion and activity for the reflection on and the sharing of the game experience to turn it into learning" (Crookall 2010). During the debriefing, participants are encouraged to air out their emotions, analyze and reflect on their moves and draw lessons from the shared experience. A proper debriefing session enables to clarify any debatable facts or situations encountered in the game and helps participants address any stressful aspects of the workshop, transforming the play into a learning opportunity.

- Results overview: facts about the game situation at the end
  - Individual reflection for all roles
  - Goals
  - Challenges
- Relationships with other roles
  - Interlinkages in the system
- Roles summary
- Discussion + facilitator's feedback
- Bridging with the real world
- Individual reflection: what have I learned?

- Optional: survey

5.3.1 Examples of debriefing questions

5.3.1.1 Individual

Each player will receive individual feedback in the form of department's reputation, which will not always be positive. The Individual results could additionally be measured through the final level of indicators. The game's rules do not define the winner.

- What are your individual results?
- Do you feel satisfied?
- What was more important to you? Reputation or the condition of the city?
- What were your goals in the game? Did you achieve them?
- What helped and what blocked you on your way to achieve your goals?
- What was your role in the group?
- Who answered to at least one Request? Why? What was the request?
- Was it difficult to make decisions under uncertainty?

5.3.1.2 City

The players should receive feedback on the condition of Population and the city (pollution and Attractiveness of the city). The final results should be correlated with descriptions/explanations of what the level could mean in the real world city, i.e via a table with levels/ranges of results. The players should also receive feedback on the environmental effects of their actions, i.e. CO_2 production, pollution and in an in-classroom game with more than one city - CO_2 accumulation across games.

- What is the result of the game?
- What are the results for the City?
- Who has implemented the most Solutions?
- What does it mean to win in this game?
- Did you apply any strategy that governed your decisions in the game.
- How did your city affect the world outside of it? Where would it lead?

6. Additional materials

6.1 Further reading

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6.2 More games

1. Games4Sustainability: https://games4sustainability.org
2. Games for Sustainability: https://gamesforsustainability.org/resources/
3. Games for change: http://www.gamesforchange.org/games/

6.3 Audiovisual materials

1. We cannot predict our future but we can design it, part 1. by Centre for Systems Solutions

Description: a short overview of what systems solutions are, and on how to solve problems in systemic way.

https://bit.ly/2lqTFTe

2. We cannot predict our future but we can design it, part 2. by Centre for Systems Solutions

Description: a short overview of what systems solutions are, and on how to solve problems in systemic way.

https://bit.ly/2lDT94f

3. How did we create the RURITAGE game?

Description: an example of game design process. Here the Ruritania game was created as a part of the Horizon 2020 project Ruritage.

https://bit.ly/2n86Dpi

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