Gamifying and evaluating problem structuring: a card game workshop for generating decision objectives

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This document complements the above-mentioned paper (https://doi.org/10.1016/j.ejdp.2022.100021).

Contents

SI 1.Game instructions.

The following pages present the game instruction, as well as the screenshots of the accompanying power point presentation.

Wastewater Shit-uations:

Objective:

Each player represents a **small, rural municipality in Europe (3000 inhabitants)**. The wastewater treatment plant in the municipality is getting old and it is the municipality's responsibility **to learn about different wastewater alternatives** in order to decide which one is best for their municipality.

A short description of the game play:

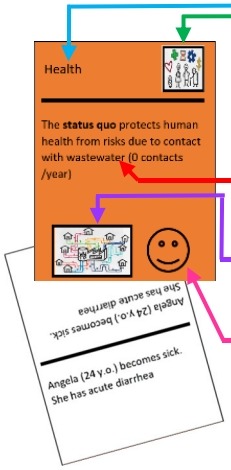
The game is played in rounds, where each round has 4 steps. Each municipality (player) is given employees (represented by *employee cards*). In the first step, the employees are **"bid"** on different testimonials from inhabitants (*situation cards*). The objective is to bid employees whose domain matches the category of the situation card. Correct bids allow for the municipality to "**officially register**" (second step) the situation cards (receive the situation card in their hand), which are used to earn points later on. In the third step, the municipalities "**share resources**" (exchange employee and situation cards). The objective of this step is to receive employee cards with desired domains and to exchange situation cards in order to be able to "**report**" the situation cards in step 4. In order to report the situation cards, at least 3 situations cards of the same category are needed. Municipalities win one point per reported situation card. These four steps are repeated until all of the situation cards have been distributed (about 5 rounds). The Municipality (player) with the most points at the end of the game wins.

Game Contents and Set Up:

The game consist of 3 different types of cards:

1) **64 Situation Cards**

The front side (white-side) of the situation cards has a testimonial from one of the inhabitants. On the backside (colored-side), the following information is found:



- The **name of the situation** and a **symbol** which represents the category to which the situation belongs to (see the list of categories, colors, and symbols to the right)
- A **description of a wastewater treatment alternative** and how it applies to that situation
- A **symbol for that wastewater treatment alternative** (see symbols in the appendix)
- A **happy or sad face** that represents the effect of the alternative for that situation (positive (☺) or negative (☹))

**** Disclaimer:** The information concerning each alternative comes from a specific case study in rural Switzerland. The effects of each alternative wastewater treatment technique may change depending on the circumstances of the rural town. The information about each alternative is not applicable to cities. Also, some of the situation cards could be applied to various treatment alternatives, though only one alternative is presented per situation card to simplify the game.*

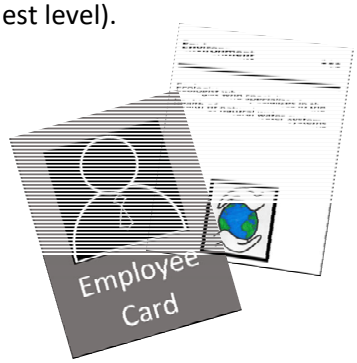
To set up the game, shuffle and distribute **6 situation cards** to each player *if playing with 4 players*. Distribute **8 situations cards** to each player *if playing with 3 players*. Place these cards in front of each

player with the colored side-up. Split the remaining cards into three equal stacks and place them story side up (color-side down), in the center of the table where each player can easily read the stories.

Note: Wastewater treatment plant is abbreviated as WWTP and wastewater is abbreviated as WW

2) 21 Employee Cards

Employee cards represent the employees of the municipality. Each card has the employee's domain (which is represented with the same 6 symbols as the situation cards) and level of expertise (represented as stars, where 1 star is the lowest level and 7+ stars is the highest level).



To set up the game, separate the employee cards into 4 stacks: one stack with the employee cards that have 1-2 stars, one stack with the employee cards with 3-4 stars, one stack with the employee cards with 5 stars, and a final stack with the employee cards containing 6 or 7+ stars. Shuffle each stack and distribute 3 employee cards to each player:

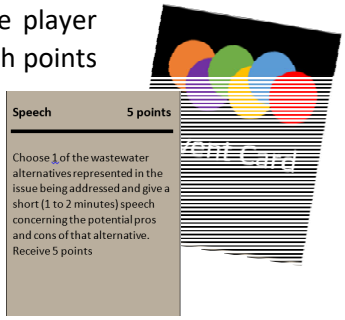
- 1 employee card with 1-2 stars
- 1 employee card with 3-4 stars
- 1 employee card with 5 stars

Each player may look at their employee cards. Shuffle all the remaining employee cards (mixing all the star groups together) and place them face down (domain symbols facing down) in a stack.

3) 20 Event Cards

Event cards are played each time a group of situations is reported and allow for municipalities (players) to earn points (or lose them!). There are four types of event cards:

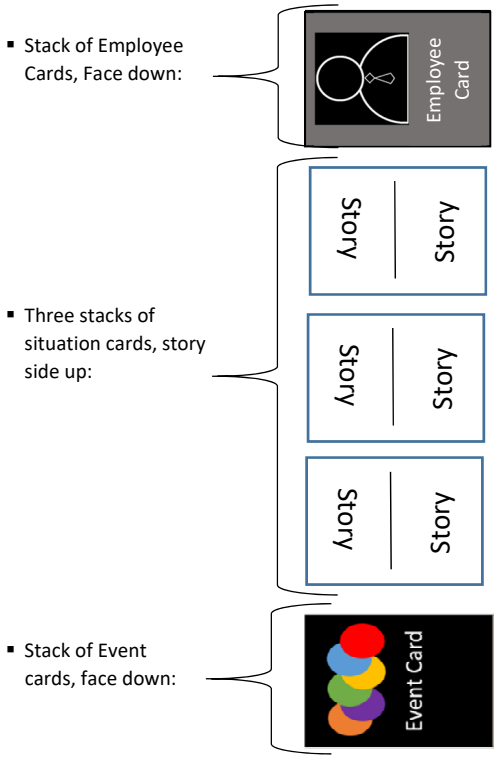
- **5 Evaluation Cards**: The player who picked the event card reads the description of the alternative in one of the situations that they are reporting and asks the other players a simple question regarding that situation, giving other players a chance to win 2 points.
- **5 Statistics Cards**: The player who picked the event card forms a simple question concerning one of the situation cards that they are reporting and asks the other players, giving the other players a chance to win 3 points. Questions can include true or false, multiple choice, and/or asking specific statistics questions (for example, the percentage of Nitrogen recovered), where the player who guesses the closest value wins the points. Any type of question is acceptable, as long as it concerns one of the situation cards being reported.
- **5 Chance Cards**: Chance events that occur and allow both the player reporting the situations and the other players to win or lose both points and employees.
- **5 Speech Cards**: The player who picked the event card gives a short (1-2 minute) speech concerning the theme written on the speech card. The player receives 5 points or an employee card (this is specified on the card, as seen in the example to the right).



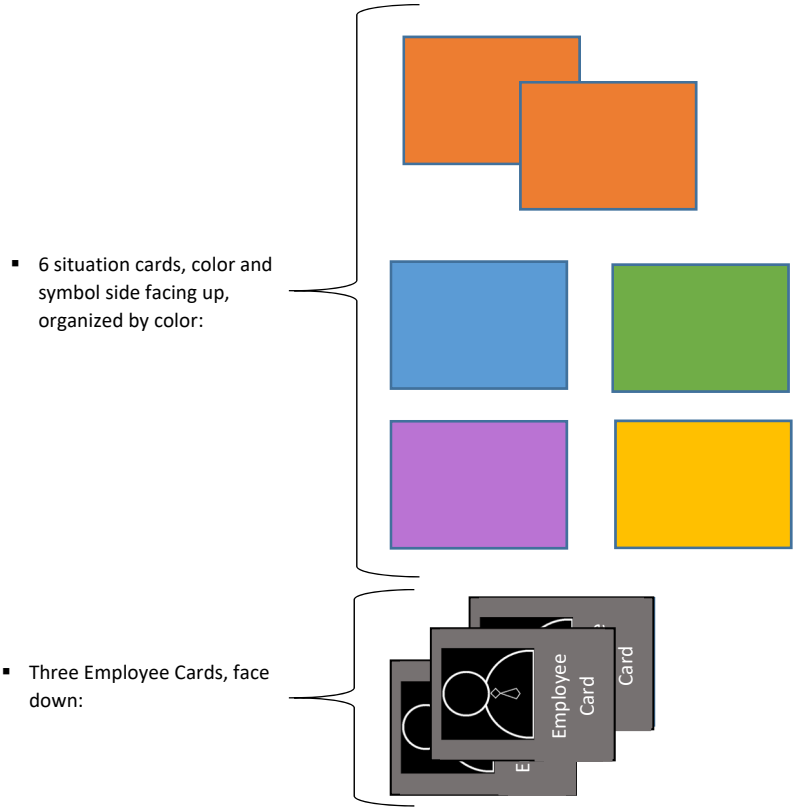
To set up the game, shuffle the event cards and place them face down in a stack.

At the beginning of the game, a table should look like this:

The Table:
(Where everyone can see and reach)



The Hand of Each Player:



Game Play

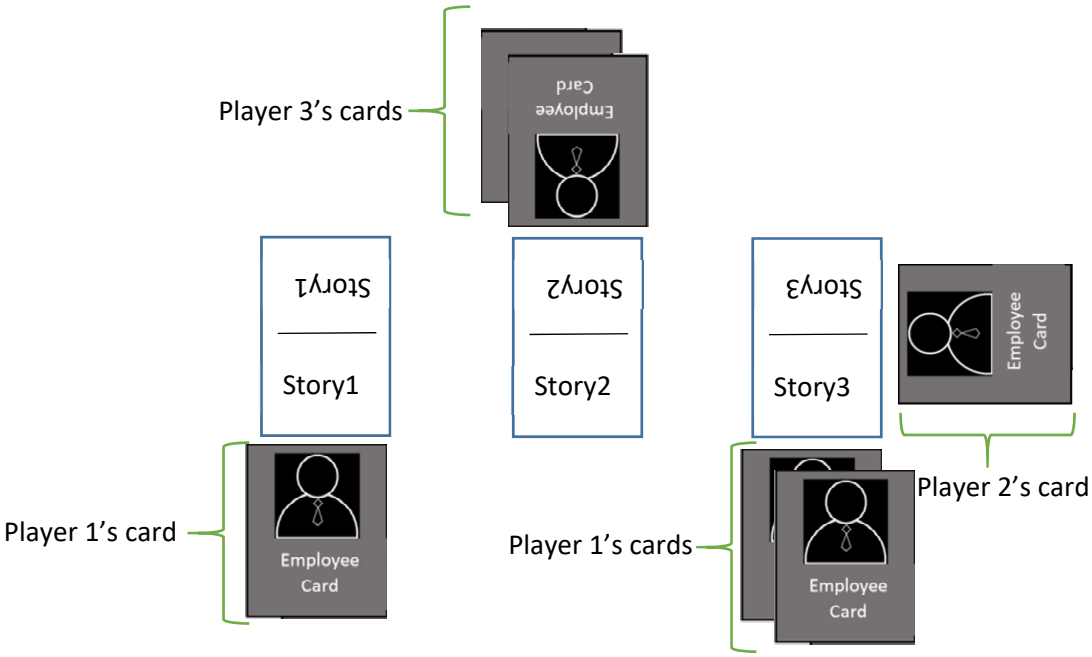
The game is played in a series of rounds, where each round has four (4) steps: Bidding, Official Registration, Resource Sharing, and Reporting. The steps should *always* be played in order.

Step 1: Bidding

Start by reading the stories on the **three situation cards** in the center of the table. For some of the situation cards, the part that is underlined shows the part of the story that is most important for that situation. During the bidding phase, each player (in no particular order) lays **face down** the employee card that they wish to bid near the situation card that they wish to bid on. **The objective is to bid employees whose domain matches the category of the situation card.** Each player can bid as many employee cards as she/he would like per situation card. Players can choose to bid on all three of the situation cards, one or two of the situation cards, or none of the situation cards. **One employee can only be bid on one situation card per bidding round**. Once an employee card has been bid (placed near the situation card), it cannot be moved.

Each player is responsible for remembering which employee cards belong to them.

For example: If Player1 has 3 employee cards, she can bid 1 employee on one of the situation cards (story 1) and 2 employees on another situation card (story 3). Player2 and Player3 also have 3 employee cards. Player2 chooses to bid only one employee card, on story 3. Player3 bids 2 employee cards on story 2. This example is seen below.

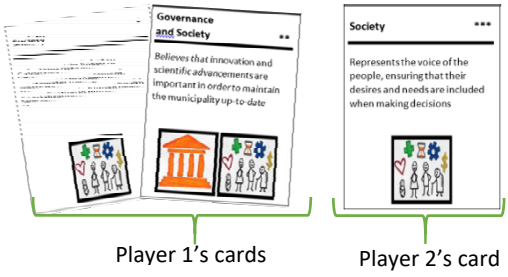


Step 2: Official Registration

Once everyone has finished bidding, flip the situation and employee cards. **The employee card whose domain matches the symbol on the situation card "registers" that situation card** (receives the situation card in their hand). The player reads the color-side of the card aloud before placing the situation card in their hand.

- ➔ *If two or more players have bid a matching employee card*, th**e employee with the most expertise** (most starts) gets to register the situation.
- ➔ *If two or more employee cards with the same symbol were bid by the same player*, **the sum of the stars on the employee cards** is used.
- ➔ *If the amount of stars is also tied*, the player who bid the employee card with **the most amount of stars wins** the situation card (see example below).

For example: Player1 has bid 2 society employees, one with 1 star and another with 2 stars on situation card 3. Player2 has bid 1 society employee with 3 stars on the same situation card. If the situation card is also a society card, **player 2 wins** the situation card because she has the employee card with the most amount of stars.



The **employee cards** whose symbol matches that of the situation card are recuperated by the player who bid the card (even if the employee was not able to officially register the situation, in the case of a tie). One half of wrongly bid employee cards (those that do not have the same symbol as the situation card that they were bid on), must be placed at the bottom of the employee card stack in the center of the table (rounding down, so if 1 card was wrongly bid, no employee cards are returned. If 2 cards were wrongly bid, 1 card must be returned, and so on).

- ➔ *In the case that no players bid on one or various situation card(s)*, the situation card(s) are placed on the bottom of the stack.
- ➔ *In the case no correct bid took place* (none of the symbols of the employees that were bid match the symbol on the situation card), the situation card is placed on the bottom of the stack.

Repeat steps 1 and 2 *three* times (a total of 9 stories should be read). After the third round of official registration, move onto step 3.

Step 3: Resource Sharing

During this step, players can exchange both situation and employee cards with other players. Any trade is possible, as long as both players partaking in the trade agree. Trading can only take place during this step.

Step 4: Reporting

For each round of Reporting, **each municipality (player) is only allowed to report one group of situations**. Situation cards can only be reported in groups of 3 or more, meaning that the municipality must have *at least 3 situation cards of the same category* (seen by the color and symbol) in order to participate in the Reporting step. The youngest player begins by picking up the 3 (or more) situation cards that he wishes to report. He then picks an event card and completes the task described on the card. Once finished, the reported situations and the event card are "filed away" (put off to the side, though kept near the player, as these cards will be used at the end of the game). The player who reported a situation **picks a new employee card** from the top of the stack and wins one point per situation card reported (minimum 3 points) along with the points allotted from the event card.

The player sitting clockwise continues and can report a group of situations, if she wishes. If a player does not have 3 situation cards of the same category or does not wish to report a group of situation cards, the game continues in clockwise order until every player has had a chance to report a group of situations.

Recall, points are rewarded as follows:

- 1 point per card in the reported group of situations (minimum 3 points per report)
- Points allotted from Event Cards played during that round

Continuation of the Game:

Repeat steps 1 to 4 (**remembering that steps 1 and 2 should be repeated 3 times per round**) five times (5 rounds), or until there are no more situation cards in the center stacks (whichever occurs first). The youngest player is the first person to report a group of situations in round 1. After round 1, the next player (in clockwise order) begins.

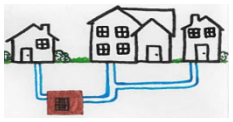
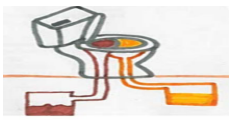
End of the game:

At the end of the 5th round, or when there are no more situation cards in the center stacks (whichever comes first), one last round of resource sharing and reporting takes place. Final scores are then added up, including the following bonus points that are rewarded to the most interdisciplinary municipalities:

- **10 bonus points** to the player with the *highest number of categories* (max 5) represented in the reported situation cards. If players tie, the points are split equally, rounding down (so if 2-way tie, 5 points each, if 3-way tie, 3 points, and if 4-way tie, 2 points)
- **10 bonus points** to players with *at least 6 different wastewater alternatives* represented in the reported situations
- **2 bonus points** for each employee domain (symbol) in the players' hand at the end of the game (2 points per symbol, one symbol cannot be counted twice, max 12 points)

The municipality (player) with the most points wins.

Appendix:

Status Quo	The business as usual: No changes to the centralized WWTP (wastewater treatment plant).	
Renovated WWTP	Renewal or replacement of the technical components of the Status Quo, expanding the service life of the plant by a decade.	
New WWTP	Rebuild the centralized WWTP using modern technologies that better meet today's water protection requirements.	
Neighboring WWTP	Existing sewer network is connected to the larger, centralized WWTP of neighboring municipality. The existing WWTP is dismantled.	
Package Plant	Small, decentralized WWTPs treat wastewater *in situ* for individual households. Treated water is seeped into the ground or discharged in a nearby waterbody.	
MBR Package Plant	Similar to Package Plants, though includes a membrane (MBR) filtration step to ensure hygienic safety. Often used for groups of households.	
Composting Toilets	Decentralized option that uses special toilets to store urine and compost faeces *in situ*. Both urine and faeces are then used in agriculture. Grey water is treated using a package plant.	
Direct Agricultural Use	All domestic wastewater is fed directly into slurry pits where it is stored and later spread on the agriculture fields with the cattle slurry.	
Sealed Pit	Stores wastewater *in situ,* in underground tanks. Tanks are emptied using special suction trucks and the contents are treated at the neighboring WWTP.	
Septic Tank	Installed *in situ.* Retains solid matter while the liquid portion is seeped away. Accumulated solids in the tank must be emptied and treated at a neighboring WWTP every 1-2 years.	
Urine Separation	Special toilets separate urine and faeces. Urine is reused as fertilizer and the greywater and faeces are treated by a centralized WWTP or package plants.	

SI 2. Card game.

Hereafter, we provide the material to reproduce the card game.

SI 2.1. Masterlist

Table 1. Master list of objectives including the level 2 objectives (categories). On the left: objectives as they were used in Haag et al., 2019. On the right: objectives adapted for the study at hand.

Category	Original Objectives (Haag et al. 2019)	Objectives used in the game
Society 	(A)Low health risks due to direct contact with wastewater or facilities	Health
	(B) High sanitary protection for recreation water use (e.g. swimming)	Sanitary Protection for Recreational water use
	(C) Few nuisances to residents (noise, odor, traffic)	Nuisances to Residents
	(D) Fair distribution of burdens and costs	Distribution of Burdens and Costs
	(E) Many jobs in the wastewater sector region	Jobs in the Wastewater Sector
	(F) High attractiveness of household installations (e.g., design, ease of use, odors)	Attractiveness of household installations
	(G) Little time required by end users	Time Required by End Users
	(R) High prestige by leading the way	Prestige
Environment 	(H) Low impairment of landscape	Impairment of Landscape
	(I) Low greenhouse gas emissions from other sources (transport of sewage sludge, sewage treatment, etc.)	Greenhouse Gas Emissions
	(J) Low impairment of protected areas (nature, landscape, river banks)	Impairment of Protected Areas
	(K) Good state of ground water and spring water resources	Ground Water Protection
	(L) Good ecological state of surface waters (rivers, lakes)	Ecological State of Surface Waters
	(M) High removal of micropollutants	Removal of Micropollutants
	(N) Health fish stock (preservation of biomass for fishing)	Fish Toxicity
Governance 	(O) Little time required by public authorities	Time Required by Public Authorities
	(P) High degree of co-determination for municipalities	Inclusive decision-making for Municipalites
	(Q) High autonomy of municipalities (few dependencies on other municipalities)	Autonomy for Municipality

Resources 	(U) High recovery of phosphorous (for fertilizer)	Phosphorous Recovery
	(V) High recovery of nitrogen (for fertilizer)	Nitrogen Recovery
	(W) low net water consumption	Water Consumption
	(X) little land consumption/space requirements	Space Requirements
	(Y) low net energy consumption (greenhouse gas emissions)	Energy Consumption
	(Z) High net heat production (for district heating, gas production from sludge)	Heat Production
Economy 	(AA) Low annual cost	Annual Costs
	(BB) Low investment cost	Investment Costs
	(S) High intergenerational equity (distribution of cost over time)	Intergenerational Equity
Technical Operation 	(CC) High operational flexibility (adaptability without construction)	Operational Flexibility
	(DD) Professional operations and management (high reliability, fast emergency response, good monitoring)	Professional Operations and Management
	(EE) High protection against wastewater spills (overflow onto street, into cellar)	Wastewater Spills and Overflows
	(FF) High structural flexibility (ease of extension, retrofitting, deconstruction)	Structural Flexiblity
	(T) High potential for innovation and knowledge gain	Innovation and Knowledge Gain

SI 2.2. Options of wastewater management

Table 2. Table presenting the options, as presented in the game. Inspired from : Beutler P, Larsen TA, Maurer M, Staufer P, Würsten M, Lienert J (2020) Zukünftige Abwasserentsorgung im ländlichen Raum – Fallstudie 1. Abschlussbericht für die Gemeinde. (Future wastewater management in rural regions – case study 2. Final report for the municipality). Eawag: Swiss Federal Institute of Aquatic Science and Technology, Dübendorf, Switzerland

Status Quo	The business as usual: No changes to the centralized WWTP (wastewater treatment plant).	
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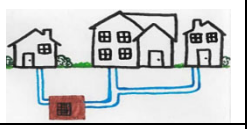
MBR Package Plant	Similar to Package Plants, though includes a membrane (MBR) filtration step to ensure hygienic safety. Often used for groups of households.	
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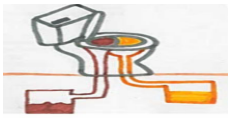
Urine Separation	Special toilets separate urine and faeces. Urine is reused as fertilizer and the greywater and faeces are treated by a centralized WWTP or package plants.	

SI 2.3. Designing details

Design of the prototype. The adapted full game material and instructions are given in SI 1-2. We adapted the KlarText card game based on (1) the above mentioned literature on techniques to generate objectives, and (2) results of a multi-criteria decision analysis case study about wastewater management in rural Switzerland (Beutler and Lienert 2020). An important element of any type of decision-making procedure is learning about the facts (Aubert and Lienert 2019). In our case, we used two types of factual information. First, we gave information about the technical options and how well these options fulfil potential objectives, e.g. to express their weakness and strength. Second, we gave information on different stakeholders' perspectives, including which objectives matter the most to the roles displayed in the game. This factual information was reviewed multiple times by two decision analyst colleagues who have carried out real-world case studies on wastewater management in Switzerland. The following six generic categories from Haag et al. (2019) were applied: societal well-being, environmental protection, municipal organization, economy, resources, and technical operation. All 32 objectives of their master list were retained (SI 2.1). We included eleven options of wastewater management in the game (SI 2.2). Designing the game, we made sure that factual information regarding positive and negative aspects were balanced. Every objective was once described as a strength (describing an option where this objective was well performing) and once as a weakness (describing an option where this same objective was badly performing). Every technical option was described by three achieved and three non-fulfilled objectives. Equally, the stakeholders' perspectives targeted each objective twice, once in a positive way, once in a negative way.

Pre-testing and fine-tuning the card game prototype. We used feedback from five game sessions with research assistants and interns at Eawag, and laypersons outside the institution to adjust the texts on the cards and clarify the rules of the game. The game material is available in Supplementary Information (SI 1-2). After pre-testing the early versions of the card game, we designed the workshop to generate the objectives list.

SI 2.4. The cards

The following pages present the cards. Printing those pages, you will be able to reproduce the full card game.

Event Card

Evaluation **2 points**

Choose one of the situation cards being reported and read the **colored side** of the card aloud, *<u>leaving out</u> the name of the* ***wastewater treatment alternative*** (in bold). Ask the other players to guess which wastewater alternative is being addressed. Each correct player **receives 2 points**

Event Card

Evaluation **2 points**

Choose one of the situation cards being reported and read the **colored side** of the card aloud. Ask the person to your **right** if this card is positive (happy face) or negative (sad face). If correct, the player **receives 2 points**

Event Card

Evaluation **2 points**

Choose one of the situation cards being reported and read the **colored side** of the card aloud, *<u>leaving out</u> the name of the* ***wastewater treatment alternative*** (in bold). Ask the other players to guess which wastewater alternative is being addressed. Each correct player **receives 2 points**

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Event Card

Statistics **3 points**

Choose one of the situation cards being reported and ask the other players a question based on the information given on the **colored** side of the card. **All players** who answer correctly receive 3 points

Example: "What resource is not reused for agriculture when using sealed pits?" (Answer: Phosphorus)

Event Card

Statistics **3 points**

Choose one of the situation cards being reported and ask the other players a question based on the information given on the **colored** side of the card. **All players** who answer correctly receive 3 points

Example: "What resource is not reused for agriculture when using sealed pits?" (Answer: Phosphorus)

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Event Card

Statistics **3 points**

Choose one of the situation cards being reported and ask the other players a question based on the information given on the **colored** side of the card. **All players** who answer correctly receive 3 points

Example: "What resource is not reused for agriculture when using sealed pits?" (Answer: Phosphorus)

Event Card

Chance **2 points**

Receive two points if both positive (☺) and negative (☹) cards are represented in the situation that you are reporting. If not, **give one point** to each other player

Event Card

Chance **points will vary**

Receive one point for each different domain (symbol) located on the employee cards in your hand (the same symbol on two different cards cannot be counted twice)

Event Card

Chance **3 points**

Receive 3 points if at least 3 different wastewater treatment alternatives are represented in the situations that you are reporting.

Event Card

Chance

Overstaffing problems: Each player must return employee cards that share the same domain (symbol) with another employee card in their hand. Each player is free to choose which employee card(s) she or he will return.

Event Card

Chance

Overstaffing problems: Each player must return employee cards that share the same domain (symbol) with another employee card in their hand. Each player is free to choose which employee card(s) she or he will return.

Event Card

Speech **5 points**

Choose 2 of the situation cards which are being reported and give a short (1 to 2 minute) speech explaining **why these *situations* should be considered when deciding what type of WWTP should be used**. Receive 5 points

Event Card

Speech **5 points**

Choose 2 of the situation cards which are being reported and give a short (1 to 2 minute) speech explaining **how these two *situations* are related.** Receive 5 points.

Event Card

Speech **1 employee card**

Choose 2 different *wastewater treatment alternatives* represented in the situations being reported and give a short (1 to 2 minute) speech explaining **how they are different**. Receive 1 employee card

Event Card

Speech **1 employee card**

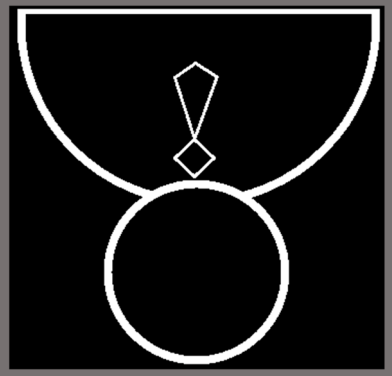
Choose 2 different *wastewater treatment alternatives* represented in the situations being reported and give a short (1 to 2 minute) speech explaining **how they are similar**. Receive 1 employee card

Event Card

Speech **5 points**

Choose 1 of the *wastewater treatment alternatives* represented in the situations being reported and give a short (1 to 2 minutes) speech **concerning the potential pros and cons of that alternative**. Receive 5 points

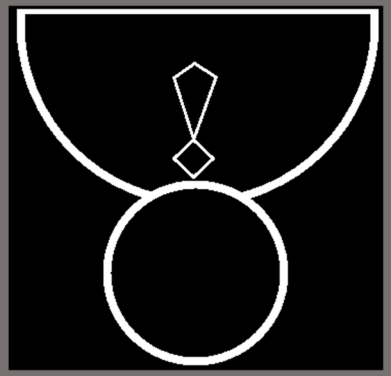
Employee Card



Societal Well-Being
Municipal Organization
Economy *

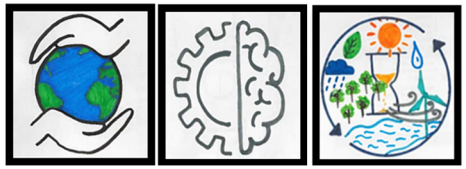
Baptiste just finished his degree and is interested in adapting municipal processes to ensure that the inhabitants' needs are taken into account when making decisions and calculating costs.

Employee Card

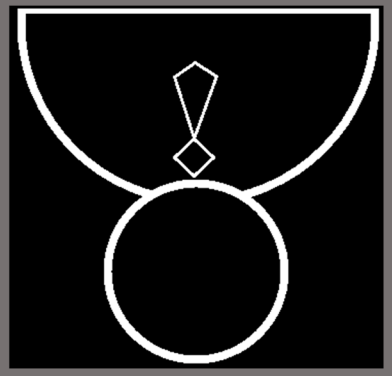


Environmental Protection
Technical Operations
Resources *

Lena just finished her degree. Her main interest is using robust, innovative, and reliable technology to conserve both the environment and resources (such as water, energy and phosphorus).

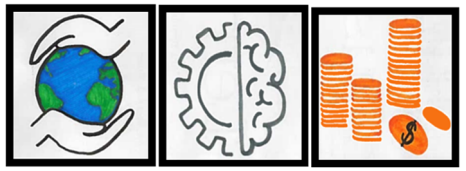


Employee Card

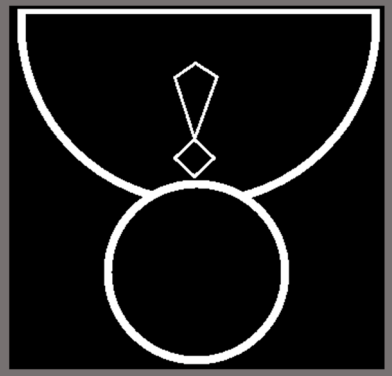


Environmental Protection
Technical Operations
Economy **

Alice is an intern responsible for calculating costs, conserving the natural environment and ensuring technical reliability and robustness.



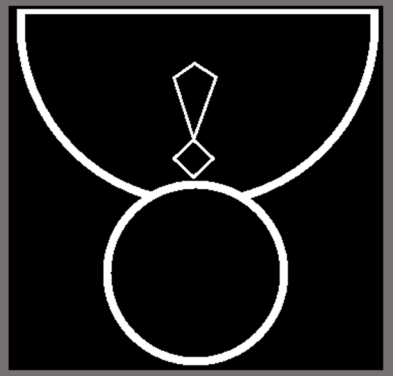
Employee Card



Societal Well-Being
Municipal Organization
Resources **

Lino is an intern responsible for ensuring high life-quality for all, learning how to manage a team of employees, and conserving resources such as water, energy, and phosphorus.

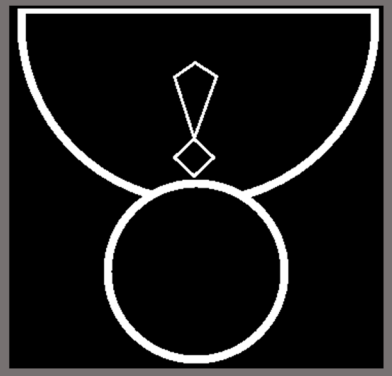
Employee Card



Societal Well-Being
Economy ***

Katerina has 1 year of experience working to ensure a high life-quality for the town's habitants and calculating costs. She spends a lot of time listening to the needs of the inhabitants.

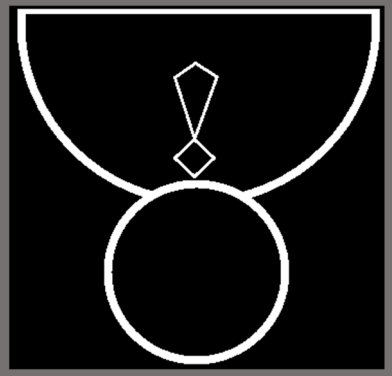
Employee Card



Environmental Protection
Resources ***

Julien has 1 year of experience working in environmental and resource protection (such as energy, water, and phosphorus). He focuses on minimalizing environmental impact from wastewater treatment.

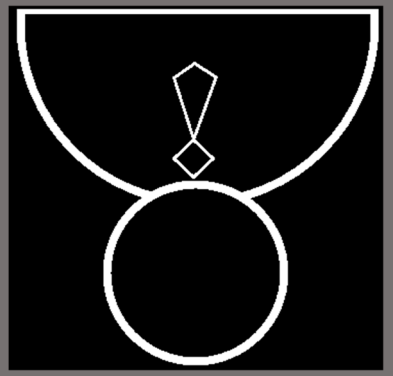
Employee Card



Societal Well-Being Resources ****

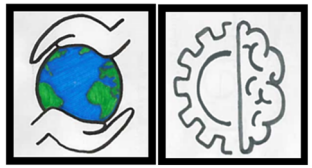
Elizabeth has 2 years of experience in ensuring that resources (such as water, energy, and phosphorus) come from renewable sources and are preserved in order to ensure a high life-quality for all inhabitants

Employee Card

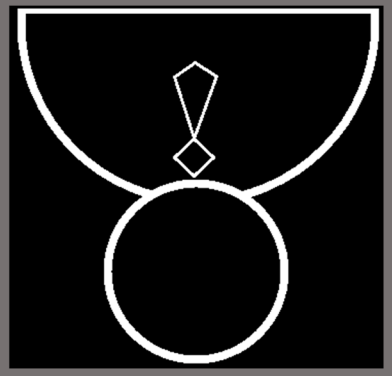


Environmental Protection Technical Operations ****

Leo has 2 years of experience in environmental engineering. He works to ensure that robust, innovative, and reliable technologies are used to conserve environmental health.



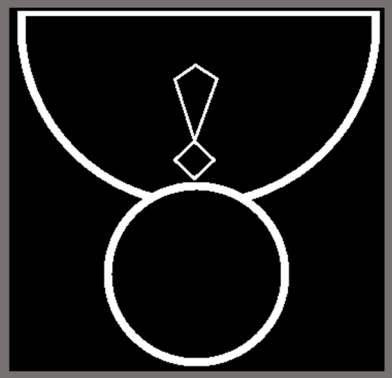
Employee Card



Municipal Organization Technical Operations *****

Emilio has 3 years of experience working in management and decision-making. He specializes in finding the best technological solutions for the municipality's needs.

Employee Card

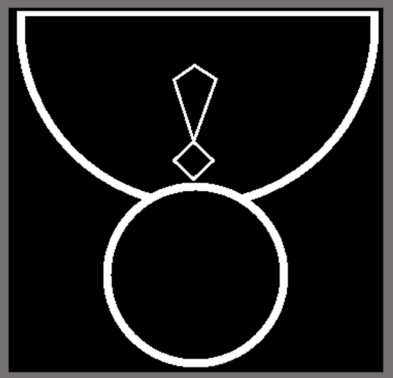


Environmental Protection

*****

Beatriz has 3 years of experience working in environmental protection. She ensures that environmental health is preserved.

Employee Card

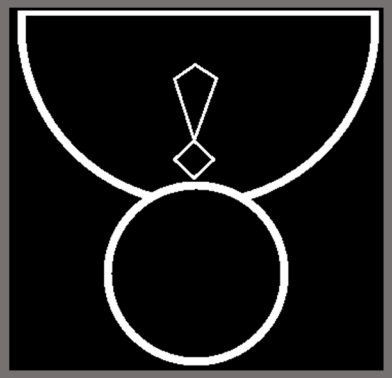


Societal Well-Being

*****

James has 3 years of experience working in societal well-being. He ensures that the habitants are happy and healthy.

Employee Card

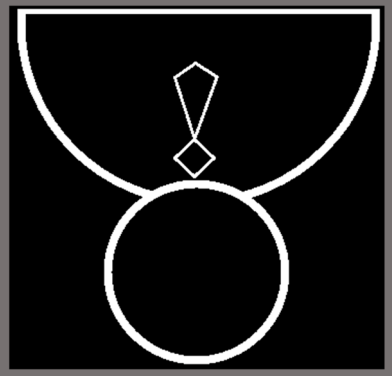


Resources

*****

Judy has 3 years of experience in material flow analysis, where she is responsible for preserving resources, such as water, energy, and phosphorus.

Employee Card

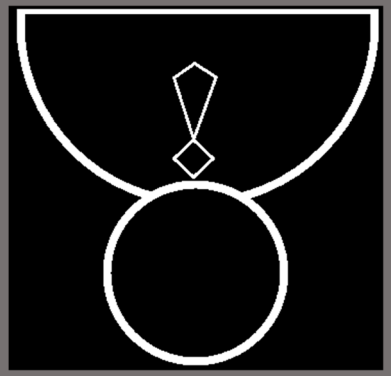


Economy

******

John has 4 years of experience working in economics. He manages costs for current and future generations.

Employee Card

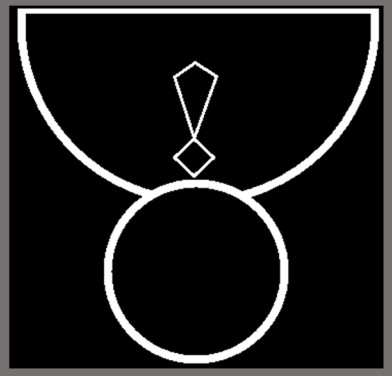


Societal Well-Being

******

Lily has 4 years of experience working in societal well-being. She listens to the needs, desires, and worries of the community and suggests solutions to ensure a high life-quality for all.

Employee Card

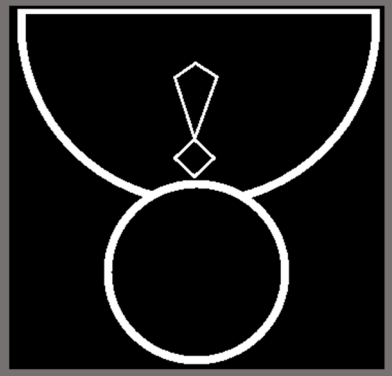


Resources

******

Benjamin has 4 years of experience ensuring that resources (such as energy, water, and phosphorus) come from renewable sources.

Employee Card

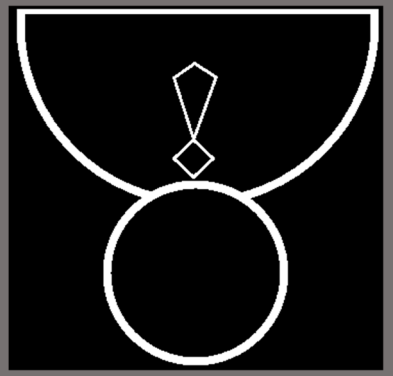


Municipal Organization

******

Sara has 4 years of experience working in team management and decision-making. She ensures that the municipality works efficiently and sustainably.

Employee Card

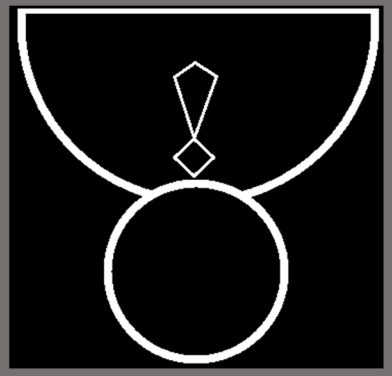


Technical Operation

******

Florian has 4 years of experience working in technical operations. He ensures that infrastructure is adapted to current and future needs and prioritizes innovation and robustness.

Employee Card

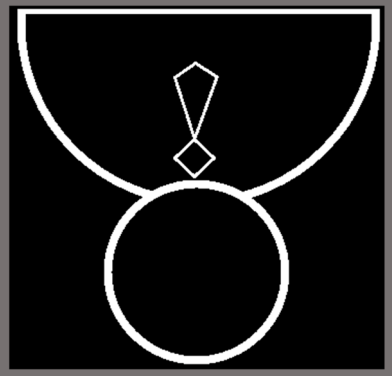


Economy

7+

Gabriela is an expert in economics. She oversees all economic decisions for the municipality. She ensures that all costs are considered for current and future generations.

Employee Card

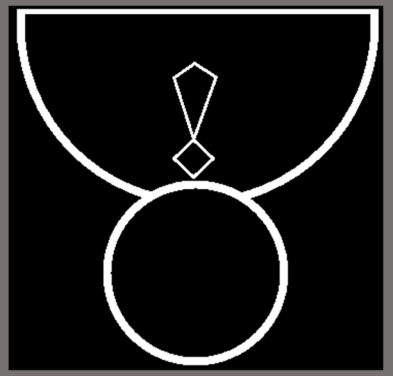


Environmental Protection

7+

Xavier is an expert in environmental protection. He ensures the protection of the natural water systems and natural parks, and promotes decreasing greenhouse gas emissions.

Employee Card

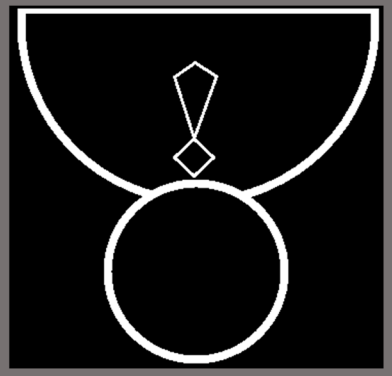


Municipal Organization

7+

Emma is an expert in municipality organization. She coordinates with other municipalities and is the head representative of her municipality.

Employee Card



Technical Operations

7+

Rodrigo is an expert in the technical aspects of wastewater treatment. He analyses how changing future circumstances can affect the robustness and reliability of alternatives.

1. **Bidding**
   Read the story and bid employee card(s)
2. **Official Registration**
   Winning employee card reads the situation card aloud and places the card in their hand
   Repeat steps 1 and 2 three times
   (9 situation cards are read in total)
3. **Resource Sharing**
   Trade employee and situation cards with other players
4. **Reporting**
   Pick up the 3 (or more) situation cards of the same symbol. Pick event card and perform the task. Receive points and Employee card

Repeat steps 1-4 five times, or until there are no situation cards left in the center deck

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5. **Bidding**
   Read the story and bid employee card(s)
6. **Official Registration**
   Winning employee card reads the situation card aloud and places the card in their hand
   Repeat steps 1 and 2 three times
   (9 situation cards are read in total)
7. **Resource Sharing**
   Trade employee and situation cards with other players
8. **Reporting**
   Pick up the 3 (or more) situation cards of the same symbol. Pick event card and perform the task. Receive points and Employee card

Repeat steps 1-4 five times, or until there are no situation cards left in the center deck

9. **Bidding**
   Read the story and bid employee card(s)
10. **Official Registration**
    Winning employee card reads the situation card aloud and places the card in their hand
    Repeat steps 1 and 2 three times
    (9 situation cards are read in total)
11. **Resource Sharing**
    Trade employee and situation cards with other players
12. **Reporting**
    Pick up the 3 (or more) situation cards of the same symbol. Pick event card and perform the task. Receive points and Employee card

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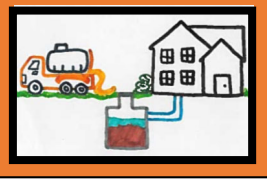
Repeat steps 1-4 five times, or until there are no situation cards left in the center deck

Max (13 y.o.) enjoys swimming in the nearby river

Max (13 y.o.) enjoys swimming in the nearby river

Sanitary Protection for Recreational water use

Sealed pits collect and retain wastewater and therefore decrease the chances of a wastewater contamination in local lakes and rivers

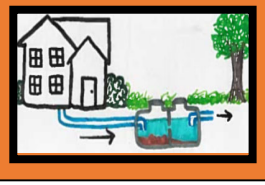


Angela (24 y.o.) becomes sick. She has acute diarrhea

Angela (24 y.o.) becomes sick. She has acute diarrhea

Health

With **septic tanks**, humans are more frequently in contact with wastewater (13 contacts/year) which increases the risk of becoming sick



Miriam (32 y.o.) does not know anyone who has had acute diarrhea

Miriam (32 y.o.) does not know anyone who has had acute diarrhea

Health

The **status quo** protects human health from risks due to contact with wastewater (0 contacts /year)

Nuisances to Residents

Agricultural use may cause bad odors (slurry pits) and increase traffic (slurry trucks)

Naomi (29 y.o.) is late to work because she was stuck behind a smelly slurry truck

Nuisances to Residents

The use of a **neighboring municipality's WWTP** avoids traffic and odors from wastewater treatment in the local community

Monica (71 y.o.) is happy that she no longer has to smell the odors from the WWTP near her home

Sanitary Protection for Recreational water use

Runoff from **agricultural use** can contaminate rivers and lakes, making them unsuitable for recreational use

Max's (13 y.o.) swimming lessons are canceled because the lake where the lessons take place has been contaminated with harmful bacteria

Jobs in the Wastewater Sector

MBR package plants increase the amount of time required by authorities (from 14 in the status quo to 45 hours/year), thus creating more local jobs.

David (46 y.o.) finds a job closer to his home, decreasing his commute time to work and giving him more time in the evenings with his family

Distribution of Burdens and Costs

Unless managed centrally, each group of households is responsible for the costs and burdens of their **MBR-Package Plants**

The neighborhood's decentralized WWTP is located in Lea's (38 y.o.) garden. Many households use the installation, though Lea's family performs all the required workload

Distribution of Burdens and Costs

Urine separation technologies can be managed centrally so that costs and burdens are equally distributed to all community members

Philipp (53 y.o.) and his neighbors fairly share the burdens (work load, costs, etc.) of their decentralized WWTP with the rest of the municipality

Richard (69 y.o.) must explain to his guests how to use the toilet

Richard (69 y.o.) must explain to his guests how to use the toilet

Attractiveness of household installations

Due to unconventional toilets and occasional odors, **composting toilets** are the least attractive alternative

Naomi (29 y.o.) buys an apartment and invites all of her family and friends for a housewarming party

Naomi (29 y.o.) buys an apartment and invites all of her family and friends for a housewarming party

Attractiveness of household installations

Of the decentralized alternatives, **package plants** are one of the most attractive options (e.g. conventional toilets, ease of use)

Philipp (53 y.o.) loses his job where he has worked the past 20 years. He struggles to find a new position

Philipp (53 y.o.) loses his job where he has worked the past 20 years. He struggles to find a new position

Jobs in the Wastewater Sector

The use of a **neighboring municipality's WWTP** signifies that the current WWTP would close and the workers would be unemployed

Prestige

Richard (69 y.o.) attends the grand opening ceremony for the new wastewater installation in his municipality. He is proud of his community

MBR package plants offer an innovative, hygienic solution for all households in the municipality

Time Required by End Users

David (46 y.o.) is a working dad with 3 children. He struggles to find time to keep up with the household tasks

Composting toilets require 23 hours/year of user time (worst-case scenario, time needed to turn and remove compost)

Time Required by End Users

Lea (38 y.o.) enjoys doing arts and crafts with her children in the evenings

Renovation of the current WWTP does not require time from users

Impairment of Landscape

The **renovation** of the WWTP requires construction and extension of the current WWTP, which may occupy new land and change the landscape

Richard (69 y.o.) can no longer see the river from his balcony due to new infrastructures that block the view

Impairment of Landscape

Septic tanks are built below ground, allowing the landscape to be preserved

Monica (71 y.o.) enjoys the view of the river and the forest from the balcony of her apartment

Prestige

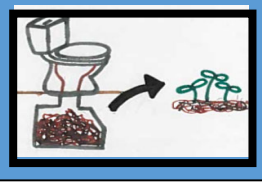
Using a **neighboring municipality's WWTP** does not inspire technical advancements within the municipality

Max (13 y.o.) is embarrassed by the town he lives in. Everything, including the people and the infrastructure, is old and nothing new is happening

Lea (38 y.o.) enjoys weekend trips to national parks, where she can see a wide variety of bird species

Impairment of Protected Areas

Composting toilets upgrade current wastewater treatment infrastructure without requiring extra space or construction in protected areas



Angela (24 y.o.) sees on the news that due to the intense heatwave and drought, there are a lot of forest fires this year

Greenhouse Gas Emissions

Urine separation is the decentralized alternative with the highest energy consumption (167 kwh/person/year)

Miriam (32 y.o.) reads that the glaciers in the valley near her home had a net growth over the past 5 years

Greenhouse Gas Emissions

Connection with a **neighboring municipality's WWTP** is the centralized alternative with the lowest energy consumption (45 kwh/person/year compared to status quo, which consumes 240 kwh/p/y))

Groundwater Protection

There is a risk of poorly treated wastewater infiltrating into the groundwater when using **septic tanks**

David (46 y.o.) buys bottled water because the well which normally supplies the town with drinking water has been contaminated

Groundwater Protection

The **status quo** protects groundwater and spring water sources by collecting wastewater and removing harmful pollutants before discharging it into nature

Philipp's (53 y.o.) lives in a village where the only water source is a well. The quality of the well water has always met drinking water standards

Impairment of Protected Areas

A **new WWTP** requires construction and space, which may infringe on protected areas

Monica (71 y.o.) watches as trees in an old protected forest are cut down

Max (13 y.o.) is able to see many fish while snorkeling in the lake because the water is so clear and clean

Ecological State of Surface Waters

Package plants remove 89% of pollutants known to cause eutrophication, making it as effective as the centralized treatment alternatives

Max's (13 y.o.) dog dies after swimming in a lake with a high concentration of Blue-Green Algae

Ecological State of Surface Waters

Agricultural use only removes 65% of pollutants known to cause eutrophication (worst-case scenario)

Richard (69 y.o.) reads that his town treats the wastewater for micropollutants before discharging the water into the environment

Removal of Micropollutants

The contents of **sealed pits** are treated at large, centralized WWTP. Because of this, 89% of micropollutants are retained from the environment (best-case scenario)

Monica (71 y.o.) can no longer go fishing at her usual spot because the water has become contaminated and the fish may also be contaminated

Fish Toxicity

Septic tanks are the worst-case scenario for nitrogen removal. This can affect ecosystems and fish populations

Max (13 y.o.) learns that the fish population in the nearby river has increased

Fish Toxicity

The contents of **sealed pits** are treated by large, centralized WWTPs, which remove 93% of nitrogen (best-case scenario)

Philipp (58 y.o.) wonders about how hormone residues influence fish species

Removal of Micropollutants

The **status quo** only removes 7% of micropollutants (worst-case scenario) which may disrupt natural ecosystems

Miriam (32 y.o.) joins the board of representatives from her municipality

Inclusive decision-making for Municipalities

A **new WWTP,** which includes treatment of wastewater from neighboring municipalities, ensures a central role of the municipality when making decisions

Miriam (32 y.o.) joins the board of representatives from her municipality

Angela (24 y.o.), a municipality employee, is asked to work extra hours and to take on a heavier workload

Time Required by Public Authorities

Urine separation requires the most time from public authorities (73 hours/year) for inspections

Angela (24 y.o.), a municipality employee, is asked to work extra hours and to take on a heavier workload

Lea (38 y.o.), a municipality employee responsible for the treatment of wastewater, has a balanced work schedule and does not feel overwhelmed

Time Required by Public Authorities

Of the decentralized options, **agriculture use** requires the least amount of time from authorities (17 hours/year)

Lea (38 y.o.), a municipality employee responsible for the treatment of wastewater, has a balanced work schedule and does not feel overwhelmed

David (46 y.o.) supports his municipality becoming autonomous because he believes that this will help prioritize the needs of the local community

Autonomy for Municipality

Renovation of the current, local WWTP allows the municipality to be independent of other municipalities

Richard (69 y.o.) feels that his needs are no longer considered now that his community is dependent on the neighboring municipality's WWTP

Autonomy for Municipality

Sealed pits must be regularly emptied. The treatment of the contents is dependent on the centralized WWTP of other municipalities

Monica (71 y.o.) is worried that her municipality board, whom she elected, will no longer represent her needs

Inclusive decision-making for Municipalities

The use of a **neighboring municipality's WWTP** signifies that the municipality must cooperate and coordinate with other municipalities

Investment Costs

Packaged plants do not require high investment costs

Even though Davids (46 y.o.) municipality does not have a lot of money, it will be able to improve the current wastewater treatment system

Annual Costs

Sealed pits have the highest annual costs for end users (about 1000$/person/year)

Richard's (69 y.o.) water and wastewater bill increases for the upcoming year

Annual Costs

Septic tanks have the lowest annual costs for end users (about 200$/person/year)

Naomi's (29 y.o.) water and wastewater bill decreases for the upcoming year

Philipp (53 y.o.) does not know how the municipality will repay the loan which was needed to cover construction costs for the new WWTP

Investment Costs

A **new WWTP** requires high investment costs

Angela (24 y.o.) believes that current costs should be distributed in a way which ensures equity for future generations

Intergenerational Equity

Composting toilets offer a robust solution for all households in the municipality

Naomi (29 y.o.) and her neighbors must pay higher taxes due to the emergency replacement of the municipality's WWTP

Intergenerational Equity

The **status quo** has a high risk of failure and unplanned costs (i.e. accident costs and future investments)

Monica (71 y.o.) uses a nitrogen fertilizer made from human urine in her small garden

Nitrogen Recovery

Urine separation recovers 87% of Nitrogen, which is then used in a patented fertilizer

Miriam (32 y.o.) struggles to find a renewable phophorus fertilizer that is produced locally

Phosphorous Recovery

Sealed pits do not allow for the agricultural reuse of the phosphorus found in wastewater

Philipp (53 y.o.) uses renewable phophorus fertilizers for his crops

Phosphorous Recovery

Agricultural use recycles 95% of phosphorus found in wastewater for fertilizer use

Max (13 y.o.) is shocked to learn that in Europe, drinking water is used to flush toilets

Max (13 y.o.) is shocked to learn that in Europe, drinking water is used to flush toilets

Water Consumption

MBR package plants consume just as much water as the status quo (26 L/person/day, worst-case scenario)

David's (46 y.o.) water consumption has decreased by 20%

David's (46 y.o.) water consumption has decreased by 20%

Water Consumption

Composting toilets do not require water for flushing (net water consumption for wastewater treatment: 0 l/person/day, best-case scenario)

Philipp (53 y.o.) must look to large, international companies in order to find nitrogen fertilizer for his farm

Philipp (53 y.o.) must look to large, international companies in order to find nitrogen fertilizer for his farm

Nitrogen Recovery

MBR package plants do not allow for a targeted recovery of Nitrogen

Miriam (32 y.o.) supports an energy neutral city and renewable energy sources

Miriam (32 y.o.) supports an energy neutral city and renewable energy sources

Energy Consumption

Septic tanks have 0 net energy consumption for the treatment of wastewater *in situ*

Lea (38 y.o.) explains to her children that the playground near their home be must removed in order to make space for the new decentralized WWTP

Lea (38 y.o.) explains to her children that the playground near their home be must removed in order to make space for the new decentralized WWTP

Space Requirements

Package plants require space in the garden or cellar (about 4m2)

Richard (69 y.o.) is happy to have received a spot in the new community garden which has been built in the liberated space where the old WWTP used to be

Richard (69 y.o.) is happy to have received a spot in the new community garden which has been built in the liberated space where the old WWTP used to be

Space Requirements

The use of a **neighboring municipality's WWTP** does not require additional space and liberates the space where the current WWTP is located

Angela (24 y.o.) wishes she could heat her home with renewable sources

Angela (24 y.o.) wishes she could <u>heat her home with renewable sources</u>

Heat Production

Composting toilets do not produce enough heat to be cost-effective and therefore do not serve as a renewable heat source

David (46 y.o.) and his family live in an apartment building which is heated with renewable sources

David (46 y.o.) and his family live in an apartment building which is <u>heated with renewable sources</u>

Heat Production

New WWTPs incinerate biogas produced from sludge decomposition, which can then be used as a renewable heat source

Angela (24 y.o.) tries to decrease her energy consumption; she wishes that her municipality would do the same

Angela (24 y.o.) tries to <u>decrease her energy consumption</u>; she wishes that her municipality would do the same

Energy Consumption

The **status quo** has the highest net energy consumption (about 240 kwh/person/year)

Professional Operations and Management

Renovated WWTPs are equipped with automatic fault detectors and use more reliable, modern technology

Lea (38 y.o.) feels confident that the wastewater effluent quality is ensured by both technology and management

Operational Flexibility

Urine separation technologies that are combined with decentralized WWTPs are sensitive to large variations in wastewater quantities within a short time period

During her birthday party, Naomi (29 y.o.) smells a bad odor coming the WWTP in her garden. She thinks that there has been an overflow

Operational Flexibility

New WWTPs serving several municipalities are capable of buffering large fluxes in wastewater volume to ensure effluent quality

David (46 y.o.) and his family are happy to be able to leave their home for 1 month and not have to worry about how the WWTP will react to the lack of WW

Wastewater Spills and Overflows

New WWTPs in zones with few rainwater infiltration sites risk overflowing during heavy rainfalls

Angela (24 y.o.) reads in the newspaper that the main street in the village was flooded with wastewater during the storm with heavy rainfall

Wastewater Spills and Overflows

Rainwater infiltration sites, such as parks or woods, act as a buffer for **status quo** WWTPs, decreasing the risk of overflows due to heavy rainfall

Monica (71 y.o.) walks home during a heavy rainstorm. Though it is raining really hard, there is no flooding in the streets

Professional Operations and Management

Package plants are not monitored on a daily basis, increasing the risk of a break or spill going unnoticed for an extended amount of time

Naomi (29 y.o.) must verify the quality of the effluent of her decentralized WWTP on a weekly basis. Public authorities verify the quality on a monthly basis

Miriam (32 y.o.) extends her decentralized WWTP to treat the wastewater from her neighbors as well

Structural Flexibility

MBR package plants can be easily built, taken out of operation, or removed in order to adapt to changing conditions

Philipp's (53 y.o.) reads that due to the increase in population of his town, the WWTP is over-capacity

Structural Flexibility

Centralized WWTPs, even when **renovated**, are not easily extended or deconstructed; Adaptations to changing conditions will increase the costs

Lea (38 y.o.) and her team of employees present the new findings from the wastewater pilot project located in their municipality

Innovation and Knowledge Gain

Urine separation uses different modern technologies, making it the alternative with the most potential knowledge gain

Miriam (32 y.o.) wishes that her municipality could be a pilot project for new wastewater treatment alternatives

Miriam (32 y.o.) wishes that her municipality could be a pilot project for new wastewater treatment alternatives

Innovation and Knowledge Gain

Renovation of the local WWTP uses well-developed and common wastewater treatment technologies

SI 3. Form used to collect the objectives list

Date: Game session / Team ID: ID of player (your initials):

INITIAL WISH LIST: To your mind, what are the most relevant objectives that should be considered when dealing with wastewater infrastructure planning? Number the objectives from most important (1) to least important.
If relevant, add objectives **after reading your first set of cards**
If relevant, add objectives **at the end of ROUND 1**
If relevant, add objectives **at the end of ROUND 2**
If relevant, add objectives **at the end of ROUND 3**
If relevant, add objectives **at the end of ROUND 4**
If relevant, add objectives **at the end of ROUND 5**
FINAL LIST OF OBJECTIVES: Please, write down here your final list of what are the most relevant objectives that should be considered when dealing with wastewater infrastructure planning? Number the objectives from most important (1) to least important.

Warning After the pre-test, the following changes should be made:

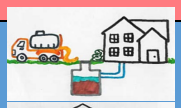
- For the final list of objectives, the facilitator has to make sure that it comprises **all** the objectives (those from the initial wish list, each round, and the finalization of the list). In the final list, participants should rank **all** the objectives. This should be clarified in the experimental sheet (above) as well.
- For each round of the game, participants should only write done **NEW** objectives.

SI 4. Files prepared for the control treatment

The following pages present the material developed for the control treatment. Printing those pages, you will be able to conduct the control workshop (without card game).

First 24

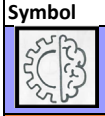
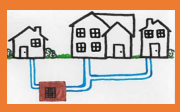
Category Symbol	Issue	Perspective	Alternative	Effect	Alternative Symbol
	Greenhouse Gas Emissions	Miriam (32 y.o.) reads that the glaciers in the valley near her home had a net growth over the past 5 years	Connection with a **neighboring municipality's WWTP** is the centralized alternative with the lowest energy consumption (45 kwh/person/year compared to status quo, which consumes 240 kwh/p/y)	☺	
	Health	Angela (24 y.o.) becomes sick. She has acute diarrhea	With **septic tanks,** humans are more frequently in contact with wastewater (13 contacts/year) which increases the risk of becoming sick	☹	
	Impairment of Protected Areas	Lea (38 y.o.) enjoys weekend trips to national parks, where she can see a wide variety of bird species	**Composting toilets** upgrade current wastewater treatment infrastructure without requiring extra space or construction in protected areas	☺	
	Fish Toxicity	Monica (71 y.o.) can no longer go fishing at her usual spot because the water has become contaminated and the fish may also be contaminated	**Septic tanks** are the worst-case scenario for nitrogen removal. This can affect ecosystems and fish populations	☹	
	Annual Costs	Naomi's (29 y.o.) water and wastewater bill decreases for the upcoming year	**Septic tanks** have the lowest annual costs for end users (about 200$/person/year)	☺	
	Ecological State of Surface Waters	Max (13 y.o.) is able to see many fish while snorkeling in the lake because the water is so clear and clean	**Package plants** remove 89% of pollutants known to cause eutrophication, making it as effective as the centralized treatment alternatives	☺	
	Impairment of Landscape	Monica (71 y.o.) enjoys the view of the river and the forest from the balcony of her apartment	**Septic Tanks** are built below ground, allowing for the landscape to be preserved	☺	
	Space Requirements	Lea (38 y.o.) explains to her children that the playground near their home must be removed in order to make space for the new decentralized WWTP	**Package plants** require space in the garden or cellar (about 4m^2)	☹	
	Impairment of Landscape	Richard (69 y.o.) can no longer see the river from his balcony due to new infrastructures that block the view	The **renovation** of the WWTP may require construction and extension of the current WWTP, which may occupy new land and change the landscape	☹	
	Time Required by Public Authorities	Lea (38 y.o.), a municipality employee responsible for the treatment of wastewater, has a balanced work schedule and does not feel overwhelmed	Of the decentralized options, **agriculture use** requires the least amount of time from authorities (17 hours/year)	☺	
	Innovation and Knowledge Gain	Lea (38 y.o.) and her team of employees present the new findings from the wastewater pilot project located in their municipality	**Urine separation** uses different modern technologies, making it the alternative with the most potential knowledge gain	☺	
	Nuisances to Residents	Naomi (29 y.o.) is late to work because she was stuck behind a smelly slurry truck	**Agricultural use** may cause bad odors (slurry pits) and increase traffic (slurry trucks)	☹	
	Heat Production	David (46 y.o.) and his family live in an apartment building which is heated with renewable sources	**New WWTPs** incinerate biogas produced from sludge decomposition, which can then be used as a renewable heat source	☺	
	Energy Consumption	Angela (24 y.o.) tries to decrease her energy consumption; she wishes that her municipality would do the same	The **status quo** has the highest net energy consumption (about 240 kwh/person/year)	☹	

	Nuisances to Residents	Monica (71 y.o.) is happy that she no longer has to smell the odors from the WWTP near her home	The use of a **neighboring municipality's wwtp** avoids traffic and odors from wastewater treatment in the local community	☺	
	Wastewater Spills and Overflows	Angela (24 y.o.) reads in the newspaper that the main street in the village was flooded with wastewater during the storm with heavy rainfall	**New WWTPs** in zones with few rainwater infiltration sites risk overflowing during heavy rainfalls	☹	
	Space Requirements	Richard (69 y.o.) is happy to have received a spot in the new community garden which has been built in the liberated space where the old WWTP used to be	The use of a **neighboring municipality's WWTP** does not require additional space and liberates the space where the current WWTP is located	☺	
	Fish Toxicity	Max (13 y.o.) learns that the fish population in the nearby river has increased	The contents of **sealed pits** are treated by large, centralized WWTPs which remove 93% of nitrogen (best-case scenario)	☺	
	Innovation and Knowledge Gain	Miriam (32 y.o.) wishes that her municipality could be a pilot project for new wastewater treatment	**Renovation** of the local WWTP uses well-developed and common wastewater treatment technologies	☹	
	Attractiveness of household installations	Richard (69 y.o.) must explain to his guests how to use the toilet	Due to unconventional toilets and odors , **composting toilets** are the least attractive alternative	☹	
	Structural Flexiblity	Philipp's (53 y.o.) reads that due to the increase in population of his town, the WWTP is over-capacity	Centralized WWTPs, even when **renovated,** are not easily extended or deconstructed. Adaptations to changing conditions will increase the costs	☹	
	Groundwater Protection	Philipp's (53 y.o.) lives in a village where the only water source is a well. The quality of the well water has always met drinking water standards	The **status quo** protects groundwater and springwater sources by collecting wastewater and removing harmful pollutants before discharging it into	☺	
	Annual Costs	Richard's (69 y.o.) water and wastewater bill increases for the upcoming year	**Sealed pits** have the highest annual costs for end users (about 1000$/person/year)	☹	
	Greenhouse Gas Emissions	Angela (24 y.o.) sees on the news that due to the intense heatwave and drought, there are a lot of forest fires this year	**Urine separation** is the decentralized alternative with the highest energy consumption (167 kwh/person/year), which may increase greenhouse gas emissions	☹	

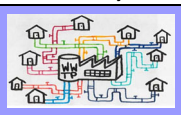
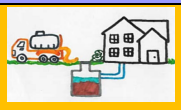
Round.1

Symbol	Issue	Perspective	Alternative	Effect	Alternative Symbol
	Attractiveness of household installations	Naomi (29 y.o.) buys an apartment and invites all of her family and friends for a housewarming party	Of the decentralized alternatives, **package plants** are one of the most attractive options (e.g. conventional toilets, ease of use)	☺	
	Water Consumption	David's (46 y.o.) water consumption has decreased by 20%	**Composting toilets** do not require water for flushing (net water consumption for wastewater treatment: 0 l/person/day, best-case scenario)	☺	
	Health	Miriam (32 y.o.) does not know anyone who has had acute diarrhea	The **status quo** protects human health from risks due to contact with wastewater (0 contacts /year)	☺	
	Impairment of Protected Areas	Monica (71 y.o.) watches as trees in an old protected forest are cut down	A n**ew WWTP** requires construction and space, which may ifringe on protected areas	☹	
	Sanitary Protection for Recreational water use	Max (13 y.o.) enjoys swimming in the nearby river	**Sealed pits** collect and retain wastewater and therefore decrease the chances of a wastewater contamination in local lakes and rivers	☺	
	Prestige	Max (13 y.o.) is embarrassed by the town he lives in. Everything, including the people and the infrastructure, is old and nothing new is happening	Using a **neighboring municipality's WWTP** does not inspire technical advancements *within* the municipality	☹	
	Intergenerational Equity	Angela (24 y.o.) believes that current costs should be distributed in a way which ensures equity for future generations	**Composting toilets** offer a robust solution for all households in the municipality	☺	
	Water Consumption	Max (13 y.o.) is shocked to learn that in Europe, drinking water is used to flush toilets	**MBR package plants** consume just as much water as the status quo (26 L/person/day, worst case scenario)	☹	
	Removal of Micropollutants	Philipp (58 y.o.) wonders about how hormone residues influence fish species	The **status quo** only removes 7% of micropollutants (worst case scenario) which may disrupt natural ecosystems	☹	

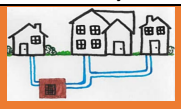
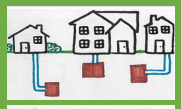
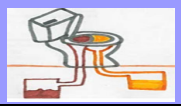
Round.2

Symbol	Issue	Perspective	Alternative	Effect	Alternative Symbol
	Structural Flexiblity	Miriam (32 y.o.) extends her decentralized WWTP to treat the wastewater from her neighbors as well	**MBR package plants** can be easily built, taken out of operation, or removed in order to adapt to changing conditions		
	Distribution of Burdens and Costs	The neighborhood's decentralized WWTP is located in Lea's (38 y.o.) garden. Many households use the installation, though Lea's family performs all the required workload	Unless managed centrally, each group of households is responsible for the costs and burdens of their **MBR-Package Plants**		
	Nuisances to Residents	Naomi (29 y.o.) is late to work because she was stuck behind a smelly slurry truck	**Agricultural use** may cause bad odors (slurry pits) and increase traffic (slurry trucks)		
	Distribution of Burdens and Costs	Philipp (53 y.o.) and his neighbors fairly share the burdens (work load, costs, etc.) of their decentralized WWTP with the rest of the municipality	**Urine separation** technologies can be managed centrally so that costs and burdens are equally distributed to all community members		
	Professional Operations and Management	Lea (38 y.o.) feels confident that the wastewater effluent quality is ensured by both technology and management	**Renovated WWTPs** are equipped with automatic fault detectors and use more reliable, modern technology		
	Professional Operations and Management	Naomi (29 y.o.) must verify the quality of the effluent of her decentralized WWTP on a weekly basis. Public authorities verify the quality on a monthly basis	**Package plants** are not monitored on a daily basis, increasing the risk of a break or spill going unnoticed for an extended amount of time		
	Energy Consumption	Miriam (32 y.o.) supports an energy neutral city and renewable energy sources	**Septic tanks** have 0 net energy consumption for the treatment of wastewater *in situ*		
	Autonomy for Municipality	David (46 y.o.) supports his municipality becoming autonomous because he believes that this will help prioritize the needs of the local	**Renovation** of the current, local WWTP allows the municipality to be independent of other municipalities		
	Ecological State of Surface Waters	Max's (13 y.o.) dog dies after swimming in a lake with a high concentration of Blue-Green Algae	**Agricultural use** only removes 65% of pollutants known to cause eutrophication (worst-case scenario)		

Round.3

Symbol	Issue	Perspective	Alternative	Effect	Alternative Symbol
	Wastewater Spills and Overflows	Monica (71 y.o.) walks home during a heavy rainstorm. Though it is raining really hard, there is no flooding in the streets	Rainwater infiltration sites, such as parks or woods, act as a buffer for **status quo** WWTPs, decreasing the risk of overflows due to heavy rainfall	☺	
	Autonomy for Municipality	Richard (69 y.o.) feels that his needs are no longer considered now that his community is dependent on the neighboring municipality's WWTP	**Sealed pits** must be regularly emptied. The treatment of the contents is dependent on the centralized WWTP of other municipalities	☹	
	Intergenerational Equity	Naomi (29 y.o.) and her neighbors must pay higher taxes due to the emergency replacement of the municipality's WWTP	The **status quo** has a high risk of failure and unplanned costs (i.e. accident costs and future investments)	☹	
	Jobs in the Wastewater Sector	Philipp (53 y.o.) loses his job where he has worked the past 20 years. He struggles to find a new position	The use of a **neighboring municpality's WWTP** signifies that the current WWTP would close and the workers would be unemployed	☹	
	Time Required by End Users	Lea (38 y.o.) enjoys doing arts and crafts with her children in the evenings	**Renovation** of the current WWTP does not require time from users	☺	
	Groundwater Protection	David (46 y.o.) buys bottled water because the well which normally supplies the town with drinking water has been contaminated	There is a risk of poorly treated wastewater infiltrating into the groundwater when using **septic tanks**	☹	
	Inclusive decision-making for Municipalites	Miriam (32 y.o.) joins the board of representatives from her municipality	A **new WWTP,** which includes treatment of wastewater from neighboring municipalities, ensures a central role of the municipality when making decisions	☺	
	Sanitary Protection for Recreational water use	Max's (13 y.o.) swimming lessons are canceled because the lake where the lessons take place has been contaminated with harmful bacteria	Runoff from **agricultural use** can contaminate rivers and lakes, making them unsuitable for recreational use	☹	
	Heat Production	Angela (24 y.o.) wishes she could heat her home with renewable sources	**Composting toilets** do not produce enough heat to be cost-effective and therefore do not serve as a renewable heat source	☹	

Round.4

Symbol	Issue	Perspective	Alternative	Effect	Alternative Symbol
	Jobs in the Wastewater Sector	David (46 y.o.) finds a job closer to his home, decreasing his commute time to work and giving him more time in the evenings with his family	**MBR package plants** increase the amount of time required by authorities (from14 in the status quo to 45 hours/year), thus creating more local jobs	☺	
	Operational Flexibility	David (46 y.o.) and his family are happy to be able to leave their home for 1 month and not have to worry about how the WWTP will react to the lack of WW	**New WWTPs** serving several municipalities are capable of buffering large fluxes in wastewater volume to ensure effluent quality	☺	
	Nitrogen Recovery	Philipp (53 y.o.) must look to large, international companies in order to find nitrogen fertilizer for his farm	**MBR package plants** do not allow for a targeted recovery of Nitrogen	☹	
	Investment Costs	Even though Davids (46 y.o.) municipality does not have a lot of money, it will be able to improve the current wastewater treatment system	**Packaged plants** do not require high investment costs	☺	
	Time Required by End Users	David (46 y.o.) is a working dad with 3 children. He struggles to find time to keep up with the household tasks	**Composting toilets** require 23 hours/year of user time (worst-case scenario, time needed to turn and remove compost)	☹	
	Investment Costs	Philipp (53 y.o.) does not know how the municipality will repay the loan which was needed to cover construction costs for the new WWTP	A **new WWTP** requires high investment costs	☹	
	Nitrogen Recovery	Monica (71 y.o.) uses a nitrogen fertilizer made from human urine in her small garden	**Urine separation** recovers 87.4% of Nitrogen, which is then used in a patented fertilizer	☺	
	Phosphorous Recovery	Philipp (53 y.o.) uses renewable phophorus fertilizers for his crops	**Agricultural use** recycles 95% of phosphorus found in wastewater for fertilizer use	☺	
	Operational Flexibility	During her birthday party, Naomi (29 y.o.) smells a bad odor coming the WWTP in her garden. She thinks that there has been an overflow	**Urine separation** technologies that are combined with decentralized WWTPs are sensitive to large variations in wastewater quantities within a short time period	☹	

Last 5

Symbol	Issue	Perspective	Alternative	Effect	Alternative Symbol
	Inclusive decision-making for Municipalites	Monica (71 y.o.) is worried that her municipality board, whom she elected, will no longer represent her needs	The use of a **neighboring municipality's WWTP** signifies that the municipality must cooperate and coordinate with other municipalities		
	Time Required by Public Authorities	Angela (24 y.o.), a municipality employee, is asked to work extra hours and to take on a heavier workload	**Urine separation** requires the most time from public authorities (73 hours/year) for inspections		
	Phosphorous Recovery	Miriam (32 y.o.) struggles to find a renewable phophorus fertilizer that is produced locally	**Sealed pits** do not allow for the direct agirucultural reuse of the phosphorus found in wastewater		
	Removal of Micropollutants	Richard (69 y.o.) reads that his town treats the wastewater for micropollutants before discharging the water into the environment	The contents of **sealed pits** are treated at large, centralized WWTP. Because of this, 89% of micropollutant are retained from the environment (best-case scenario)		
	Prestige	Richard (69 y.o.) attends the grand opening ceremony for the new wastewater installation in his municipality. He is proud of his community	**MBR package plants** offer an innovative, hygienic solution for all households in the municipality		

SI 5. Facilitated post-game discussion (debriefing)

Hereafter, we report the questions that were guiding the discussion following the intervention.

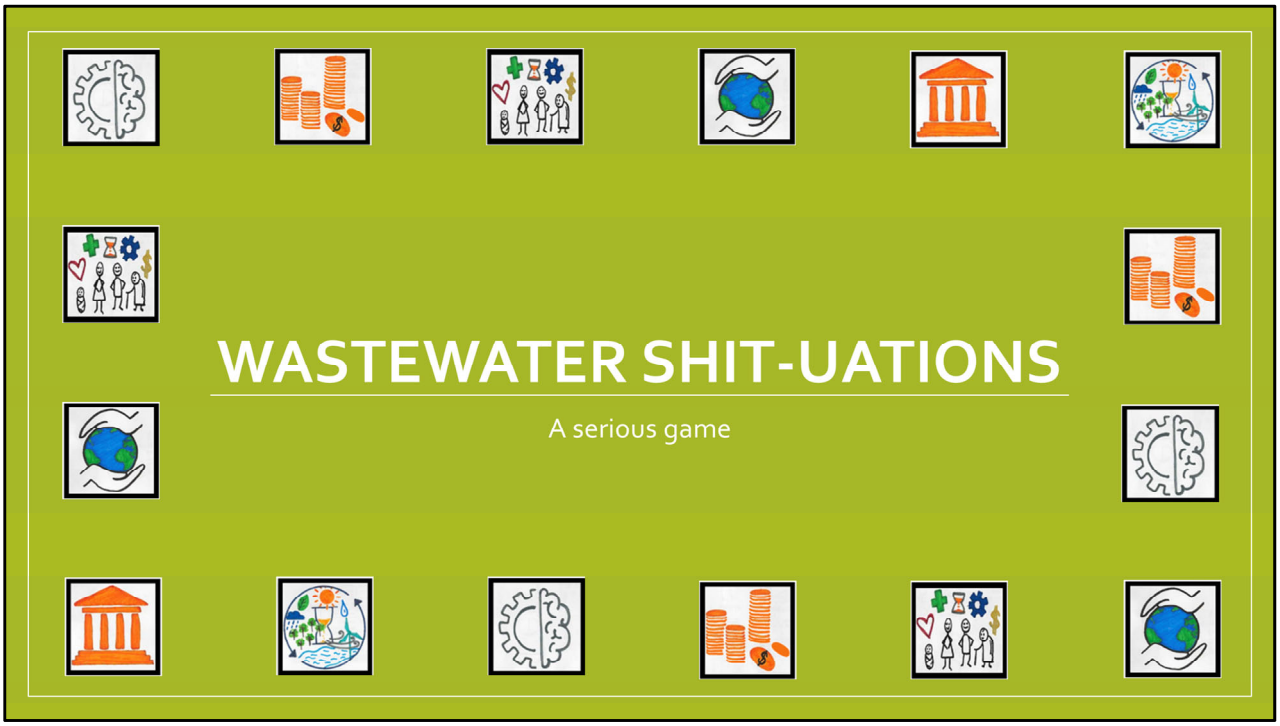
- How did it feel playing the game?
  (Possible post-it exercise, if you have to describe spontaneously your experience of the game with a single word, which word is coming first? Collect them, and use that to start a discussion)

- What did you think of the game?
- What did you learn?
- Did you miss something?
- Did any of the information surprise you?
- Do you think this kind of activity would work in the “real world”?

  Stress on the fact that decision-making has to be context specific
  - *choice of options may differ,*
  - *performance of options on the criteria will differ,*
  - *worldviews will differ*

- What worked in the game?
- Did you find the instructions easy to follow?
- What needs improvement?

SI 6. Introduction slides used with the students


WASTEWATER SHIT-UATIONS
A serious game

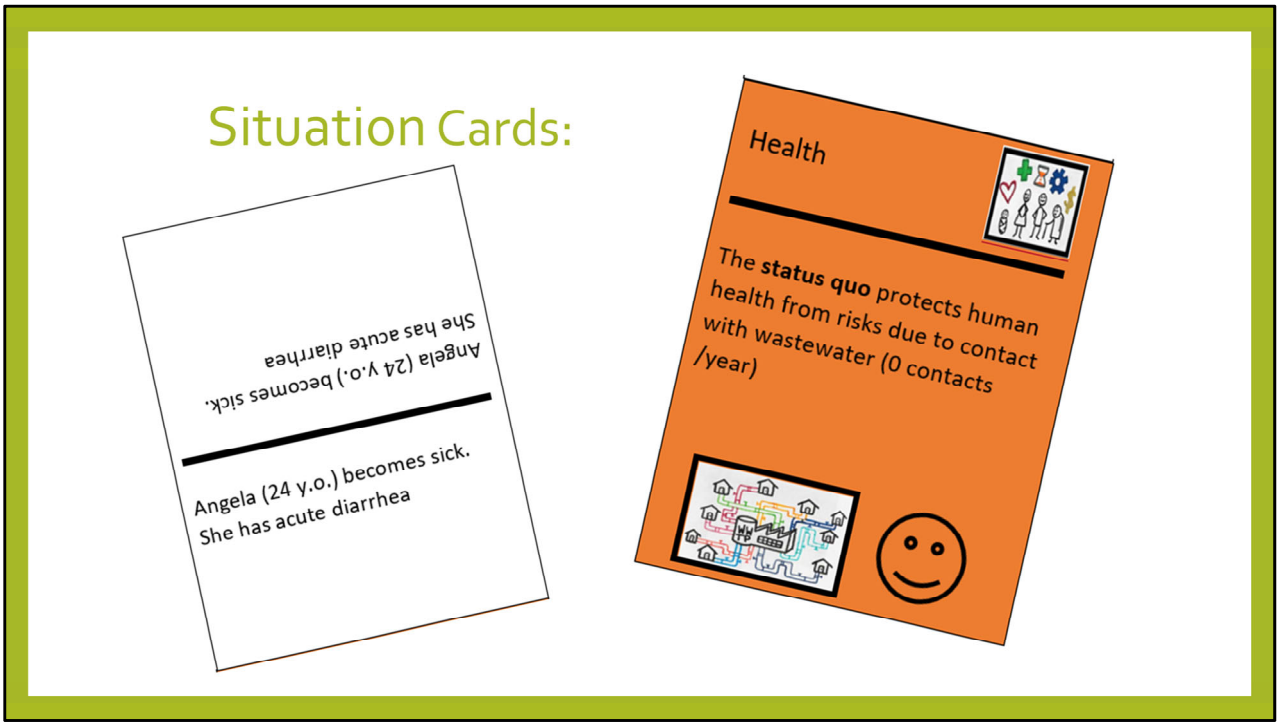
Each player represents a **small, rural municipality in Europe.** The wastewater treatment plant in the municipality is getting old and it is the municipality's responsibility **to learn about different wastewater alternatives** in order to decide which one is best for their municipality

How:
Will go into detail, but in general, the game is played in rounds where each municipality competes against the other municipalities to earn points. In each round, the municipalities use their employee cards to win situation cards. The situation cards gathered by each municipality are then reported, which is how the municipality earns points. At the end of the game, the municipality with the most points wins.

There are three types of cards: employee cards, situation cards, and event cards.

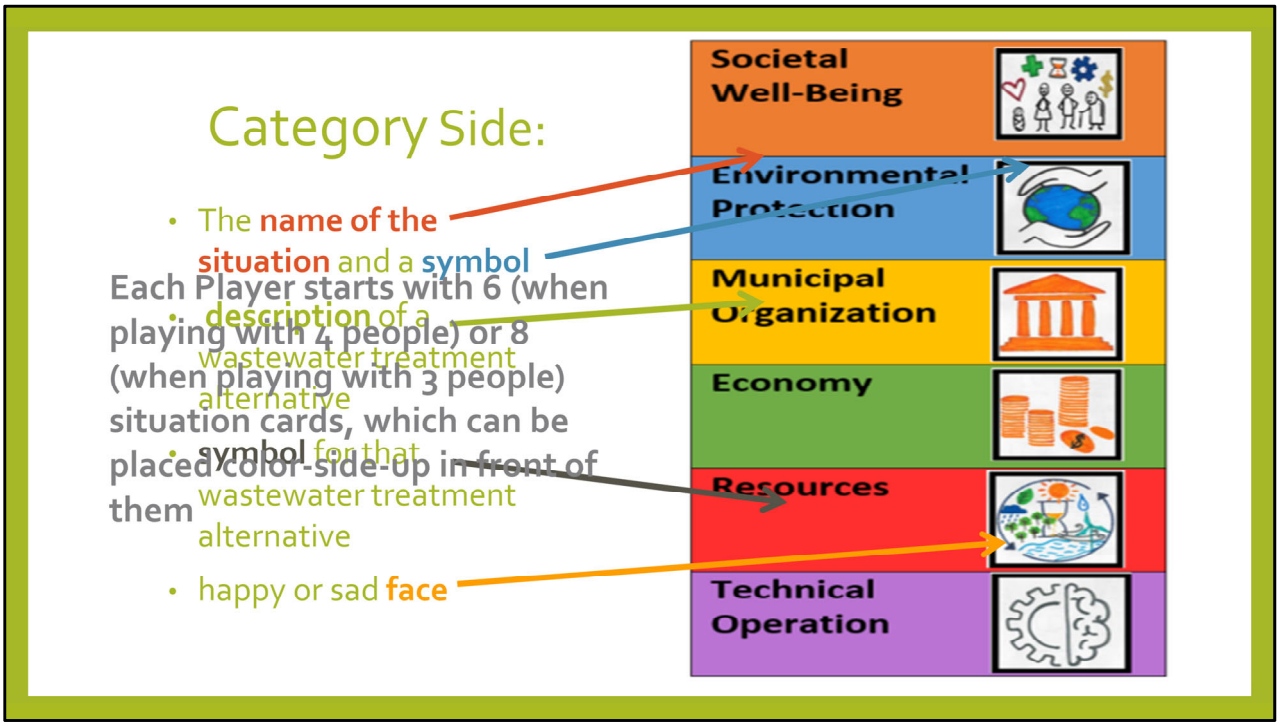
Domain name and symbol. Employees may have 1, 2 or 3 domains. These domains match the categories that are seen on the situation cards, which will be explained next.
Continuing with the employee cards, the description of the employee helps better understand the domains in which the employee is specialized.
Finally, the level of expertise describes the strength of the employee. 1 star is the least amount of experience, and 7 stars is the maximum amount of experience.

Each player will start with 3 employee cards, 1 with 1 or 2 stars, 1 with 3 or 4 stars, and 1 with 5 stars. the other employee cards are shuffled and set in a stack in the middle of the table.



1: two sides to each situation card. Front side is the white side, back side is the colored side.

Story side: this is as short story or testimonial of a habitant of the municipality. During the game, the story will be read by all the player and the player will try to guess which category the story belongs to. There are 7 categories. These categories are the same as the domains on the employee cards.



Name and symbol. symbol represents the category to which the situation belongs to, remember, there are 6 different categories.

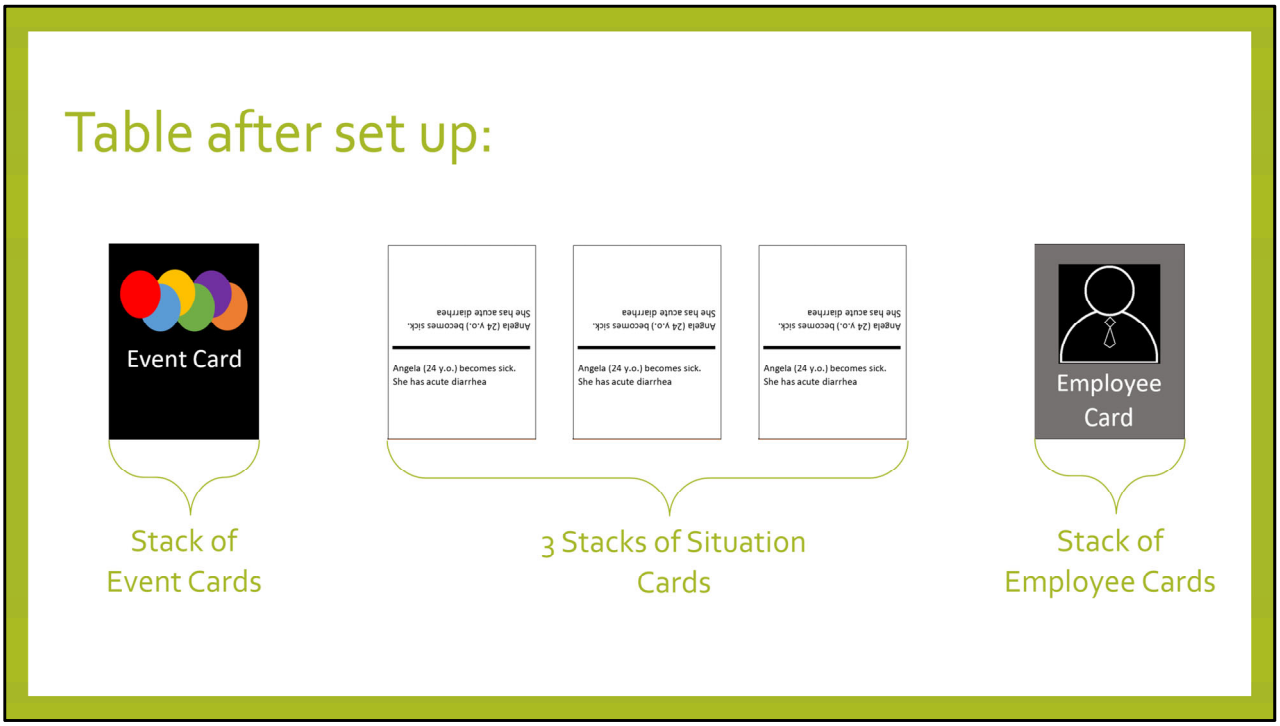
Description of the WW treatment alternative and how and how it applies to that situation

Symbol of the WWT alternative, see list given in appendix of game instructions

happy or sad face that represents the effect of the alternative for that situation (positive (☺) or negative (☹))

At the beginning of the game, each player starts with 6 or 8 situation cards, which are placed in front of each player, colored side up. The other situation cards are placed in three equal stacks, story-side up, in the middle of the table.

Event cards allow players to win points. Each even card has a small task which must be performed by the player who picks the card. There are four types of event cards:
Evaluation and Statistics cards: poses a question to the other players, giving the other players a chance to win points
Chance: win points or loose employee cards
Speech: give a small, 1 to 2 minutes speech concerning the issue proposed by the card. The player who gives the speech wins points or employee card.



At the beginning of the game, the table should look like this, with a stack of the event cards to one side, the shuffled stack of employee cards on the other, and three stacks of situation cards in the center.

Players' hand after set up:

Each player should have 3 employee cards and 8 situation cards (if playing with 3 players, 6 if playing with 4). The situation cards can be placed colored side up in front of each player. Take some time to read the different situation cards as well as your employee cards before beginning the game. Reading the cards can help better understand what types of issues go into the different categories, which can help during the game ;)

Game Play

Step 1: Bidding

Step 2: Official Registration

Repeat steps 1 and 2 three times (9 situation cards in total)

Step 3: Resource Sharing

Step 4: Reporting

Repeat steps 1-4 five times, or until there are no situation cards left in the center deck

Step 1: Bidding
Read the story and bid employee card(s)

Step 2: Official Registration
Winning employee card reads the situation card aloud and places the card in their hand

Repeat steps 1 and 2 three times (9 situation cards are read in total)

Step 3: Resource Sharing
Trade employee and situation cards with other players

Step 4: Reporting
Pick up the 3 (or more) situation cards of the same symbol. Pick event card and perform the task. Receive points and Employee card

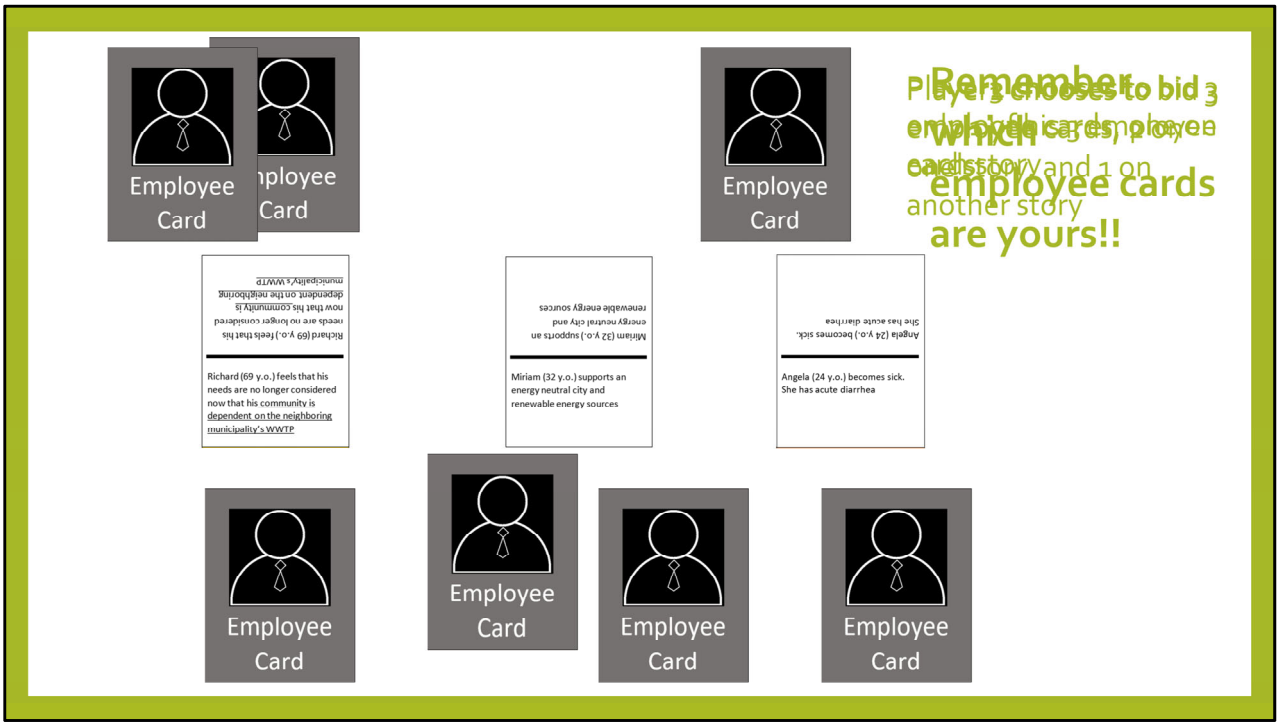
Repeat steps 1-4 five times, or until there are no situation cards left in the center deck

Step 1:
Bidding

- Read the three stories
- "Bid" employee card
  - Lay employee card FACE DOWN next to situation card
    - Can bid multiple employee cards on the same situation card
    - Can choose not to bid
    - 1 employee card can only be bid on 2 situation card per round

OBJECTIVE: Bid employee card whose domain matches the category of the situation card

-Start by reading the stories on the **three situation cards** in the center of the table. For some of the situation cards, the part that is underlined shows the part of the story that is most important for that situation.
-During the bidding phase, each player (*in no particular order*) lays **face down** the employee card that they wish to bid near the situation card which they are wanting to bid on. **The objective is to bid employees whose domain matches the category of the situation card.**
-Each player can bid as many employee cards as she/he would like per situation card. Players can choose to bid on all three of the situation cards, one or two of the situation cards, or none of the situation cards. **One employee can only be bid on one situation card per bidding round**. Once an employee card has been bid (placed near the situation card), it cannot be moved.
Each player is responsible for remembering which employee cards belong to them.


Employee Card
Employee Card
Employee Card
Richard (69 y.o.) feels that his needs are no longer considered now that his community is dependent on the neighboring municipality's WWTP
Richard (69 y.o.) feels that his needs are no longer considered now that his community is dependent on the neighboring municipality's WWTP
Miriam (32 y.o.) supports an energy neutral city and renewable energy sources
Miriam (32 y.o.) supports an energy neutral city and renewable energy sources
Angela (24 y.o.) becomes sick. She has acute diarrhea
Angela (24 y.o.) becomes sick. She has acute diarrhea
Employee Card
Employee Card
Employee Card
Employee Card
Remember
employee cards
are yours!!
another story

Step 2:
Official Registration

- Flip the situation and employee cards
- The employee card whose domain matches the category of the situation card "Officially Registers" the situation card

  → *If two players bid matching employee cards*, **the employee with the most expertise** registers the issue
  → *If two employee cards with the same domain were bid by one player*, **the sum of the stars is used**
  → *If the amount of stars is also tied*, the player who bid the employee card with **the most amount of stars wins**

Employee cards which were correctly bid are recuperated at the end. ½ of the wrongly bid employee cards are returned to the stack of employee cards (round down).

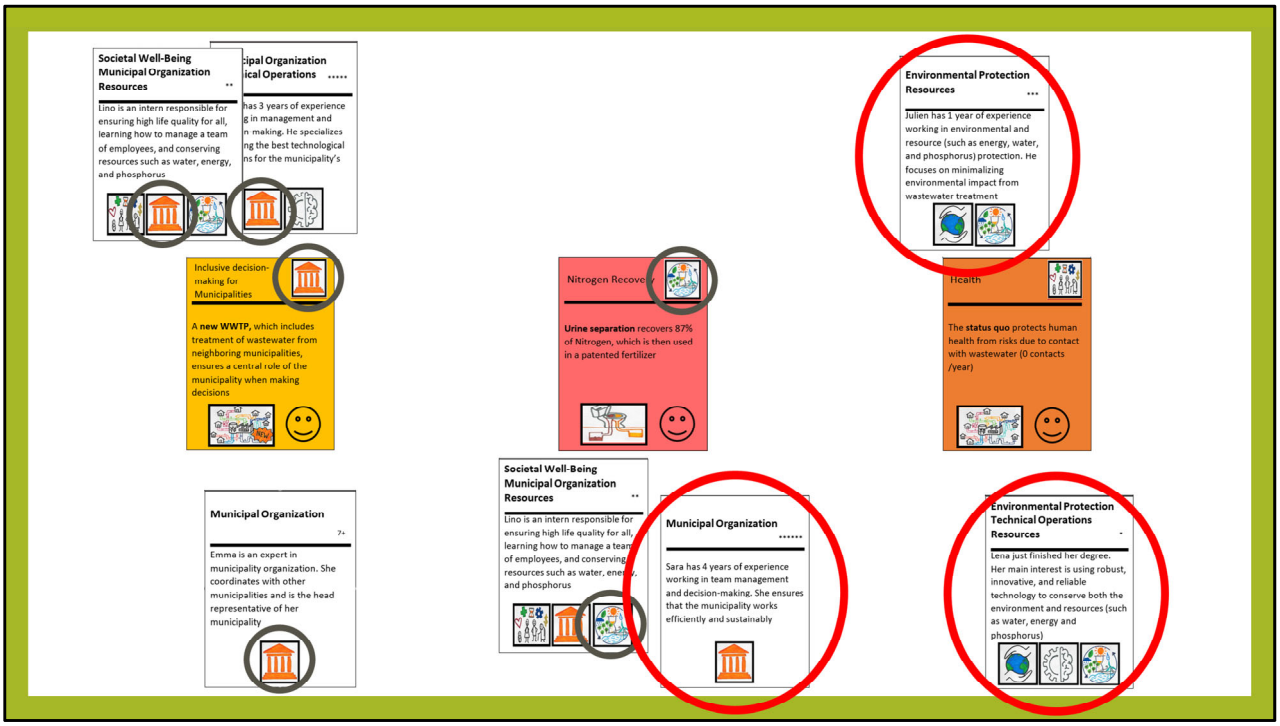
Once everyone has finished bidding, flip the situation and employee cards. **The employee card whose domain matches the symbol on the situation card "registers" that situation card** (receives the situation card in their hand). The player reads the color-side of the card aloud before placing the situation card in their hand.

If two or more players have bid a matching employee card, th**e employee with the most expertise** (most starts) gets to register the situation.
If two or more employee cards with the same symbol were bid by the same player, **the sum of the stars on the employee cards** is used.
If the amount of stars is also tied, the player who bid the employee card with **the most amount of stars wins** the situation card (see example below). *For example*: Player1 has bid 2 society employees, one with 1 star and another with 2 stars on situation card 3.

The **employee cards** whose symbol matches that of the situation card are recuperated by the player who bid the card (even if the employee was not able to officially register the situation, in the case of a tie). One half of wrongly bid employee cards (those that do not have the same symbol as the situation card that they were bid on), must be placed at the bottom of the employee card stack in the center of the

table (rounding down, so if 1 card was wrongly bid, no employee cards are returned. If 2 cards were wrongly bid, 1 card must be returned, and so on).

In the case that no players bid on one or various situation card(s), the situation card(s) are placed on the bottom of the stack.
In the case no correct bid took place (none of the symbols of the employees that were bid match the symbol on the situation card), the situation card is placed on the bottom of the stack.



Flip situation and employee card over.

For the first situation card (the yellow card), all employee cards were bid correctly (CLICK: employee domain matches domain of situation card). Player 1 bid 2 employee cards, one with 2 stars and another with 5. Player 3 bid one employee card with 7 stars. Player 3 registers the situation card because they have the same amount of stars as player 1 in just one card.

CLICK For the second situation card (pink), player 2 bid an employee card whose domain matches that of the situation card. Player 3 wrongly bid their situation card. Player 2 registers the situation card. Remember, players must read the situation card aloud before placing it into their hand.

CLICK For the 3rd situation card (orange), neither player 1 nor player 3 correctly bid an employee card. The situation card is placed at the bottom of the stack.

CLICK Player 3 wrongly bid 2 employee cards and therefore looses ½… or 1 employee card. Player 1 can choose which of the two wrongly bid employee card that she will return to the bottom of the employee card stack in the center of the table.

CLICK Player 1 wrongly bid 1 employee card. Rounding down, no employee cards are lost.

REPEAT STEPS 1 AND 2 THREE TIMES

A total of 9 stories should be read

Step 3:
Resource Sharing

- Exchange Employees and/or Situation cards
- **Objective**: have at least 3 situation cards of the same category in order to Report (step 4…)

Step 4:

Reporting

- Need **3 or more situation cards** belonging to the same category (same symbol/color)
- Pick up the situation cards and pick an event card. Complete the task on the event card
- Mark points:
  - 1 point for each situation card reported
  - Points from event card, if applicable
- Pick up new employee card from the center stack

Each player can report ONE group of situations per round

- For each round of reporting, each municipality (player) is only allowed to report <u>one</u> group of situations.
-Situation cards can only be reported in groups of 3 or more, meaning that the municipality must have *at least 3 situation cards of the same category* (seen by the color and symbol) in order to participate in the reporting.
-**The youngest player begins** by picking up the 3 (or more) situation cards that he wishes to report.
-He then picks an event card and completes the task described on the card.
-**Once finished, the reported situations and the event card are "filed away" (put off to the side, though kept near the player, as these cards will be used at the end of the game).**
-The player who reported a situation picks a new employee card from the top of the stack and wins one point per situation card reported (minimum 3 points) along with the points allotted from the event card.
-**The player sitting clockwise continues and can report a report a group of situation cards, the game continues in clockwise order until every player has had a chance to report a group of situations.**

Game Continuation

- Repeat steps 1-4 (remember, steps 1 and 2 are repeated 3 times!)
- After 5 rounds or when no issue cards are remaining in the center stack (whichever comes first), do final round of resource sharing and reporting

Game End

Add up final points, including bonus points:

- **10 bonus points** to the player with the most amount of categories represented in the reported situation cards
- **10 bonus points** to players with at least 6 different wastewater alternatives represented in the reported situations
- **2 points** for each employee domain (symbol) in the players' hand at the end of the game

-read slide, clarify bonus points:
1- most categories represented in reported situation cards: cannot count the same category twice.
2- 6 different WWT alternatives in reported cards (does not include cards which remain in the player's hand but were not reported)
3- same symbol cannot be counted twice. 6 different domains, so maximum 12 points.

The player with the most points at the end of the game wins.

ENJOY!

Any Questions?

SI 7. Experimental design of our pre-test of workshop with card game

After the introduction and signing consent forms, The experiment followed asking for the initial objectives list (wish list, or individual brainstorming): “To your mind, what are the most relevant objectives that should be considered when dealing with wastewater infrastructure planning?”. Participants ranked the objectives in order of preference (1 being the objective considered as most important). Then, the facilitator introduced the rules of the game. A short break followed. During the following 1 ¼ hour, participants played three rounds of the card game. At the beginning of the game, 24 situation cards were distributed to the participants, who had to read their cards out loud, and update their objectives list (if relevant). At the end of each round, participants were asked to update their objectives list. At the end of the game, participants had a last chance to complete their objectives list, according to the following instruction: “During the last minutes, you have made your initial list of objectives grow. You have some additional time to double check this list, and add missing objectives that are relevant when planning a wastewater infrastructure”. Then, they ranked the objectives of the final list in order of their preference. Finally, the post treatment parts took place: the knowledge test and the self-reported experience directly after the intervention, and the other self-reported evaluation, the socio-demographic questions and debriefing session after a break.

SI 8. Measures used

The main text include a summary table and accompanying text. Hereafter, the exact wording of questions are made available.

SI 8.1. Measures for self-reported usefulness of each technique to generate objectives.

Answers were given on a 7-point Likert scale from 1. very low / very little, 2. low, 3. moderately low, 4. moderate, 5. moderately high, 6. high, 7. very high level / a great deal.

How much did the reading about the testimonials of inhabitants (story side of situation cards) make you critically reevaluate the objectives that you initially found important (listed in your wish list)?

How much did the reading about the options of wastewater management (longer text on the colored side of the situation cards) make you critically reevaluate the objectives that you initially found important (listed in your wish list)?

How much did the thinking about the categories/ domain (six colored categories) make you critically reevaluate the objectives that you initially found important (listed in your wish list)?

How much did reading about the objectives (title on the colored side of the situation cards) make you critically reevaluate the objectives that you initially found important (listed in your wish list)?

How much did the wish list uncover new objectives that you and/or others did not initially consider?

How much did reading about the testimonials of inhabitants (story side of situation cards) uncover new objectives that you and/or others did not initially consider?

How much did the reading about the options of wastewater management (longer text on the colored side of the situation cards) uncover new objectives that you and/or others did not initially consider?

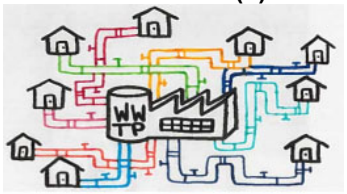
How much did the thinking about the categories/ domain (six colored categories) uncover new objectives that you and/or others did not initially consider?

How much did reading about the objectives (title on the colored side of the situation cards) uncover new objectives that you and/or others did not initially consider?

SI 8.2. Measures for learning about technical options.

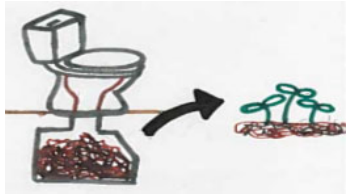
Table 3. Measures used for learning about technical options. The correct answers are marked as such and colored in red.

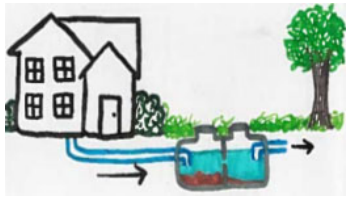
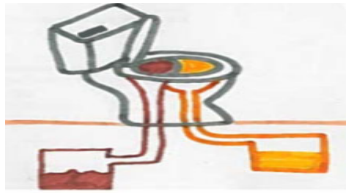
Choose the true statement(s) concerning each option. Note, the statements are relative to the eleven wastewater treatment options considered in the game, which is specific to a case in study in rural Switzerland. (For example, the statement "The status quo is the worst-case scenario for micropollutant removal" is relative to the other ten alternatives compared in this study used to create the game.)

Question	Question type	Answer
The status quo is the business as usual alternative, using the existing centralized wastewater treatment plant (WWTP). Select the true statement(s): 	Multiple choice	The status quo is the worst-case scenario for micropollutant removal (correct answer) The status quo poses a risk to groundwater as it discharges partially treated wastewater into nature The status quo protects human health from risks due to contact with wastewater (best-case scenario for human health) (correct answer) The status quo has the lowest net energy consumption when compared to all other alternatives (best-case scenario) None of the above statements is correct
The renovation of the status quo replaces technical components and expands the lifespan of the centralized WWTP. Select the true statement(s): 	Multiple choice	A renovated WWTP is flexible to changing future conditions and can be easily extended or deconstructed Renovated WWTPs are equipped with automatic fault detectors and use more reliable technology (correct answer) A renovated WWTP allows for the municipality to act as a pilot project for innovative technologies When using a renovated WWTP, the municipality is dependent on other municipalities for treatment of some of the wastewater None of the above statements is correct

Question	Question type	Answer
A new WWTP is built using modern technologies that better meet today's water protection requirements. Select the true statement(s): 	Multiple choice	A new WWTP has a risk of overflow during heavy rainfalls (correct answer) A new WWTP can treat wastewater from neighboring municipalities (correct answer) A new WWTP may pose a risk to protected areas (correct answer) A new WWTP is not capable of valorizing the heat produced from sludge decomposition None of the above statements is correct
The use of a neighboring municipality's WWTP requires that the local community's sewer system be connected to the larger WWTP of the neighboring municipality. (For this question, the local community refers to the community that would no longer have a WWTP in their municipality). Select the true statement(s): 	Multiple choice	The use of a neighboring municipality's WWTP is the centralized alternative with the lowest energy consumption (correct answer) The use of a neighboring municipality's WWTP requires additional space in order to connect the local community sewer system to the neighboring municipality's WWTP The use of a neighboring municipality's WWTP inspires technical advancements within the local community (best-case scenario for knowledge gain) The use of a neighboring municipality's WWTP requires cooperation and coordination between the neighboring community and the local community (correct answer) None of the above statements is correct
Package plants are small, decentralized WWTP that treat the wastewater from each	Multiple choice	Package plants are as effective as centralized WWTPs in removing pollutants known to cause eutrophication (correct answer)

Question	Question type	Answer
individual household *in situ*. Select the true statement(s): 		Package plants do not require high investment costs for the municipality (correct answer) Package plants have an increased risk of breaks and/or spills going unnoticed (correct answer) Package plants require a space of about 8m^2 in the garden or cellar None of the above statements is correct
Membrane (MBR) package plants are similar to package plants, though include a membrane filtration step to ensure hygienic safety. Select the true statement(s): 	Multiple choice	MBR package plants reduce water consumption by using special toilets MBR package plants require the same amount of time from authorities as the status quo MBR package plants use well-developed and common wastewater treatment technologies MBR package plants cannot be built, taken out of operation, or removed in order to adapt to changing conditions None of the above statements is correct (correct answer)
Sealed pits store all domestic wastewater *in situ*. The tanks must be regularly emptied and treated at a neighboring WWTP. Select the true statement(s):	Multiple choice	Sealed pits are the best case scenario for phosphorus recuperation and reuse for agriculture Sealed pits pose a threat to the health of fish in natural water bodies (worst-case scenario) Sealed pits have the highest annual costs for end users (correct answer) Sealed pits ensure safe recreational use of local lakes and rivers (correct answer) None of the above statements is correct

Question	Question type	Answer
		
Agricultural use feeds domestic wastewater directly into slurry pits, where it is stored until it is spread on agriculture fields. Select the true statement(s): 	Multiple choice	Agricultural use avoids odors and decreases traffic in the community Agricultural use protects rivers and lakes from contamination due to runoff Agricultural use is the worst-case scenario for eutrophication (correct answer) Agricultural use recycles 95% of phosphorus found in wastewater for fertilizer (correct answer) None of the above statements is correct
Composting toilets store both urine and faeces *in situ* before recycling them in agriculture. Select the true statement(s): 	Multiple choice	Composting toilets require just as much water as conventional toilets Composting toilets are the worst-case scenario when considering time required by end users (correct answer) Composting toilets cause occasional odors, making it the least-attractive option for end users (correct answer) Composting toilets cannot be applied in all households in the municipality None of the above statements is correct

Question	Question type	Answer
Septic tanks are installed *in situ* and retain coarse matter while seeping away the liquid portion. Select the true statement(s): 	Multiple choice	Septic tanks have the lowest annual costs for end users (correct answer) Septic tanks use energy to pump the water through the tank and therefore do not decrease the net energy consumption Septic tanks recover the most amount of nitrogen when compared to the other options (Best-case scenario) Septic tanks pose the highest risk to human health due to an increased frequency of human contact with wastewater (correct answer) None of the above statements is correct
Urine separation uses special toilets allowing for urine and faeces to be treated separately. Select the true statement(s): 	Multiple choice	Urine separation requires the most amount of time from public employees (worst-case scenario) (correct answer) Urine separation techniques are flexible to large fluxes of wastewater quantities Urine separation uses well-developed and common wastewater treatment Urine separation is the decentralized alternative with the highest energy consumption (correct answer) None of the above statements is correct

SI 8.3. Measures for learning about stakeholders' perspective.

Table 4. Measures used for learning about stakeholders' perspective

Question	Question type	Answer
Please tick in the list below the stakeholder(s) who appeared in the game on the situation cards, story side. *** WARNING*** Our pre-test showed that this question should be changed to one similar to the following two!	Multiple choice	Inhabitants of the municipality (correct answer) Farmers of the municipality (correct answer) Employees of the municipal wastewater facility (correct answer) Decision-makers (e.g. citizen with a political mandate) of the municipality (correct answer) Decision-makers of the neighboring municipality Authorities responsible for environmental protection (correct answer) Authorities responsible for road and transport Authorities responsible for public health Infrastructure investment bank Fishermen of the municipality (correct answer) Environmental activists (correct answer) Technology providers (e.g. private companies developing sensors) None of the above stakeholders
In the game, which stakeholder(s) gave relatively higher importance to lowering costs than to lowering water consumption? Tick the correct statement(s).	Multiple choice	Managers of wastewater facility (correct answer) Decision-makers of the municipality (correct answer) Environmental activists Infrastructure investment bank

		None of the above stakeholders
In the game, stakeholders have different perspectives. Which of the following statement(s) are in line with the game material? Tick the correct statement(s).	Multiple choice	Farmers give relatively more importance to energy resource use than managers of the municipal wastewater facility do. Citizens of the municipality all agree that the most important objectives for wastewater management is environmental protection. Decision-makers of the neighboring municipality give more importance to fair governance processes than decision-makers of the municipality do. Fishermen give more importance to river health than decision-makers of the municipality do. (correct answer) None of the above statements is correct.

Our empirical measure of factual learning about options and stakeholders' perspectives needs further testing. For instance, a control group should answer the knowledge questions once at t_0, and a second time after a few days (t_1). Another group should repeat the knowledge questions at t_1 after receiving the information, i.e. after playing, or reading the relevant informative content. Our factual learning measurement would be validated if participants' scores in the control did not increase at t_1 compared to t_0 whereas those of informed participants did. Because we successfully tested a similar factual learning measurement in a previous study, we are confident that the instrument proposed here is reliable as well (Aubert et al. submitted). However, the first question of the learning about stakeholders' perspectives measurement must change. This question consisted of a memory test of which stakeholders were included in the game. On second thought, to increase the internal consistency with the other questions, it should be redesigned along the lines of the other questions for learning and be a selection of true statements among a list of four.

SI 8.4. Measures for experience (facilitators' observations).

Name of observer:

Date:

Game session / Team ID:

Number of players (and ID of players): -
-
-
-

In the following line, mark down each instances of

Laughter/ positive small talk/ signs of enjoyment ☺ *(count)*	
(If possible, and identifiable, specify the context/ moment of game, time/round)	- - - - - - -
Sighs, grunting, yawning/ negative small talk by observer/ signs of boredom, aggressiveness, anger ☹*(count)*	
(If possible, and identifiable, specify the context/ moment of game, time/round)	- - - - - - -

In the following lines, mark down each instance when participants required help/ clarifications:

Moment in the game session (e.g. which round?)	**Rule**	**Unclear Text**	**Categorization of Objectives**	**Specify** if possible what card, rule or objective was unclear
	if **rule** unclear, they do not know what to do next	if text on the cards is unclear (e.g. description of **option or worldviews**)	if they question the assignment of an **objective in a category**	
…	More lines were	Included in the sheets.		

SI 8.5. Measures for self-reported experience: GAMEFULQUEST.

Original reference for the test: Högberg, J., Hamari, J., & Wästlund, E. (2019). Gameful Experience Questionnaire (GAMEFULQUEST): an instrument for measuring the perceived gamefulness of system use. *User Modeling and User-Adapted Interaction, 29*(3), 619-660. doi:https://doi.org/10.1007/s11257-019-09223-w

Please indicate how much you agree with the following statements, regarding your feelings while playing the Wastewater game.

Answers 7-point Likert scales: strongly disagree / disagree / somewhat disagree / neither agree nor disagree / somewhat agree / agree / strongly agree

In this SI, we present the items per construct, the original, and the one we used in case it needed to be adapted. In the survey, we randomized the order of the items.

Constructs are separated by color.

Accomplishment (goal achievement and progress)
Challenge (experiencing demand for **great effort** in order to be successful, thus the **ability** of the person is **tested)**
Competition (rivalry towards e.g. self, others, service, group, to gain scarce outcome)
Guided Experience (guided on how (what and when) to do, and how to improve at task level or general goal, feedbacks)
Immersion (short-term in-game effect, absorbed, emotional reaction, time passing quickly, gamification to distract from the load/effort)
Playfulness (voluntary and pleasurable)
Social experience (direct and indirect presence of people, NPC)

Table 5. The original items for the GAMEFULQUEST and those we used in case we adapted the items.

Original Item	**Our Item if adapted.**
Makes me feel that I need to complete things	Makes me feel that I need to complete an extensive list of objectives
Pushes me to strive for accomplishments	Pushes me to strive for a comprehensive understanding of wastewater management
Inspires me to maintain my standards of performance	Inspires me to think in terms of objectives to achieve when deciding on a wastewater infrastructure
Makes me feel that success comes through accomplishments	Makes me feel that success comes through accomplishing the required task
Makes me strive to take myself to the next level	Makes me strive to learn new things
Motivates me to progress and get better	Motivates me to progress and get better understanding of wastewater management
Makes me feel like I have clear goals	Kept as original
Gives me the feeling that I need to reach goals	Kept as original
Makes me push my limits	Makes me widen my views concerning important objectives for wastewater treatment

Original Item	**Our Item if adapted.**
Drives me in a good way to the brink of wanting to give up	Drives me to the edge of wanting to give up (this item is REVERSED)
Pressures me in a positive way by its high demands	Pressures me in a positive way by its high demands in system thinking
Challenges me	Kept as original Additional item: Challenges me to maximize the use of all my abilities
Calls for a lot of effort in order for me to be successful	Calls on me to make an effort in order to be the best municipality
Motivates me to do things that feel highly demanding	Motivates me to keep focused despite the high load of information
Makes me feel like I continuously need to improve in order to do well	Makes me feel like I continuously need to learn in order to be the best municipality
Makes me work at a level close to what I am capable of	Engages me in tasks that I feel capable of doing
Feels like participating in a competition	Kept as original
Inspires me to compete	Kept as original
Involves me by its competitive aspects	Kept as original
Makes me want to be in first place	Kept as original
Makes victory feel important	Kept as original
Feels like being in a race	Feels like being in a competition (to be the best municipality, have the best team of employee, etc.)
Makes me feel that I need to win to succeed	Kept as original
Makes me feel guided	Kept as original
Gives me a sense of being directed	Gives me a sense of direction (I know what to do and how to achieve the goal)
Makes me feel like someone is keeping me on track	Makes me feel like someone is keeping me on task
Gives me the feeling that I have an instructor	Gives me the feeling that I have an instructor when listing the objectives I find important
Gives me the sense I am getting help to be structured	Gives me the sense I am getting help structuring my list of the objectives
Gives me a sense of knowing what I need to do to do better	Kept as original
Gives me useful feedback so I can adapt	Allows me to learn so that I can adapt
Gives me the feeling that time passes quickly	Kept as original
Grabs all of my attention	Kept as original
Gives me a sense of being separated from the real world	Kept as original

Original Item	**Our Item if adapted.**
Makes me lose myself in what I am doing	Makes me very focused on what I am doing
Makes my actions seem to come automatically	Makes my actions flow in a way that comes automatically
Causes me to stop noticing when I get tired	Kept as original
Causes me to forget about my everyday concerns	Kept as original
Makes me ignore everything around me	Kept as original
Gets me fully emotionally involved	Kept as original
Gives me an overall playful experience	Kept as original
Leaves room for me to be spontaneous	Kept as original
Taps into my imagination	Kept as original
Makes me feel that I can be creative	Kept as original
Gives me the feeling that I explore things	Kept as original
Feels like a mystery to reveal	Feels like it revealed new things
Gives me a feeling that I want to know what comes next	Kept as original
Makes me feel like I discover new things	Kept as original
Appeals to my curiosity	Kept as original
Gives me the feeling that I'm not on my own	Kept as original
Gives me a sense of social support	Kept as original
Makes me feel like I am socially involved	Kept as original
Gives me a feeling of being connected to others	Kept as original
Feels like a social experience	Kept as original
Gives me a sense of having someone to share my endeavors with	Makes me behave differently than I normally would, because of the interaction with the other players
Influences me through its social aspects	Makes me behave differently than I normally would, because of reading the social information in the game (story side of situation cards)
Gives me a sense of being noticed for what I have achieved	Gives me a sense of being noticed when I earn points

Future application of the evaluation procedure should check for the internal consistency of our items for each construct. Our small sample size did not enable us to do so. Good practice requires several items (or questions) to measure dimensions (or constructs) expressed on Likert scales (Kline 2000). One should verify that those items are actually consistent, i.e. measuring the same dimension, before calculating the mean for the construct. Alpha's Cronbach is usually used to estimate this internal consistency between items measuring a single construct. Our self-reported questions should undergo this test, with a larger sample.

SI 8.6. Measures for self-reported group effect.

The measures are adapted from measures of group dynamics, developed for the European Working Group on Behavioral Operational Research meeting in January 2018 (Eawag, Duebendorf) (Franco 2018).

Answers 7-point Likert scales:

1. very low level/very little
2. low
3. moderately low
4. moderate
5. moderately high
6. high
7. very high level/a great deal

Subset of questions about the **influence of the group on objective generation**:

To what extent do you believe that people in your group influenced your final list of objectives?

To what extent did you incorporate inputs and suggestions from others into your final list of objectives?

To what extent do you feel that your final objective list reflects your own opinion, independently of other group members' opinion?

To what extent did the group discourage dissent in the face of an emerging majority opinion?

Subset of questions about **the group atmosphere**:

How much did you know the other participants of the group?

How much did you enjoy working with this group on today's exercise?

To what extent did a leader emerge in the group during the exercise?

How comfortable would you feel working with other members of the group in the future?

How much do you feel that you were really part of the group?

How much personal friction surfaced within the group during the game?

How many personality clashes between group members became evident during the game?

How welcome did you feel to express opinions freely to other group members during the game session?

*** WARNING*** Our pre-test showed that the question "To what extent did a leader emerge in the group during the exercise?" should be changed as one (or several) of the following propositions:

To what extent did a team member take the lead in making decisions?

To what extent did a leader emerge in the group, who had a strong influence on the group's decisions?

Has a team member been overshadowing/commanding/domineering/ overbearing during the exercise?

SI 8.7. Questions for socio-demographics and other.

Gender

- ◯ Masculine
- ◯ Feminine
- ◯ Else: _ _ _

Age (free text, only number)

Nationality (dropdown list, Sweden set as default option)

Mother tongue (dropdown list, Swedish set as default option)

Self-reported level of English

- ◯ Very good
- ◯ Rather good
- ◯ Neither good, nor bad
- ◯ Rather bad
- ◯ Very bad

Cumulative professional experience on wastewater (sum of working months, including internship) (free text, only number)

Highest achieved qualification

- ◯ High school degree (or equivalent)
- ◯ Bachelor degree (or equivalent)
- ◯ Master degree (or equivalent)
- ◯ PhD (or equivalent)

Table 6. Demographics of the sample. M = mean, SD = standard deviation, N (%) = count and percent.

		N (%)
Gender	Female	4 (40%)
	Male	6 (60%)
	Else	0 (0%)
Age (M = 25, SD = 1.63)	23	2 (20%)
	24	3 (20%)
	25	3 (30%)
	26	1 (10%)
	27	1 (10%)
	28	1 (10%)
Nationality	Swedish	10 (100%)
Mother tongue	Swedish	10 (100%)
Self-reported level of English:	1 Very good	3 (30%)
	2 Rather good	7 (70%)
	3 Neither good, nor bad	0 (0%)
	4 Rather bad	0 (0%)
	5 Very bad	0 (0%)
Cumulative professional experience on wastewater (sum of working months, including internship):	0	7 (70%)
	3	1 (10%)
	4	1 (10%)
	6	1 (10%)
Highest achieved qualification:	1 High school degree	0 (0%)
	2 Bachelor degree	9 (90%)
	3 Master degree	1 (10%)
	4 PhD	0 (0%)

SI 9. Overview of pre-test: illustrative analyses

SI 9.1 Objective generation (RQ1)

Each groups played three rounds of the game. At each round, each individual added between zero and five objectives (Figure SI 9.1.1, tables in SI 10.1). The difference between the wish and final lists in number of objectives was between 1 and 10 (Mean M = 3.9, and Standard Deviation SD = 2.77). The number of objectives in the wish list was statistically significantly smaller than in the final list (Wilcoxon signed rank test with continuity correction: V = 0, p = .003, d = -0.70). The workshop with card game helped participants to generate more objectives. Note: we are fully aware of the limitations of small sample sizes in all the test results.

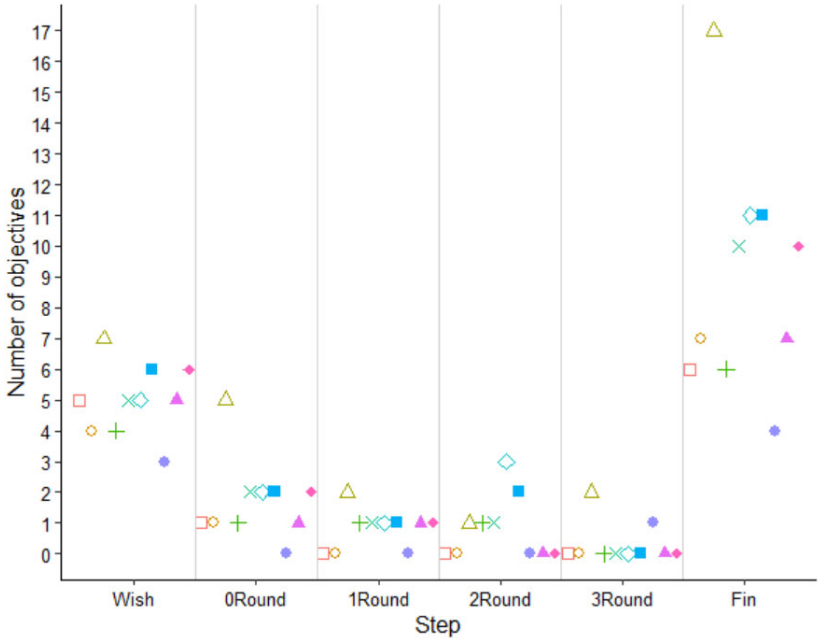


Figure SI 9.1.1. Number of objectives generated at each step of the card game (the wish list, each update of the list after reading the first set of cards (0Round), and each round of the game (1Round, 2Round, 3Round), and the number of objectives in the final list (Fin = sum of all the objectives).

In terms of diversity of objectives, the difference between the wish and final lists in number of categories was between 0 (three out of 10 players) and 2 (one player; M = 0.8, SD = 0.63; SI 10.1). Note, there were six categories: societal well-being, environmental protection, municipal organization, economy, resources, and technical operation. The number of categories was significantly smaller in the wish list than in the final list (Wilcoxon as above: V = 0, p = .007, d = -0.87). The workshop with card game helped participants to generate more diverse objectives, with most participants identifying at least one more category in the final list.

In the self-report, confidence in the generated final list of objectives was moderate to moderately high (M = 4.63, SD = 1.02; with 1 very low level/very little to 7 very high level/a great deal). For instance, participants were moderately confident (M = 3.9, SD = 1.37), that their final list included all objectives that

are important to consider when deciding about wastewater management, but they were moderately to highly confident (M = 4.9, SD = 0.88), that their final list extensively covered the different aspects of wastewater management (SI 10.1). These results corroborate participants' performance at generating objectives.

The various techniques used in the study made participants moderately low to moderately re-evaluate the objectives that they initially found important (M = 3.72, SD = 0.93; SI 10.1). Thinking in terms of generic objectives (categories) was rated as least influential in relation to the critical revaluation (M = 3.4, SD = 1.17). The self-reported influence of the various techniques on the uncovering of new objectives was somewhat higher (M = 4.18, SD = 0.93; SI 10.1). None of the techniques were attributed with notably more or less influence than the others in relation to uncovering new objectives.

SI 9.2 Learning about options (RQ2)

Participants performed moderately well in the knowledge test about the technical options (M = 4.9, SD = 1.91, the best possible score being 11). Given the students' background, this was surprising. Self-reporting learning was also moderate (M = 3.78, SD = 0.73; SI 10.2). For instance, participants felt that the information provided in the description of options was moderately in conflict with their previous knowledge (M = 4.00, SD = 1.05; same scale as RQ1).

SI 9.3 Learning about stakeholders' perspectives (RQ3)

Participants performed moderately in the knowledge test about stakeholders' perspectives (M = 2.05, SD = 1.21, the best possible score being 5). Self-reporting learning was also moderate (M = 4.82, SD = 0.79; SI 10.3). For instance, participants thought that they became only moderately more aware of clashes of interest when deciding about wastewater (M = 3.80, SD = 1.62), while they thought, that high friction between stakeholders can surface when deciding about wastewater management (M = 6.10, SD = 0.74).

SI 9.4 Positive experience (RQ4)

The facilitators observed between zero and 9 signs of negative experiences per group (e.g. sighs, grunting, etc.), while they counted between 16 and 22 signs of positive experiences (e.g. laughter, positive small talk, etc.). Between the three groups, this makes an average of 4 (SD = 4.58) negative signs and 18 (SD = 3.46) positive signs (SI 10.4). The negative signs systematically occurred in relation to starting the game and/or being confused when reading cards. Overall, given the ratio between positive and negative signs (ratio = 4.5), the card game provided a positive experience. Qualitative data from the audio-recorded post-game discussion supported this. "Fun" was the first word used to describe their experience, and it

was used 11 times in the recording. In the discussion, the major issue degrading the experience was the amount of informative content. The following quote summarised this well: “It was quite exciting when we were supposed to pick the cards, it got that sense of excitement that at least triggered me in my competitive side, because other than that it was mostly informative…”

In more detail, the GAMEFULQUEST revealed that the card game offered a moderately high sense of accomplishment (achieving a goal, and progressing, Figure SI 9.4.1, SI 10.4), challenging experience (demanding effort to success in achieving the goal, i.e. challenging the abilities of the participants), competitive setting (with rivalry towards self and/or others), and playfulness (voluntary and pleasurable), and a moderate guided experience, immersion, and social experience. These evaluations were positive, but showed that the card game could be improved, particularly with respect to the last three aspects.

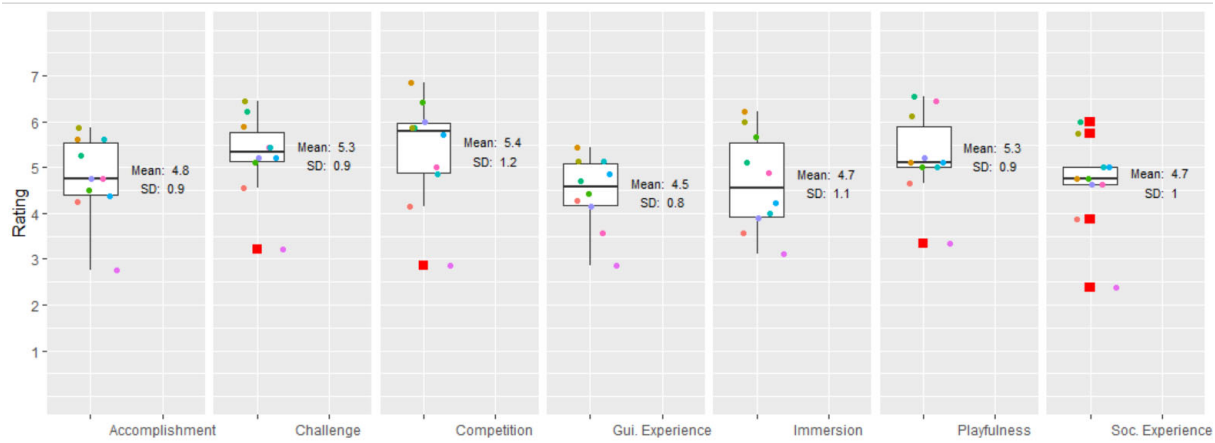


Figure SI 9.4.1. Self-reported experience (GAMEFULQUEST). Boxplots depicting the self-reported answers to the seven constructs of experience (x-axis), rated on a 7-point Likert scale (y-axis) by the participants (coloured dots). Likert scale: 1= strongly disagree, 2= disagree, 3= somewhat disagree, 4= neither agree nor disagree, 5= somewhat agree, 6= agree, 7= strongly agree. Outliers are additionally marked with a red square.

SI 9.5 Group effect (RQ5)

Consistent with the increase in the number of objectives generated by each participant between the initial and final list of objectives (RQ1), the number of shared objectives within a group also increased. Additionally, the number of group total objectives increased between the initial and final lists (counting all objectives of all group participants, removing double counts). As the number of objectives increased, the objective lists of participants within a group became less “consensual” (negative difference between initial and final ratio: ratio diff, Table SI 9.5.1), or did not increase strongly after the game (max ratio diff = 0.12; note in case of complete consensus ratio diff = 1). Only group 3 reached a higher consensus at the end of the game, compared to the start, but consensus score remained low. These results, confirmed the positive effect of the workshop with card game on objective generation. Additionally, they suggest that the occurrence of groupthink – a bias that should be avoided in the diverging phase of objective generation –

was not enhanced by adding a card game in the workshop. The highest observed consensus of a participant with the group was 0.40, which was low, and observed in the initial list.

Self-reporting supported this observation. All items for group consensus were rated low to moderately low (M = 2.94, SD = 0.91; SI 10.5). For instance, participants rated that their group discouraged dissent as moderately low (M = 3.20, SD = 1.55). Note, the results varied greatly between the groups (on the extreme: group 1 reported low groupthink (M = 2.00) and group 3 moderate groupthink (M = 3.67)). The group atmosphere was rated highly positively (e.g. How much did you enjoy working with this group on today's exercise? M = 6.03, SD = 0.56; SI 10.5).

Table SI 9.5.1. Consensus between participants, within their group. Group = group number; **ID** = player identification number, **List**: ini = initial list, fin = final list; **Number of objectives** = number of objectives per participant. **Number of shared objectives**: number of objectives shared between single player and his or her group. **Ratio**: calculated as "number of shared/number of unique". **Group total objectives**: number of unique objectives in the respective group. **Ratio diff**: difference between initial and final ratio for each participants.

Group	ID	List	Number of objectives	Number of shared objectives	Ratio	Group total objectives	Ratio diff
1	1	ini	5	3	0.33	9	-0.03
		fin	6	4	0.31	13	
	2	ini	4	3	0.33	9	-0.03
		fin	7	4	0.31	13	
	4	ini	4	3	0.33	9	-0.03
		fin	6	4	0.31	13	
	8	ini	3	2	0.22	9	0.01
		fin	4	3	0.23	13	
2	5	ini	5	4	0.40	10	-0.09
		fin	10	5	0.31	16	
	9	ini	5	4	0.40	10	-0.09
		fin	7	5	0.31	16	
	10	ini	6	2	0.20	10	0.11
		fin	10	5	0.31	16	
3	3	ini	7	3	0.27	11	0.08
		fin	17	7	0.35	20	
	6	ini	5	2	0.18	11	0.12
		fin	11	6	0.30	20	
	7	ini	6	3	0.27	11	0.03
		fin	11	6	0.30	20	

Our ratio to measure group consensus depends on the total number of objectives the participants listed. Our search of the literature for a consensus score or an agreement index did not return formulas transposable to our case (Hou 2015; Jabeur and Martel 2010; Scott et al. 2013). Thus, we created the proposed one, which lead to interpretable results. However, one should be careful with the interpretation. For instance, if in a group, one player lists 30 objectives, then the chances for a match between objectives

listed by the other players of this group are higher than in a group where each player listed only a few objectives. We failed to develop a consensus score that corrects for the total number of objectives, while remaining mathematically sound, and interpretable. This is a clear area for further study.

SI 9.6 Associated discussion on the gamification

We verified the playability of the game in a controlled setting, under neutral observation, and determined the length of play. The design of the card game was guided by the literature about techniques to support comprehensive generation of objectives (Bond et al. 2008; Bond et al. 2010; Ferretti 2019; Haag et al. 2019; Keeney 1996). Objective generation is a crucial early step of MCDA, as missing an important objective can strongly influence the outcome of the MCDA. However, apart from these studies, the literature is scarce. The card game included five techniques previously reported for generating objectives: wish list (individual brainstorming), considering generic objectives (categories), technical options, stakeholders' perspectives, and a master list of objectives. In addition to generating objectives, the card game should enhance factual learning about options and stakeholders' perspectives, provide a positive experience, and avoid creating groupthink. We applied the game to the topical issue of sustainable wastewater management.

We assessed the workshop with card game using a structured evaluation procedure. Gamification and serious games are seldom thoroughly evaluated. Due to few registered students and the pandemic preventing group workshop to take place, i.e. preventing further data collection, we could not carry out the proper evaluation, and therefore cannot conclude whether adding the card game in the workshop is better than a control workshop. In that sense, in the current state, our study illustrates the typical weaknesses observed in evaluation of game-based approaches, i.e. a small sample size and no control treatment (Bailey et al. 2015; Koivisto and Hamari 2019; Lumsden et al. 2016; Seaborn and Fels 2015). Thus, we are fully aware that further work is needed to conclude on the benefits (or drawbacks) of the proposed workshop with card game versus a control workshop to generate objectives.

Nevertheless, the pre-test (results in SI 9-10) suggests that the game supported generating a comprehensive objective list for decision-making about sustainable wastewater management (RQ1). The length and diversity of the objective lists increased after playing, and self-reported answers showed confidence in the lists. With our small sample, none of the techniques appeared better than another. Further data collection might be able to distinguish the most effective techniques. For instance, it could confirm whether thinking in terms of generic objectives (categories) enhances objective generation more than other techniques (Haag et al. 2019).

The factual and social learning (RQ2 and 3) in the pre-test were moderate. The post-game recorded debriefing gave two explanations. First, participants explained being caught up in the card game

and highlighted that it can be played without careful reading. Thereby, no factual information is processed, and learning is hindered. Second, participants highlighted discrepancies between their pre-existing knowledge about wastewater management in Sweden and the card game information. These differences, explained by the specific game context (rural Switzerland, Beutler and Lienert 2020), were discussed in the post-game debriefing. The strengths and weaknesses between a few technical options (e.g. septic tank, urine source separation, connecting to neighbouring infrastructure) differed between Sweden and Switzerland. Future workshops with card game should seize the opportunity created by such cognitive dissonances (Adcock 2012) to spark discussions about pre-existing knowledge between participants.

Overall, the card game provided a rather positive experience (RQ4). Constructs from the GAMEFULQUEST that rated relatively lower than others were “guided experience”, “immersion”, and “social experience” (SI 9.4). Observations indicated when the negative signs occurred, and the debriefing corroborated the feeling of confusion at the start of the game. In the post-game debriefing, students suggested that future workshops with card game start with a facilitated tutorial first round, to help participants with understanding the game mechanics. Better tutorials and guidance could probably also enhance immersion and social dynamics.

The group dynamic was rated as high (RQ5, SI 9.5), and this was not associated with higher consensus at the end of the workshop with card game compared to the start (neither with our consensus score, nor with the self-reporting). Playing the card game in the workshop created an experience, raising emotional commitment and providing multiple perspectives. Such experiences create conditions to avoid groupthink (Eden 1992). Finding that positive group dynamic did not increase consensus is good news for group decision-making and negotiation. The literature usually reports that suppressed or absent positive conflicts can lead to groupthink (Chidambaram and Bostrom 1997; Esser 1998; Janis 1982). However, low consensus in a group is not a necessary condition to avoid poor decisions (Kerr and Tindale 2004). Rather, specifically in the diverging phase of objective generation, it is that we desire a low consensus.

Overall, the structured evaluation – though still with small sample size and missing the control treatment – found that the workshop with card game gave promising preliminary results that need to be consolidated with further data collection. Playing the card game in the diverging phase of problem structuring workshop enhanced generating objectives. It also offered a positive experience, which at the same time did not increased too early convergence of the individuals lists. The game mechanics worked, which was not surprising given that we adapted the existing game KlarText (Bundesamt für Statistik 2008). Further use of the card game in workshops should: (1) emphasize that generating a comprehensive objective list is the aim of the workshop, (2) guide the players more in the first round, (3) remind the players to read the text carefully, and (4) use the cognitive dissonances on the facts to enhance sharing knowledge and opinions on the topic, particularly during the post-game debriefing.

SI 10. Complementary results

SI 10.1. Additional results on objective generation (RQ1).

Table 7. Central tendencies of the self-reporting items about generating the objectives list. Min = lowest rating given to the item over all respondents; Max = highest rating given to the item over all respondents; Med = Median; SD = standard deviation; N = total number of respondents.

Item	Min	Max	Med	Mean (SD)	N
To what extent are you confident that your final list of objectives includes all objectives important to consider when deciding about wastewater management? (#131)	2	6	4	3.9 (1.37)	10
How much do you think your final list of objective extensively covers the different aspects of wastewater management? (#132)	3	6	5	4.9 (0.88)	10
How satisfied are you with your final list of objectives? (#133)	3	7	5	5 (1.15)	10
How comfortable would you be using the objectives from your list to decide about wastewater management? (#134)	2	6	5	4.7 (1.25)	10
Subscale "confidence in the final list" (131-134)	**2.5**	**6**	**4.75**	**4.62 (1.02)**	**10**
How much did the reading about the testimonials of inhabitants (story side of situation cards) make you critically reevaluate the objectives that you initially found important (listed in your wish list)? (#135b)	1	7	4.5	3.9 (1.85)	10
How much did the reading about the alternatives of wastewater management (longer text on the colored side of the situation cards) make you critically reevaluate the objectives that you initially found important (listed in your wish list)? (#135c)	2	5	4	3.7 (0.82)	10
How much did the thinking about the categories/ domain (six colored categories) make you critically reevaluate the objectives that you initially found important (listed in your wish list)? (#135d)	2	6	3	3.4 (1.17)	10
How much did reading about the objectives (title on the colored side of the situation cards) make you critically reevaluate the objectives that you initially found important (listed in your wish list)? (#135e)	2	6	4	3.9 (1.10)	10
Subscale "critical reevalutaion" (135b-e)	**2**	**5.25**	**3.88**	**3.72 (0.93)**	**10**
How much did the wish list uncover new objectives that you and/or others did not initially consider? (#136a)	3	5	4	4.2 (0.79)	10
How much did reading about the testimonials of inhabitants (story side of situation cards) uncover new objectives that you and/or others did not initially consider? (#136b)	1	7	4	4 (1.83)	10
How much did the reading about the alternatives of wastewater management (longer text on the colored side of the situation cards) uncover new objectives that you and/or others did not initially consider? (#136c)	2	6	4.5	4.3 (1.34)	10
How much did the thinking about the categories/ domain (six colored categories) uncover new objectives that you and/or others did not initially consider? (#136d)	2	7	4.5	4.3 (1.42)	10
How much did reading about the objectives (title on the colored side of the situation cards) uncover new objectives that you and/or others did not initially consider? (#136e)	3	5	4	4.1 (0.88)	10
Subscale "Uncovering of objectives" (136a-e)	**3**	**5.4**	**4.20**	**4.18 (0.93)**	**10**
Overall scale 131-136e	2.69	5.46	4.23	4.18 (0.82)	10

Table 8. Counts of the number of objectives generated at each step of the intervention per player (the initial list (Wish), each update of the list after reading the first set of cards (0Round), and each round of the game (1Round, 2Round, 3Round) and the number of objectives in the final list (Fin = sum of objectives from each round). pid = player id

pid	Wish	0Round	1Round	2Round	3Round	Fin
A	5	1	0	0	0	6
B	4	1	0	0	0	7
C	7	5	2	1	2	17
D	4	1	1	1	0	6*
E	5	2	1	1	0	10
F	5	2	1	3	0	11
G	6	2	1	2	0	11
H	3	0	0	0	1	4
I	5	1	1	0	0	7
J	6	2	1	0	0	10

* Player D added the same objectives again, i.e. Wish = Obj.A Obj.B Obj.C Obj.D, 0Round = Obj.A, 1Round = Obj.B, 2 Round = Obj.E and FIN = Obj.A Obj.B Obj.C Obj.D Obj.E Obj.F

Table 9. Central tendencies of the number of objectives generated at each step of the intervention (the initial list (Wish), each update of the list after reading the first set of cards (0Round), and each round of the game (1Round, 2Round, 3Round) and the number of objectives in the final list (Fin = sum of objectives from each round).

Step	Min	Max	Med	Mean (SD)
Wish	3	7	5	5.00 (1.15)
0Round	0	5	1.5	1.70 (1.34)
1Round	0	2	1	0.80 (0.63)
2Round	0	3	0.5	0.80 (1.03)
3Round	0	2	0	0.30 (0.67)
Fin	4	17	8.5	8.90 (3.73)

Table 10. Number of categories covered in initial (Wish) and final (Fin) list. Diff = number of categories added during the game.

pid	Wish	Fin	Diff
A	3	4	1
B	3	5	2
C	5	6	1
D	4	5	1
E	4	5	1
F	4	4	0
G	4	5	1
H	3	3	0
I	3	3	0
J	4	5	1
Min	3	3	0
Max	5	6	2
Med	4	5	1
Mean (SD)	3.70 (0.67)	4.50 (0.97)	0.80 (0.63)

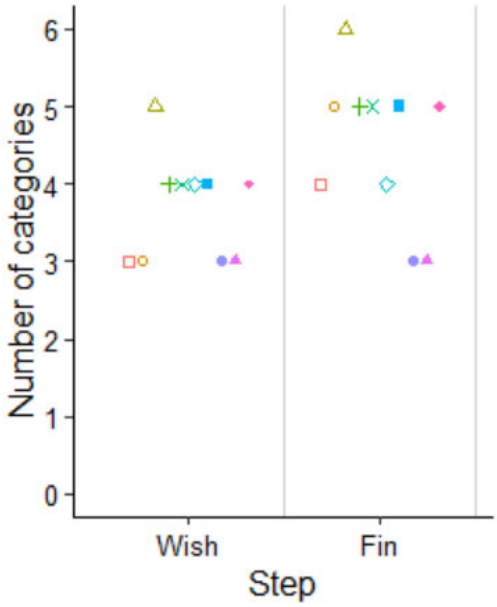


Figure 1. Number of categories covered in initial (Wish) and final (Fin) list per player.

SI 10.2. Additional results on learning about options (RQ2).

Table 11. Central tendencies of the self-reporting items about learning about options. Min = lowest rating given to the item over all respondents; Max = highest rating given to the item over all respondents; Med = Median; SD = standard deviation; N = total number of respondents.

Item	Min	Max	Med	Mean (SD)	N
How much did the exercise make you critically reevaluate your initial knowledge about the alternatives of wastewater management? (#221)	2	6	3	3.80 (1.40)	10
To what degree do you think that the information provided in the descriptions of alternatives (longer text on the colored side of the situation cards) was in conflict with your previous knowledge? (#222)	2	6	4	4.00 (1.05)	10
How much did the exercise confront you with information about alternatives that you did not know before? (#223)	2	5	3	3.30 (1.06)	10
How much did the game uncover new alternatives or facts about alternatives that you did not initially consider? (#224)	2	5	4	4.00 (0.94)	10
Subscale "learning about option" (221-224)	**2.75**	**5.00**	**3.63**	**3.78 (0.73)**	**10**

SI 10.3. Additional results on learning about stakeholders' perspectives (RQ3).

Table 12. Central tendencies of the self-reporting items about learning about stakeholders. Min = lowest rating given to the item over all respondents; Max = highest rating given to the item over all respondents; Med = Median; SD = standard deviation; N = total number of respondents.

Item	Min	Max	Med	Mean (SD)	N
How many different stakeholders' perspectives about wastewater management need to be worked through to make a decision? (#321)	4	7	5	5.50 (0.97)	10
How much friction between stakeholders can surface when deciding about wastewater management? (#322)	5	7	6	6.10 (0.74)	10
How much more aware did you become of clashes of interest when deciding about wastewater management? (#323)	2	7	3	3.80 (1.62)	10
To what extent do you believe the social information in the game (e.g. story side of situation cards) exposed a fair representation of the different perspectives about wastewater management? (#324)	3	6	4.5	4.60 (0.97)	10
To what extent does the social information in the game (e.g. story side of situation cards) consider each stakeholder's opinion carefully? (#325)	2	6	4	4.10 (1.37)	10
Subscale "learning about SH' perspectives" (321-325)	**3.80**	**6.40**	**4.60**	**4.82 (0.79)**	**10**

SI 10.4. Additional results on experience (RQ4).

Table 13. Number of signs of positive and negative valence per group.

group	positive	negative
1	22	0
2	16	9
3	16	3
Total	54	12
Mean (SD)	18 (3.46)	4 (4.58)

Table 14. Time of occurrence shows at which point of the game the signs of positive and negative valence occurred. We did not count how many signs there were per point of game.

group	valence	time of occurrence
1	positive	- Reading through the situation cards in the beginning - Bidding - Resource sharing - Event card
2	positive	- Reading story - Bidding - Resource sharing - Counting points
	negative	- Reading & start / reading alternatives
3	positive	- Bidding-winning - Stories - Resource sharing - Competition - Speech
	negative	- Confusion on reading cards

Table 15. Central tendencies of the items of the GAMEFULQUEST. Scale shows the results averaged over all items of the concerning scale. Min = lowest rating given to the item over all respondents; Max = highest rating given to the item over all respondents; Med = Median; SD = standard deviation; N = total number of respondents.

Scale	Item	Min	Max	Med	Mean (SD)	N
Accomplishment	Makes me feel that I need to complete an extensive list of objectives	2	6	4.5	4.30 (1.16)	10
	Pushes me to strive for a comprehensive understanding of wastewater management	2	7	5	5.00 (1.49)	10
	Inspires me to think in terms of objectives to achieve when deciding on a wastewater infrastructure	2	7	4.5	4.50 (1.43)	10
	Makes me feel that success comes through accomplishing the required task	1	6	5	4.80 (1.55)	10
	Makes me strive to learn new things	3	6	5	5.00 (0.94)	10
	Motivates me to progress and get better understanding of wastewater management	4	7	6	5.60 (0.97)	10
	Makes me feel like I have clear goals	2	6	5	4.20 (1.55)	10
	Gives me the feeling that I need to reach goals	3	6	5	4.80 (1.14)	10
	Scale (α = 0.85)	**2.75**	**5.88**	**4.75**	**4.78 (0.91)**	**10**

Scale	Item	Min	Max	Med	Mean (SD)	N
Challenge	Makes me widen my views concerning important objectives for wastewater treatment	2	7	5.5	5.30 (1.49)	10
	Challenges me to maximize the use of all my abilities	3	5	4.5	4.40 (0.7)	10
	Drives me to the edge of wanting to give up (REVERSED)	3	7	6.5	6.10 (1.29)	10
	Pressures me in a positive way by its high demands in system thinking	4	7	5	5.40 (0.84)	10
	Challenges me	4	7	5.5	5.40 (0.97)	10
	Calls on me to make an effort in order to be the best municipality	4	6	5	5.10 (0.88)	10
	Motivates me to keep focused despite the high load of information	3	7	6	5.40 (1.58)	10
	Makes me feel like I continuously need to learn in order to be the best municipality	2	7	6	5.10 (1.73)	10
	Engages me in tasks that I feel capable of doing	2	7	6	5.30 (1.83)	10
	Scale (α = 0.86)	**3.22**	**6.44**	**5.33**	**5.28 (0.91)**	**10**
Competition	Feels like participating in a competition	3	7	6	5.50 (1.65)	10
	Inspires me to compete	2	7	7	5.70 (1.95)	10
	Involves me by its competitive aspects	3	7	5.5	5.70 (1.34)	10
	Makes me want to be in first place	2	7	6	5.60 (1.43)	10
	Makes victory feel important	1	7	5	4.70 (2.00)	10
	Feels like being in a competition (to be the best municipality, have the best team of employee, etc.)	3	7	6	5.70 (1.34)	10
	Makes me feel that I need to win to succeed	1	7	5	4.60 (1.78)	10
	Scale (α = 0.83)	**2.86**	**6.86**	**5.79**	**5.36 (1.18)**	**10**
Guided experience	Makes me feel guided	2	6	5	4.80 (1.14)	10
	Gives me a sense of direction (I know what to do and how to achieve the goal)	1	6	5	4.40 (1.78)	10
	Makes me feel like someone is keeping me on task	2	6	4	4.10 (1.29)	10
	Gives me the feeling that I have an instructor when listing the objectives I find important	3	7	3.5	3.90 (1.29)	10
	Gives me the sense I am getting help structuring my list of the objectives	4	6	5	4.80 (0.63)	10
	Gives me a sense of knowing what I need to do better	2	6	4	4.10 (1.29)	10
	Allows me to learn so that I can adapt	4	6	5	5.10 (0.88)	10
	Scale (α = 0.76)	**2.86**	**5.43**	**4.57**	**4.46 (0.79)**	**10**
Immersion	Gives me the feeling that time passes quickly	4	7	6	5.50 (1.35)	10
	Grabs all of my attention	3	7	5	5.00 (1.41)	10
	Gives me a sense of being separated from the real world	1	5	4	3.50 (1.27)	10
	Makes me very focused on what I am doing	4	7	5.5	5.70 (1.06)	10
	Makes my actions flow in a way that comes automatically	2	7	4.5	4.60 (1.51)	10
	Causes me to stop noticing when I get tired	2	7	4	4.30 (1.64)	10
	Causes me to forget about my everyday concerns	3	7	5.5	5.30 (1.34)	10
	Makes me ignore everything around me	2	6	4	3.70 (1.49)	10
	Gets me fully emotionally involved	2	6	5	4.40 (1.43)	10
	Scale (α = 0.91)	**3.11**	**6.22**	**4.56**	**4.67 (1.07)**	**10**
Playfulness	Gives me an overall playful experience	5	7	6	6.00 (0.82)	10
	Leaves room for me to be spontaneous	4	6	5	5.10 (0.88)	10
	Taps into my imagination	1	7	5	4.70 (1.83)	10
	Makes me feel that I can be creative	1	7	5	4.40 (1.58)	10
	Gives me the feeling that I am exploring things	4	7	5	5.70 (1.16)	10

Scale	Item	Min	Max	Med	Mean (SD)	N
	Feels like it revealed new things	4	7	5.5	5.50 (0.85)	10
	Gives me a feeling that I want to know what comes next	4	6	5.5	5.40 (0.7)	10
	Makes me feel like I discover new things	2	7	5	5.10 (1.29)	10
	Appeals to my curiosity	2	7	6	5.40 (1.51)	10
	Scale (α = 0.91)	**3.33**	**6.56**	**5.11**	**5.26 (0.95)**	**10**
Social experience	Gives me the feeling that I am not on my own	1	6	4.5	4.30 (1.49)	10
	Gives me a sense of social support	3	6	4	4.40 (1.07)	10
	Makes me feel like I am socially involved	2	7	5.5	5.30 (1.64)	10
	Gives me a feeling of being connected to others	2	6	5	5.00 (1.25)	10
	Feels like a social experience	3	7	5	5.10 (1.29)	10
	Gives me a sense of having someone to share my endeavors with	3	6	4	4.50 (0.97)	10
	Makes me behave differently than I normally would, because of the interaction with the other players	2	6	5	4.50 (1.65)	10
	Makes me behave differently than I normally would, because of reading the social information in the game (story side of situation cards)	2	6	5	4.30 (1.42)	10
	Scale (α = 0.88)	**2.38**	**6.00**	**4.75**	**4.68 (1.00)**	**10**

SI 10.5. Additional results on group effect (RQ5).

Table 16. Group consensus for each group and over all three groups. In the first columns are the single items and the averaged score over these items. Min = lowest rating given to the item; Max = highest rating given to the item; Med = Median; SD = standard deviation; N = total number of respondents.

	Group 1					Group 2					Group 3					Overall				
	Min	**Max**	**Med**	**Mean (SD)**	**N**	**Min**	**Max**	**Med**	**Mean (SD)**	**N**	**Min**	**Max**	**Med**	**Mean (SD)**	**N**	**Min**	**Max**	**Med**	**Mean (SD)**	**N**
To what extent do you believe that people in your group influenced your final list of objectives?	2	3	2.5	2.50 (0.58)	4	3	4	3	3.33 (0.58)	3	4	5	5	4.67 (0.58)	3	2	5	3	3.40 (1.07)	10
To what extent did you incorporate inputs and suggestions from others into your final list of objectives?	1	6	3	3.25 (2.22)	4	1	4	2	2.33 (1.53)	3	4	6	5	5.00 (1.00)	3	1	6	4	3.50 (1.90)	10
To what extent do you feel that your final objective list reflects your own opinion, independently of other group members' opinion?	1	3	2	2.00 (0.82)	4	1	4	3	2.67 (1.53)	3	3	4	4	3.67 (0.58)	3	1	4	3	2.70 (1.16)	10
To what extent did the group discourage dissent in the face of an emerging majority opinion?	1	5	2.5	2.75 (1.71)	4	2	4	3	3.00 (1.00)	3	2	6	4	4.00 (2.00)	3	1	6	3	3.20 (1.55)	10
Group consensus	1.6	2.8	2.4	2.3 (0.53)	4	2.6	2.8	2.6	2.67 (0.12)	3	3.4	4.8	4	4.07 (0.70)	3	1.6	4.8	2.7	2.94 (0.91)	10

Table 17. Group atmosphere for each group and over all three groups. In the first columns are the single items and the average score over these items. Min = lowest rating given to the item; Max = highest rating given to the item; Med = Median; SD = standard deviation; N = total number of respondents.

	Group 1					Group 2					Group 3					Overall				
	Min	**Max**	**Med**	**Mean (SD)**	**N**	**Min**	**Max**	**Med**	**Mean (SD)**	**N**	**Min**	**Max**	**Med**	**Mean (SD)**	**N**	**Min**	**Max**	**Med**	**Mean (SD)**	**N**
How much did you know the other participants of the group?	6	7	6	6.25 (0.50)	4	4	6	6	5.33 (1.15)	3	6	7	6	6.33 (0.58)	3	4	7	6	6.00 (0.82)	10
How much did you enjoy working with this group on today's exercise?	5	7	6.5	6.25 (0.96)	4	2	7	6	5.00 (2.65)	3	5	7	7	6.33 (1.15)	3	2	7	6.5	5.90 (1.6)	10
To what extent did a leader emerge in the group during the exercise? (REVERSED)	6	7	6	6.25 (0.50)	4	3	7	4	4.67 (2.08)	3	3	6	6	5.00 (1.73)	3	3	7	6	5.40 (1.51)	10
How comfortable would you feel working with other members of the group in the future?	5	7	7	6.50 (1.00)	4	5	6	6	5.67 (0.58)	3	5	7	7	6.33 (1.15)	3	5	7	6.5	6.20 (0.92)	10
How much do you feel that you were really part of the group?	6	7	6.5	6.50 (0.58)	4	5	7	7	6.33 (1.15)	3	6	7	7	6.67 (0.58)	3	5	7	7	6.50 (0.71)	10
How much personal friction surfaced within the group during the game? (REVERSED)	4	7	6	5.75 (1.26)	4	3	7	7	5.67 (2.31)	3	6	7	6	6.33 (0.58)	3	3	7	6	5.90 (1.37)	10
How many personality clashes between group members became evident during the game? (REVERSED)	3	7	6	5.50 (1.73)	4	3	7	7	5.67 (2.31)	3	6	7	7	6.67 (0.58)	3	3	7	6.5	5.90 (1.60)	10
How welcome did you feel to express opinions freely to other group members during the game session?	6	7	6	6.25 (0.50)	4	5	7	7	6.33 (1.15)	3	6	7	7	6.67 (0.58)	3	5	7	6.5	6.40 (0.70)	10
Group atmosphere	5.22	5.89	5.61	5.58 (0.36)	4	4.78	5.89	4.89	5.19 (0.61)	3	5.44	6.33	6.00	5.93 (0.45)	3	5.13	6.75	6.13	6.03 (0.56)	10

SI 11. References from the SI

Adcock A (2012) Cognitive dissonance in the learning process. In: Seel NM (ed) Encyclopedia of the Sciences of Learning. Springer, New York Dordrecht Heidelberg London, pp 2182-2184. doi:10.1007/ 978-1-4419-1428-6

Aubert AH, Lienert J (2019) Gamified online survey to elicit citizens' preferences and enhance learning for environmental decisions Environmental Modelling & Software 111:1-12 doi:https://doi.org/10.1016/j.envsoft.2018.09.013

Aubert AH, Lienert J, von Helversen B (submitted) Gamified environmental Multi-Criteria Decision Analysis: Information on objectives and range insensitivity bias

Bailey P, Pritchard G, Kernohan H (2015) Gamification in market research: Increasing enjoyment, participant engagement and richness of data, but what of data validity? International Journal of Market Research 57:17-28 doi:10.2501/IJMR-2015-003

Beutler P, Lienert J (2020) Zukünftige Abwasserentsorgung im ländlichen Raum - Fallstudie 1. Technischer Bericht zur Entscheidungsunterstützung für die Gemeinde. Dübendorf, Switzerland. doi:https://www.dora.lib4ri.ch/eawag/islandora/object/eawag:19949

Bond SD, Carlson KA, Keeney RL (2008) Generating objectives: Can decision makers articulate what they want? Management Science 54:56-70 doi:10.1287/mnsc.1070.0754

Bond SD, Carlson KA, Keeney RL (2010) Improving the generation of decision objectives Decision Analysis 7:238-255 doi:10.1287/deca.1100.0172

Bundesamt für Statistik (2008) KLARTEXT Kartenspiel. https://www.bfs.admin.ch/bfs/de/home/statistiken/nachhaltige-entwicklung/monet-2030/klartext-kartenspiel.html (retrieved on 13.10.2020).

Chidambaram L, Bostrom R (1997) Group Development (I): A Review and Synthesis of Development Models Group Decision and Negotiation 6:159-187 doi:10.1023/A:1008603328241

Eden C (1992) A framework for thinking about Group Decision Support Systems (GDSS) Group Decision and Negotiation 1:199-218 doi:10.1007/BF00126263

Esser JK (1998) Alive and Well after 25 Years: A Review of Groupthink Research Organizational Behavior and Human Decision Processes 73:116-141 doi:https://doi.org/10.1006/obhd.1998.2758

Ferretti V (2019) Why Is It Worth It to Expand Your Set of Objectives? Impacts from Behavioral Decision Analysis in Action. Paper presented at the Group Decision and Negotiation: Behavior, Models, and Support. GDN 2019. Lecture Notes in Business Information Processing,

Franco LA (2018) Measures of group dynamics - developed for the EWG-BOR meeting in January 2018 (Duebendorf).

Haag F, Zürcher S, Lienert J (2019) Enhancing the elicitation of diverse decision objectives for public planning European Journal of Operational Research doi:https://doi.org/10.1016/j.ejor.2019.06.002

Hou F (2015) A Consensus Gap Indicator and Its Application to Group Decision Making Group Decision and Negotiation 24:415-428 doi:10.1007/s10726-014-9396-4

Jabeur K, Martel J-M (2010) An Agreement Index with Respect to a Consensus Preorder Group Decision and Negotiation 19:571-590 doi:10.1007/s10726-009-9160-3

Janis IL (1982) Groupthink: Psychological Studies Of Policy Decisions And Fiascoes. Houghton Mifflin, Boston

Keeney RL (1996) Value-focused thinking: Identifying decision opportunities and creating alternatives European Journal of Operational Research 92:537-549 doi:http://dx.doi.org/10.1016/0377-2217(96)00004-5

Kerr NL, Tindale RS (2004) Group Performance and Decision Making Annual Review of Psychology 55:623-655 doi:10.1146/annurev.psych.55.090902.142009

Kline P (2000) The handbook of psychological testing. 2nd ed. edn. Routledge, New York

Koivisto J, Hamari J (2019) The rise of motivational information systems: A review of gamification research International Journal of Information Management 45:191-210 doi:https://doi.org/10.1016/j.ijinfomgt.2018.10.013

Lumsden J, Edwards EA, Lawrence NS, Coyle D, Munafo MR (2016) Gamification of cognitive assessment and cognitive training: A systematic review of applications and efficacy Jmir Serious Games 4 doi:10.2196/games.5888

Scott RJ, Cavana RY, Cameron D (2013) Evaluating immediate and long-term impacts of qualitative group model building workshops on participants' mental models System Dynamics Review 29:216-236 doi:10.1002/sdr.1505

Seaborn K, Fels DI (2015) Gamification in theory and action: A survey International Journal of Human-Computer Studies 74:14-31 doi:http://dx.doi.org/10.1016/j.ijhcs.2014.09.006