Facilitating systems thinking in serious game design by highlighting inter-player relationships

Emily Hofstetter
Ola Leifler
Björn Johansson
Peter Berggren
emily.hofstetter@liu.se
ola.leifler@liu.se
bjorn.j.johansson@liu.se
peter.berggren@liu.se
Linköping University
Linköping, Sweden

ABSTRACT

This paper examines the affordances of a component in a serious game, specifically how one material design choice affected the interactions and opportunities for agency and learning. The game examined is a megagame, a large-scale (20-100 participants) social learning environment combining board-gaming with role-playing. The megagame poses participants the challenge of creating a sustainable society, and focuses on developing participants' understanding of how different stakeholders in a regional energy system and society are interconnected. Negotiation over conflicting goals was a primary activity in the game, and agreements were formalized through paper contracts. Contracts were designed to act as boundary objects between player teams, and defined their financial exchanges. This exploratory study finds evidence in the interactions between participants that the paper contract system facilitated opportunities for participants to develop understanding about the interdependencies between teams and resources, and to exert agency over their role in these relations. Players actively maintained and prioritized the correspondence between copies of contracts as a means of regulating both the game's economic system in the game and their mutual intersubjectivity. Overall, the study highlights the importance enabling participants to experience how joint actions cumulatively produce future consequences, and how opportunities for agency and negotiation educate about the ongoing global polycrises of energy, climate and social tension.

CCS CONCEPTS

• **Human-centered computing → Systems and tools for interaction design**; **Empirical studies in interaction design**; **Empirical studies in collaborative and social computing**.

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KEYWORDS

megagame, sustainability, systems thinking, game design, sensemaking, ethnomethodology

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1 INTRODUCTION

The ongoing global crises of ecosystem collapse, climate crisis, social tensions and scarcity of food, water and energy can be described as polycrisis [4, 14], where traditional problem-solving of any one aspect can make another aspect worse. As current global events impact the supply, distribution and use of energy in society, fundamental disagreements have emerged over which problems with the energy system should be solved first, and what agency different actors have or should have. Such disagreements can be difficult to resolve in many real-life problem situations, where problems tend to be wicked rather than well-defined [22], and climate change is an especially clear example. We need to develop the competence to see and think about problems in terms of connected systems, and not reduce them to simple, linear cause-and-effect structures (c.f. [19]). Substantial research in human problem solving and decision making has repeatedly shown that humans in general have difficulties in dealing with systems characterized by complex interactions, dynamic behaviours, and slow feedback [5, 8–10]. New educational tools are needed that enable participants to develop systems thinking, an understanding of how systems interrelate and self-organize, and to experience how choices collectively produce possible futures (c.f. [27]).

An increasingly popular method, including within education about sustainable futures, is the use of serious games [8], which include a wide variety of digital, role-play, and boardgame environments that enable participants to explore the consequences of their ideas and actions on bigger systems. Together, such formats offer multiple design possibilities to help players recognize their role's interdependencies with others and how the outcomes of their actions affect the game world, including dressing the part of roles,

participating at a political 'round table' or 'parliament', or having tokens, boards, or cards that represent certain types of goods or services available in the game.

1.1 Study objectives

In this study, we focus on the affordances of one specific design feature in a large-scale social learning environment, the megagame "Switching the Current", in which players try to transform regional energy systems to be more just and sustainable. The game provides a unique opportunity to examine how players deal with complexity, as megagames designedly involve so many players that one cannot keep track of or participate in all the decisions and events in the game. Specifically here, we examine how the players use one design element–paper 'contracts'–and the learning affordances of this material, shared documentation. This is primarily done through interaction analysis of video recordings made during megagames. The objective is to increase our understanding of, and provide examples of, how the participants interact with and through the contracts, and how the contracts promote sense-making and learning among different stakeholder teams.

1.2 Gaming as a tool for educating about systemic complexity

Games and simulations have been used extensively to support learners' understanding of the dynamics of complex systems, as they offer potentially immersive environments that can represent some of the salient features of the system(s) in question, and cognitively appropriate means to manipulate them [25]. Although there are a wide variety of serious game designs representing complex systems, designs that promote systems thinking in social contexts tend to use elements from board-games, simulations (with or without computer elements) and role-playing, to different degrees [21]. Effective designs for learning about the consequences of actions on complex systems requires creating narrative frames that allow actors to explore future scenarios and to make informed decisions about how to change the overall goals of the system in which they operate [1]. When participants take on a fictional role and attempt to navigate a fictional future (rather than, for example, arranging for participants to negotiate with others what that future should look like based on their own opinions), they learn to pay attention to what options are available and to see issues from the perspectives of others [11]. Basing negotiations on a simulated world state offers the ability to negotiate on tangible opportunities, instead of proposing impossible options or making empty promises (ibid).

A particular type of large-scale social simulation is the Megagame format [1], where 20-100 players take on roles and play simultaneously. Players typically need to collaborate in order to achieve game actions, which has the pedagogical benefit of forcing participants to discuss and negotiate. Megagames offer a unique opportunity for players to experience the emergent effects of their choices on a larger whole. For example, megagames have been used to help participants understand and discuss issues arising in political negotiations and conflict scenarios [20] and in climate change [23]. Players are constantly confronted with the (often designedly conflicting) goals of other players; achieving any task in a megagame requires discovering the other players' motivations and needs.

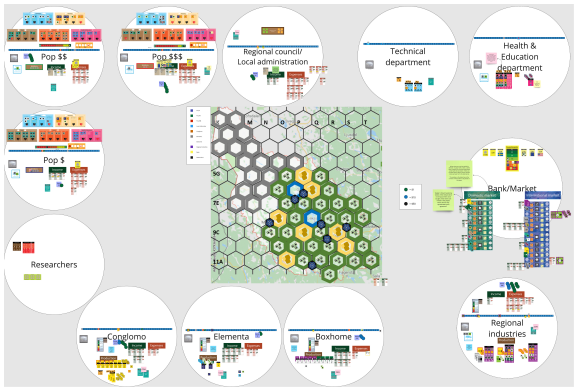

Figure 1: Diagram of game. Each circle represents a team table, with tokens for energy, finances, food, etc., contracts, and any produced goods (e.g. energy).

Few studies to date have researched the actual interactional practices that players use to negotiate with other players [13, 18, 28, 31]. Johansson, Laere and Berggren [16] intentionally designed components in a serious game to serve as 'boundary objects' (see [3, 26]) to stimulate and support interaction between different stakeholders in the game. The concept of boundary objects originates from studies where different objects are found to serve as points of interaction in workplaces or public places [17], but Johansson et al. proposed that in-game components can be purposefully designed to serve as boundary objects, and encourage interaction and understanding between players. As interaction is the medium through which player experience occurs, understanding exactly how players interact, and upon what boundary objects, allows for the game design to be improved and better facilitate those interactions that promote exposure to complex systems.

1.3 Switching the Current Megagame

The megagame in this study concerns regional energy systems and how they need to transform in response to both needs for carbon reductions, but also to dwindling, unfair distributions of resources in society (see also [15, 30]. The game involves 20-100 players who play in teams of 3-4 people, simulating a society at a regional scale. Teams are organized around individual tables that represent the different stakeholders in the game, such as population groups (divided socio-economically), energy companies, industrial producers, banks, scientists, or politicians. Participants have individual game roles within their teams, such as manager of a factory. The teams can scale according to the number of participants. All players have objectives at three different levels in the game: personal (based on the assigned role), team-based, and overall objectives. In a population team, a player representing the elderly may have different priorities than the young, but they all wish to maintain the overall quality of life for the population they represent. The overall objective is to move away from fossil fuel energy and to respecting the boundaries of local ecosystems' sustainability; failure to work towards that goal is, though game mechanics, met with the increasingly dire consequences that science predicts for the planet. Game

facilitators may also feed in additional events or consequences to the game based on players' progress.

Besides the player roles, there are also facilitators of the game, referred to as Control, who provide information about game rules, and occasionally judge the acceptability of actions. Their goal is to enable players to make their own choices, rather than to mediate conflict or make rulings on play. In megagames, players are encouraged to invent new actions beyond the stated rules. Control participants help facilitate player inventiveness, more than ensuring consistency of play. This also means megagames have designed, inherent variability, as well as a large scale.

This study examines *one* design component: the contracts that players use to negotiate and document agreed exchanges of resources. The game is based on a steady state system, meaning that each game table is organized around a number of statuses that change depending on different agreements or events in the game. Statuses include the finances of each table (income and expenses), CO2 released by the team's activities, general happiness, and health of a team. Contracts are of special interest as they allow players to set up standing (multi-round) agreements and therefore became a focus for, and representation of, the players' choices, negotiations, and how they prioritized their goals. For example, industry teams have contracts for purchasing raw materials, transportation, and energy use, as well as paying a workforce, and selling produced goods. Changes to any one contract will have ripple effects on other teams; an increase in energy costs means industries must raise prices on produced goods to compensate, negotiate cheaper raw materials, or pay their workforce less, meanwhile more expensive goods means the municipality has to either reduce the services they provide (e.g. healthcare) or raise taxes, all of which requires renegotiating contracts with other teams. The contracts are designed to serve as boundary objects: gateways to interaction between different teams in the game, as well as formal representations of these relations. The analysis investigates if, and in what way, the contracts serve this purpose, and how they actually affect gameplay. There were many overlapping and mutually reinforcing components designed into the game that affected how players were exposed to complexity and other players' motivations, including a stock market, tracking depletion of forests (and capacity for CO2 uptake), a feedback loop of bad health leading to reduced opportunities for income, and so on. However, in order to demonstrate the actual interactional effects of the design on player experience and learning, this paper focuses on the contracts; future work will examine synergy with other components.

2 METHOD

This study draws on iterative design studies that use actual interactional episodes to inform further development of a design, specifically those within the approach of ethnomethodology and conversation analysis (e.g. [6, 24]). Such work aims to understand what resources (voice, body, materials, spatiality, temporality, etc.) participants mobilize to make sense of the game and others' behaviour. The analyses provide an emic (participant) perspective on the experiences of the players; to understand how the design affects their play, the approach analyzes interaction to see how participants make public sense of the design in order to do actions with each other. Participants' actual, situated use of the game design

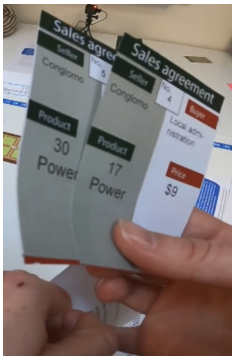

Figure 2: Example contract in player's hand.

during play provides a counterpoint to drawing on reported experiences; it is possible to see and analyze the participant behaviours in real-time, and locate the specifics of how the design was used and understood, without relying on memory or opinion. This method is observational, using participants' self-organised behaviour as evidence of how they collaboratively understand the game design and activity. Accordingly, the analysis presents extracts of actual gameplay behaviour. The claims of the analysis should be rediscoverable in these materials [24], meaning that readers should use the extracts as the basis for evaluating this study's claims. The method of the interaction analytic approach is inductive; cases of the phenomenon are found through (repeated) observation. The aim is to find normative patterns of behaviour (rather than probable ones), so deviant cases where participants attend to events as problematic or absent are especially informative [7]. The cases presented in this paper are chosen to demonstrate these normative orientations, but are representative of the entire sampled dataset.

2.1 Participants and Data Collection

Each game involved between 19 and 79 participants (146 total). Few had any experience with megagames, though many had some experience with board games or role-playing games. Participants were recruited from different groups, including students at different education levels, researchers, and public officials (see 2.1). Groups were recruited by their teachers or local institutional organizer; prior interest or experience in climate problems varied between game iterations (e.g. climate scientists had far more experience than high school students).

Four megagames were conducted between 2022-2023. Each game should be seen as a unique occasion, as the design of the game was altered between each occasion, and the participants were different. Design changes were conducted iteratively based on experiences from each game, and to adapt the game scenarios to local conditions. Each game took between 3 to 6 hours. Participants were recorded at their tables as well as when they moved between discussions with multiple cameras and microphones. A total of over 214 unique hours of interactions were recorded. Interactions occurred primarily in Swedish, with occasional English.

Game	Number of participants	Hours of interaction recorded	Participant recruitment pool
New Town	18 (13 F)	30	Municipality officials
Student Town	25 (11 F)	59.5	University students
Woods Town	24 (10 F)	50	Climate researchers & policy makers
Coast Town	79 (28 F)	75	High school students

Table 1: Participants and data recorded in each game session.

2.2 Analytic procedure

Ethnomethodological interaction analysis involves iterative, inductive observation of data. Initial observation occurred by ethnographically observing, during gameplay, how players managed correspondence between their contract copies, and how Control participants would point out connections between contracts and tokens. Subsequent analysis sought out further cases of contract use and discussion in the recordings, and compared the sequences of interaction. Four different player teams, one from each game iteration to date, and each representing different roles in the game (electricity distributor, municipal government, high-income population, and low-income population), were reviewed, and each instance where players interacted with the contract were analyzed. This sample reviews 8% of the data corpus, and produced 46 sequences of players working with the matching design features. Such sampling deviates from typical conversation analysis [24], as the analysis is meant to minimize transformations on the data and present as whole a picture as possible for any reader [29]. However, the amount of data (214 hours) prevents (re)reviewing all materials for each analysis. The sampling done here, informed by ethnographic observation of all games during the original recording, is done to balance depth of interaction analysis with breadth of materials, and specifically aimed to review as diverse a set of interactions in the recordings as possible by drawing from each game and different roles.

3 RESULTS

The design of the contracts enabled players to see the systematic connections between teams. Each contract contained information about what is being exchanged (who buys what from whom, and at what price), which players discovered through reading or when they requested explanations of how to buy or sell. Contracts could be re-negotiated or cancelled at any point during gameplay. Players used the contracts to track their exchanges of resources, and took careful steps to ensure that all parties to changes had matching records, that is, identically updated contracts. Extracts from the recordings are presented to exemplify how participants make sense of, and use, the contracts in gameplay.

3.1 Contracts as boundary objects supporting discoverability of relationships

When starting the game, the players gradually discover that the resources they need to maintain their team's 'happiness' or 'income' are produced by other players in the room, meaning the players are immediately placed within a set of relationships. The paper contracts document what ongoing exchanges the players have, for example, how much energy and for what price from the distributor. When faced with a deficit in quantity or too high a price, the contract is what players use to track and renegotiate their exchanges with other teams.

Figure 3 demonstrates one instance of how contracts were introduced to players, and how the contract then enabled players to notice where their resources came from, and what other teams provided them. The players (HIA and HIB) were asking how they can buy more sustainable ('green') food that decrease their CO2 footprint. The game facilitators, or 'Control' (CONJ and CONM) draw their attention to the contract and allow them to inspect it (lines 2-3), upon which the players not only notice the relevant team name they need to visit (L4), but also proceed to discover how their current game pieces are furnished by that team and how the contract documents that connection (L14-16).

Once the players' attention is drawn to the contract, they discover information about how their resources are connected to other teams in the game, and thereby where to go to change their resources to more sustainable options. The paper contract provides a material point of organizing the information about how their resources appeared on their table, thereby situating the players in the game's system of connections and enabling their agency to choose what actions to take.

3.2 Maintaining intersubjectivity by matching contracts

After (re)negotiating a contract, players immediately undertook (re)writing it in order to track the agreement, and were careful to make the changes on both parties' copies, while still in each other's presence. This maintained the coherence of the game system. It also allowed players to exert agency over their relationships and negotiate the meaning and value of their exchanges in the game systems. Figure 4 shows an example of how players undertook these mutual updates. In this case, players in the role of electricity distributors (CEO and COO) are renegotiating the price of electricity with a client (CLIENT and MAY). They have agreed to a new price of thirteen, upon which the distributor CEO rewrites their own contract and shows the change to the client (L1-2). The client likewise updates their corresponding copy. Critically, the CEO does not leave the table or treat the deal as completed until the client has finished the changes (L5-10).

Each aspect of closing the interactional encounter (i.e., all the steps towards leaving the table, such as leaving behind the borrowed pen, and physically moving away) is withheld until both teams have identical contracts: CEO holds on to their own pen until the exact moment that the client finishes writing (L9), and CEO and COO physically wait at the table. When the writing is done, CEO picks up their paperwork and is preparing to leave (L10), treating the interaction as complete now that they have matching contracts and

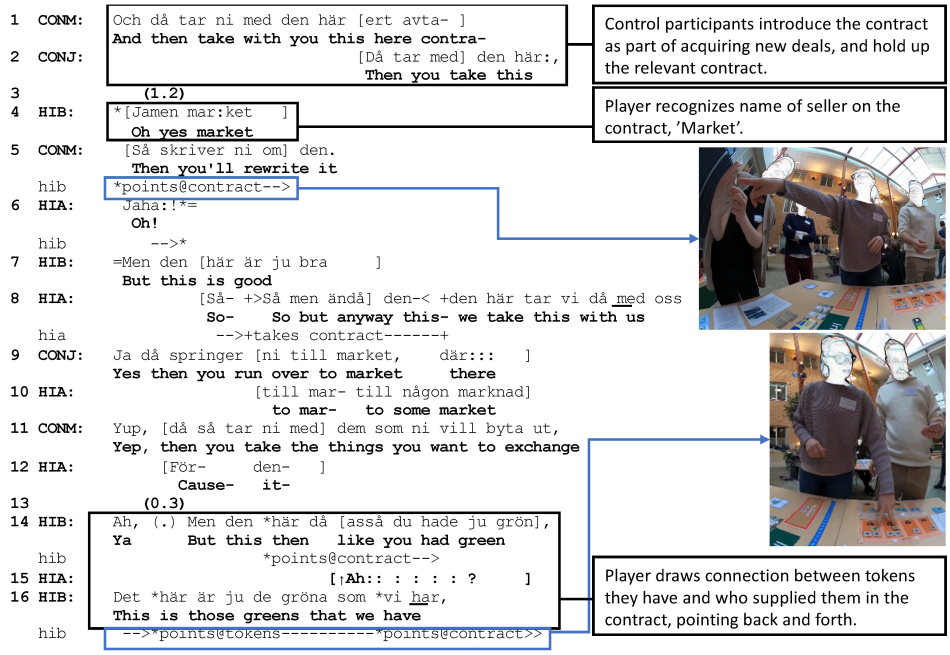

Figure 3: Players are introduced to contracts and discover the connection between the contract document and resources on their table.

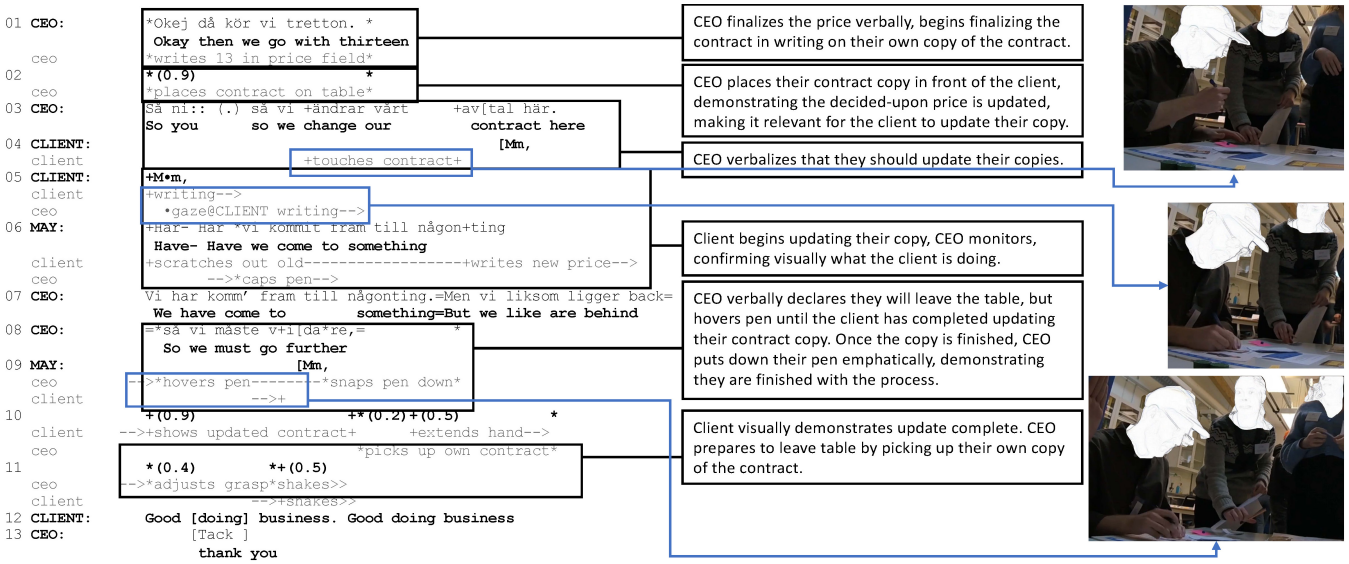

Figure 4: Players agree on a contract price and ensure their contracts correspond.

material intersubjectivity. The client offers a handshake, though, resulting in an 'extra' contract closing device.

3.3 Contracts inspiring further system reasoning

The contracts inspired players to see connections to other teams by naming current buyers and sellers as well as resources the teams distributed elsewhere in the game system. This enabled players to then consider what other stakeholder teams would be most likely to participate in (re)negotiations. Figure 5 shows an example where a team has just discovered they are selling a resource for a potentially low price (not shown). This inspires the team to consider what other teams besides that on the contract might be motivated to buy their resource (L53-54, 60-64). The contract provided a starting point for the players' problem solving: if they can get a higher price

for the resources they are selling, they will have the money to solve another problem. Another player then points out that this could have a ripple effect (L66-68), solving other problems such as how to afford better food purchases. The contract inspires the players' to consider the potential new actions they can take and of what parts of the game system they can best take advantage.

4 DISCUSSION

In this paper, we have reported observations of the consequences of a megagame design feature, finding that the player-organized, paper contracts provided a mechanism by which players could discover their in-game relationships to other teams, as well as a material component with which they could take an active role in negotiating those relationships and the development overall game narrative. Contracts were a concrete (and literally material) option to exert agency over the game system. The players' shift from discovery through trialling and enacting changes via contract negotiations, and then to ensuring the maintained coherence of the contracts, demonstrates their continually improving understanding of the game; the players acquire information about the game system, as well as meta-information about where to inform themselves, test how to change it, and then take on a semi-referee like role by managing the consistency of changes. The players not only perceive the system but learn how to take an active and custodial role in changing and organizing the game system. The contracts provide a space for this learning to occur (see [2]).

The decentralization of the work of maintaining correspondence gave players a resource for co-operation [12], facilitating player awareness of and commitment to the functioning game system and inter-team relationships. Such decentralization promotes one of the goals of megagames, to expose participants to complex systems and encourage systems thinking, where players see their choices' emergent effects on the larger system. If contracts were centralized and managed by Control, players would make all actions with reference to Control, rather than to each other, and they would lose the opportunity to deal with other players' motivations directly. As a boundary object [16], the paper contract system mean that players had to handle correspondence between contracts themselves, manually, which increased the need for inter-player interaction and encouraged them to engage in participatory meaning making.

5 IMPLICATIONS FOR SERIOUS GAME DESIGN

The uptake by players of the paper contract design suggests three principles, each of which help to situate players in interwoven relationships and to learn about complex systems. First, foster discovery of the system through the design. The megagame accomplished fostering discovery by setting up relationships between teams prior to the start of the game, and then providing game components that gave players information about these relationships. The contracts are task inspiring in that they imply action to be done—(re)negotiation—as well as being thematically situated in the game world's economy. Furthermore, the contracts indicate that the resources players need for successful goal completion are in the hands of other players, and invite players to seek out and modify how they acquire those resources.

Second, enable player agency. The megagame accomplished this by giving players information about multiple possible options of who they could interact with, but not specifying specific required tasks or connections. Furthermore, the contract provided a workable object upon which to enact changes, both in a material and conceptual sense. The contract could be modified with provided pens, and blank contracts were also available, giving players an easily fillable 'form'. It was a familiar object that suggested relations of exchange, but also an obvious 'space' in which to undertake action to change their current circumstances.

Third, encourage intersubjectivity. With multiple, rapidly changing relations ongoing at all times in the game, having a relatively stable document to track agreements gave players an opportunity to ensure they were sharing the same understanding of the game system and agreement at hand. It also encouraged players to specify exactly what their agreement was in concrete terms, so that other game components could be reliably managed. The renegotiation contract was a common goal for communications between teams, inspiring the initiation of contact with other teams, or of speaking to them again, which brought players together and led to discussions and awareness of the other players' or teams' concerns. Players thereby came to hear about other events and problems when dealing with contracts, which increased mutual understanding about the game as a whole.

Each of these principles encourages players to participate in the game and to interact with each other, which in turn promotes their engagement with the game's systems, and moreover, their understanding of their own situation within those interconnected systems. The players are not only exposed to the complexity the game models, but are moreover actively reproducing and altering those systems, and therein learning how those systems function together. These principles provide points of accessibility for players in complex, serious games, and are tools for improving player participatory learning.

6 CONCLUSIONS

In this paper, we used ethnomethodological interaction analysis to analyze video recordings from the large-scale social megagame *Switching the Current*, which is designed to facilitate systems thinking concerning the sustainability of energy systems. We examined game interactions to uncover how the design of boundary objects, in the form of paper contracts, facilitated discovery, participatory sense-making, and problem solving.

- Contracts help players understand their own relation to other players. Both in the megagame, as well as in reality, such paths of interaction are often otheriwise obscured and difficult to grasp.
- Contracts support player agency, representing mutual decisions and changes on the game world.
- Contracts support building intersubjectivity with others. The creation and updating of contracts in the megagame created space for building a shared understanding of the processes underlying the production and consumption of what is being traded, as well as the financial pre-conditions for the deal– in other words, intersubjectivity about other stakeholders' concerns.

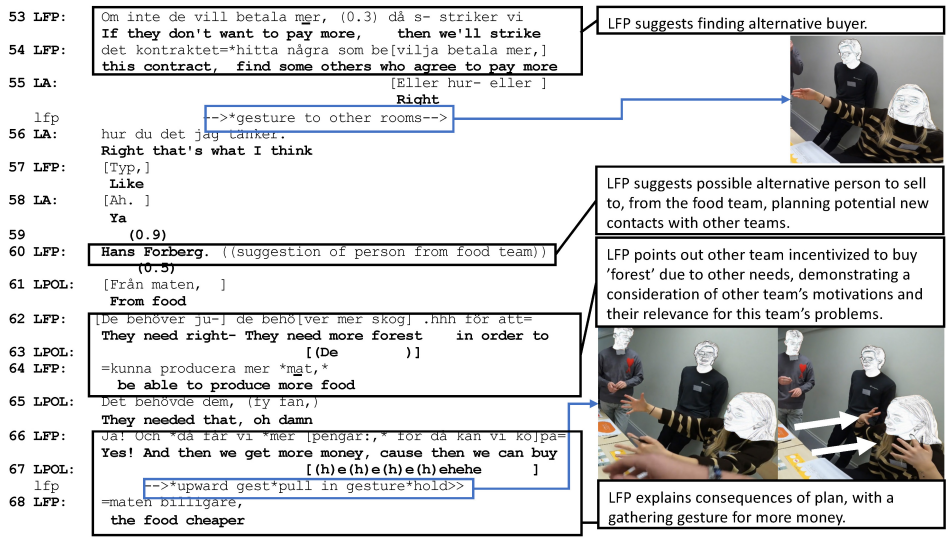

Figure 5: Players notice their contracted price could be increased.

The implications for game design are that purposeful design of relatively simple components as boundary objects can encourage (even force) interaction between stakeholders in large-scale social games. Moreover, having player-managed resources that track agreements and inspire negotiation facilitated players participatory sense-making, engaging them in the game system both mechanically and thematically.

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