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Gaming for the energy transition. Experimenting and learning in co-designing a serious game prototype

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ABSTRACT

Experimenting and learning are increasingly considered as means to innovate governance approaches for pursuing a more sustainable society. Learning and experimenting can unfold in different formats, such as games or co-design processes. This paper investigates an experimental co-design process conducted in the Dutch Province of Groningen to collaboratively design a serious game called the 'Energy Safari'. Serious games can mimic real-world issues and thus provide a safe and open environment that is inviting for exploring, experimenting and learning. Co-designing games is recognized for its capacity to support the integration of 'real world' components in games, which is also our first ambition with the experimental co-design process of the 'Energy Safari'. Little attention has been paid, however, to the role of the game-co-design process itself to instigate civic learning events. Our second ambition targets this research gap. The analysis illustrates that co-designers are very well capable to experiment with serious game components in a way that creates a meaningful and recognizable regional narrative that deeply embeds regional challenges. Linked to playful game prototyping learning events also occurred during the co-design practises and the debriefing cover a wide range of learning activities, ranging from single loop to triple loop learning. Ambiguity and procedural gaps forced the co-designers to question practises and institutions by confronting them with their real-world experience. Our analysis suggests, that prototypes thus need a nuanced balance between generic and specific to generate an open experimentation and learning space that is however deeply rooted in a regional narrative. Doing so can subsequently trigger a rich variety of civic learning activities. Nevertheless, it is also clear that the promotion of more inquisitive triple loop learning effects will not easily emerge and likely require active promotion.

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1. Introduction

Experimenting and learning recently gained increased attention for being central elements within many novel governance approaches (e.g. Bulkeley and Castan Broto, 2013; Nevens et al., 2013). Serious games provide environments for civic learning and experimentation (Gee, 2003; Raphael et al., 2010). By mimicking 'real world' situations, they allow players to engage with these situations in an experiential, explorative and inquisitive fashion with the advantage to experience different possible responses but no 'real-world' consequences. As such, serious games provide an interesting environment for exploring ambiguous and contested societal

challenges, such as the pursuit of a sustainable energy system in the region of Groningen (NL). Serious games allow for experimentation that can trigger shared knowledge, the finding of common ground, conflict resolution and to experiment with institutions or motivate goal achievement (Bluemink et al., 2010; Devisch et al., 2016; Guzzetti et al., 1993; Härmäläinen, 2011; Poplin, 2014; Tan, 2014). For living up to the expectations placed, it is crucial that serious games are reflecting 'real-world' situations and their particular context. Collaborative and participatory design approaches are potentially helpful for developing serious games that are well embedded in such real world situations. They can help expressing and translating existing narratives, social conflicts and institutional responses into a game context. Although the benefits are recognized in literature, various scholars stress that collaborative and participatory design approaches for the development of serious games has still attracted only limited academic attention yet (e.g. Dörner et al., 2016; Khaled and Vasalou, 2014; Mildner and Mueller,

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2016). We address this gap in our research, by reflecting on using a co-design approach for the development of a serious-game called the 'Energy Safari'.

Our first goal is to explore how co-design supported the embeddedness of the game in its specific regional context and notably, if co-design helped produce a game considered meaningful for future players in reflecting a broad variety of regional challenges and conflicts. Our second ambition moves beyond an investigation upon how co-design influenced the development of the game. Co-design activities can themselves be environments that encourage collaborative civic learning processes (Gee, 2003; Raphael et al., 2010). Hence, our second question is, whether the process of co-designing serious games is *itself* already showing evidence of a process of consolidated civic learning. Notably, we are interested in how civic learning through co-design helps illuminate social conflicts and the experimenting with spatial and institutional practices.

The 'Energy Safari' targets the pursuit of a sustainable energy system in the northern Dutch province of Groningen. This pursuit to a systole energy system provides an attractive arena for our investigation as this pursuit is not only characterized as urgent, but it is also contested and showing a process of institutional experimentation. Urgency is perceived on different levels of authority. The European Union Climate and Energy targets that have set the share of renewables in the Union's energy mix at 20% in the year 2020 (CEC, 2010). This has in a Dutch context been translated in a shift from a 5% share of renewables in 2013 to a 16% share in 2023 (SER, 2013). The province of Groningen is considered as one of the key arenas in which this pursuit will become manifested (e.g. Spijkerboer et al., 2016; Zuidema and de Boer, 2017). Historically, the producing of natural gas in the large Groningen gas field has propelled the region as the 'energy valley' of the Netherlands. The same gas production has, however, also triggered the occurrence of earthquakes resulting in serious property damages, pressures on the livability of rural villages and social controversy. In this volatile social and political context, the pursuit of a sustainable energy system seems to be both, welcomed and contested. Moving beyond fossil fuels and natural gas is a widely accepted ambition in the region, but the integration of renewable technologies in the regional landscape is debated (e.g. de Boer and Zuidema, 2015). Controversies can easily emerge as renewables such as wind, solar or hydropower are above the ground, highly visible and require vast amounts of space as compared to a fossil fuel based energy system and are often perceived as visual disturbance (e.g. Pasqualetti, 2012; Stremke and Koh, 2011). Furthermore, renewables can also create externalities such as noise and odor pollution produced by wind farms and bio-digesters (e.g. de Boer and Zuidema, 2015). With renewables becoming an increasingly common element in our landscapes, it is all but surprising that they are attracting considerable social resistance (e.g. Cass et al., 2010; Jones and Richard Eiser, 2010; Walker et al., 2010; Wüstenhagen et al., 2007). The integration of renewable energy systems into our spatial and socio-economic landscapes is therefore both a necessary and contested process (e.g. de Boer and Zuidema, 2016), which in Groningen seems even more prompt. Hence, regionally embedding the 'Energy Safari' is crucial to ensure it captures and illuminates the richness of the existing social conflicts for the game to be considered a realistic game context.

In the meantime, responding to the controversies related to renewable energy generation is not yet a widely institutionalized practice. The current energy system and the institutional rules involved are largely adjusted to accommodate energy generation based on fossil fuels (Farla et al., 2012; Simmie, 2012; Verbong and Loorbach, 2012). Responding to the spatial and social implications of developing a multitude of decentralized production units is not a

common part of this system. Consequently, the pursuit of a more sustainable energy system takes place in a physical, social and institutional context, ill-adapted to accommodate such a pursuit. Institutional barriers such as spatial zoning plans, energy laws and regulations, contracts between producers and consumers and the organization and functioning of electricity grids are among the examples of the hurdles that renewable energy projects can easily face (e.g. Beaulieu et al., 2016). Hence, also the development and implementation of renewable energy projects is an iterative process of exploring, pioneering, innovating, learning and adapting (e.g. Cumming et al., 2012; Foxon et al., 2009; Loorbach, 2010; Loorbach and Rotmans, 2010). Such exploration and experimentation might occur unconstrained by lengthy 'real world' procedures and actual 'real world' consequences, due to the safe environment serious game provide. They and also contribute to the illumination of social conflicts, institutional experimentation and civic learning. Although we are also after such civic learning, we also question if not only a finalized serious game, but already the process of co-design itself, might be an arena for civic learning and experimentation. Our hypothesis is that co-design processes can rather benefit from freeform, ambiguous sets of rules than finalized, fixed rule sets that are guiding the co-designers behaviour. We therefore aim to establish whether this allows for creatively and collectively negotiating and experimenting with alternative social perspectives, alternative narratives and institutional responses. We thus also chose to target more informed individuals for the co-design so as to gain the capacity for critical reflection and the (re)design of existing social and institutional practices.

The current context of institutional experimentation and searching that surround energy transitions within the volatile real-world context of Groningen makes the 'Energy Safari' a promising context for pursuing our ambitions. To better understand these ambitions, section two will introduce the academic debates about how co-designing serious games can create the kind of environment that generates our desired learning. In section three we introduce the 'Energy Safari', the process of co-design used in its development and our research methodology. Section four contains the main results, findings and the analysis of them. Finally, in section five we come back to our main ambitions in the conclusion. It is there we will suggest that the process of co-design itself can indeed trigger civic learning, while using an ambiguous rule set in the game prototype seems a key-accommodating factor.

2. Co-designing games as learning and experimentation environments

Games, digital and gamified environments and tools have been put forward in a broad variety of sectors. These range from gamified learning, health, urban and community planning, transport to energy related issues (Berger et al., 2013; Devisch et al., 2016; Kleinhans et al., 2015; Mohammed and Pruyt, 2014; Poplin, 2014; Tan, 2014). Games are artificial environments where learning and experimenting is activated through gameful (rule-based) and playful (free-form) activities (Deterding et al., 2011). Games support the development of improved cognitive and social learning (Erhel and Jamet, 2013; Gee, 2005; Hamari et al., 2016; Prensky, 2006). Thus, as 'serious' learning technologies, games are expected to increase literacy, raise awareness, build up skills, create coalitions and strategies, and provide immediate feedback on the decisions taken and experience the consequences of those decisions (Crookall, 2010). The safe game environment supports experimentation, taking risks and exploring extreme pathways without facing the 'real' consequences of failing or causing damages (Devisch et al., 2015; Juul, 2016; Raphael et al., 2010). They are thus exploration environments to improve system understanding and

perhaps support the identification of novel solutions and approaches. Learning subsequently can take place during the game-play (in-game related activities) and in the debriefing where participants individually and collectively reflect on their experiences (e.g. actions, social practices, values). Various authors stress the importance of the debriefing as the core moment in which game experiences are transferred into deeper levels of learning (e.g. Crookall, 2010; Lederman, 1992).

The notions of learning and exploration are well established within game design (e.g. Abeele et al., 2012; Mildner and Mueller, 2016). Less attention has been paid to the processes of learning and experimenting that might occur during participatory game design processes, other than solving usability and playability issues (Mildner and Mueller, 2016). In the meantime, more participatory game design processes might well be relevant for especially 'serious' games as these games aim to express narratives related to real world complexities. These are games in need of contextual embeddedness and civic learning is among the prime objectives of the game rather than pure entertainment. Furthermore, the target audience consists of highly differentiated groups including 'non-gamers'. Hence, game designers and game design researchers more recently began exploring the possibilities for introducing participatory and co-design approaches in game design methodology (Abeele et al., 2012; Hourcade, 2008; Khaled and Vasalou, 2014; Mildner and Mueller, 2016).

2.1. Co-design processes

Co-design is a concept with a broad range of application in the planning and design field. In this article, we consider co-design as any act of collective creativity that is experienced within a group of co-designers and is applied throughout the design process (Sanders and Stappers, 2008). In co-design processes different actors contribute with their knowledge, skills and experience and act as 'experts of their experiences' (Sleeswijk Visser et al., 2005). Involving different actors in design processes is considered beneficial regarding ideation, mutual learning, enhanced communication and collaboration, lowering biases from professional designers and evoke learning and capacity building processes of the involved individuals (Magnusson, 2009, 2003; Muller, 2003; Schuler and Namioka, 1993; Vines et al., 2013).

Co-design relies on an iterative design processes, a notion also well developed in game design (Adams, 2013; Salen and Zimmerman, 2004). While in co-design individuals are participating throughout the process, in traditional game design collaborative elements are occurring rather late in the design process, when almost fully developed game prototypes already exist. (Sotamaa, 2007; Khaled and Vasalou, 2014; but see Sanders and Stappers, 2014). For a game co-design approach it is thus advised that the actual co-design phase is preceded by a conceptual one, used to explore the problem domain, the particular aspirations and understanding of possible future player groups and set up initial aims the game shall achieve (Mildner and Mueller, 2016). The initial goals thus need to be transferred into an initial game design concept and prototypes the co-designers than later onwards can engage with.

Prototypes allow an early hands-on approach in the design process (Blomkvist et al., 2012; Osborne and Strokosch, 2013; Stappers, 2013). Engaging with prototypes is in design studies explicitly considered beneficial for exploring a speculative, uncertain and non-linear future (Keller et al., 2009; Kirby, 2010; Sanders and Stappers, 2014). Faced with such uncertainties, prototypes become an attractive starting point of the actual subsequent game design process by iterative playing, validating and creating. In design studies they are notably valued because they can (i) evoke

focused group discussions, (ii) confront existing cognitive models, concepts and theories, (iii) confront the real-world and different conditions, because prototypes are specific and are not masked in abstraction, (iv) have transformative power, due to the activity and the prototypes' concrete nature to create experiences (Sanders and Stappers, 2014). Hence, engaging with prototypes can instigate learning and subsequently might also create new knowledge.

Playing, as the most basic form of learning (Huizinga, 1999; Piaget, 1962), is crucial for creating and validating different game components and ideas in the co-design process. It is also crucial to ensure that the game remains balanced and playable (Adams, 2013; Salen and Zimmerman, 2004). To ensure that, technical game design skills are needed, which are easily outside of the scope of co-designers. Integrating the input and insights developed during the playing with prototypes thus requires choices are needed upon what can be integrated in the game and how this changes the existing prototype into a new prototype. Given the sometimes rather technical nature of having to pursue such integration, the role of the facilitating designers is not only to facilitate and capture the learning process taking place during co-design sessions. They are also important in translating the creativity and learning of a session into changed prototypes that can subsequently be played and altered with in a next co-design session; i.e. what Khaled and Vasalou (2014) calls a transformative approach.

2.2. Environments for learning and experimenting

While co-design is recognized for its ability to stimulate experimenting and learning, using it as method for game-design is less recognized. Instead, most attention has gone to experimenting and learning by gameful (rule-based) or playful (free-form) (Deterding et al., 2011) activities within finished games (Dewey, 1938; Huizinga, 1999; Piaget, 1962). This attention has experienced a renaissance with the late rise of digital tools, the increasing popularity of games and the evolving debate around experimental innovation and governance in living labs (e.g. Luederitz et al., 2016; Neef et al., 2017).

Experimentation is than a key basis to contribute to learning, through an iterative process of exploration and exploitation (Gupta et al., 2006), trying-out, discovery, testing, failing and learning, also facilitated in planning, policymaking and governance (e.g. Bulkeley and Castan Broto, 2013; Luederitz et al., 2016; Nevens et al., 2013). In this literature scholars are considering experimenting and learning as beneficial to support key processes for sustainability transitions, such as coalition-building, networking, questioning existing models and co-creating shared visions (e.g. Frantzeskaki et al., 2014; Nevens et al., 2013; Wittmayer et al., 2014; Wittmayer and Schöpke, 2014). Notably, such learning would than have to occur not merely on an individual level, but on the level of the group; i.e. group learning.

Learning is in a general the process of acquiring knowledge and skills through different processes, such as experiencing, schooling or problem solving. Building up knowledge and skills through personal reflection by oneself frames individual learning, while in group or organizational learning individuals act collaboratively or within a community (e.g. Whitmore, 2009; Dominguez, 2012; Pretty et al., 1995; Senge, 1990). The group exceeds single talents and knowledge and develops capacity for further collaborative action. It increases the understanding of diverse perspectives and plays an important role for developing or re-interpreting existing cognitive models, concepts and social perceptions. In response, Lozano (2014) proposes an integrated approach on learning that amalgamates different learning concepts. It combines (a) the idea that learning can be organized in several loops (single, double, triple loop learning), which expresses the degree to which

assumptions are questioned, with (b) the idea that there are alternative strategies of learning: adaptive, anticipatory and action based learning (see Table 1). Lozano stresses that 'learning for sustainability'-transitions requires consolidated learning processes, advocating the integration of these different learning modes, ranging from single loop schooling to complex inquisitive triple loop learning that questions and re-frames existing concepts and models. If that learning process explicitly involves civic topics, learning becomes associated with that of 'civic learning' (Gordon and Baldwin-Philippi, 2014).

Civic learning is experience based and occurs when civic action is reflected on and contextualized within the wider social, cultural and environmental context and subsequently transferred into learning experiences (Dahlgren, 2009; Gordon and Baldwin-Philippi, 2014). This is exactly the kind of learning desired in the pursuit of a more sustainable energy system and that the co-design of the 'Energy Safari' thus aims to encourage. Co-designed civic games specifically relate to our first research goal as they are claimed to have the potential to better integrate real-world components in the game by influencing the rules (institutions) and game mechanics (Adams and Dormans, 2012; Khaled and Vasalou, 2014). Following Sanders and Stappers (2014), we notably aim to assess if co-design helped evoke focused group discussions for confronting existing cognitive models, concepts and theories within a real-world context. More specifically, we evaluated whether the co-design process improved how co-designers (a) recognized the game narratives as realistic and meaningful, (b) considered the rule set as representing existing institutional and social practices and (c) saw the representation of social conflicts as unbiased.

Our second aim specially targets the process of consolidated, civic learning that the co-design might contribute to. Civic learning processes are crucial for responding to documented challenges that limit or inhibit that civics enter an informed dialogue and decision

making processes, such as domain literacy, resources, skills and administrative capacity (Ekman and Amnå, 2012; Milam and Howell-Moroney, 2010; Yang and Callahan, 2007). This is also the case regarding the development of renewable energy projects in Groningen (Terpstra, 2016). Hence, there is both a need for the development of novel institutional formats, skills and social practices. While playing with finalized games can be an arena for doing so, the more experimental and explorative environment of co-design might also. Co-designers of games and later on players of collaborative games (Wendel and Konert, 2016) can develop shared knowledge, gain common ground, resolve conflicts, experiment with institutions or motivate goal achievement (Bluemink et al., 2010; Devisch et al., 2016; Guzzetti et al., 1993; Hämäläinen, 2011; Poplin, 2014; Tan, 2014). Hence our interest in assessing how co-design through iterative prototyping can support processes of consolidated, civic learning (Gee, 2003; Lozano, 2014; Raphael et al., 2010). This is the kind of learning that would then move beyond receiving new information or skills, but also consists of actively discussing, creating and testing (new) social and institutional practices. This is also what is noted by Lozano (2014), who considers civic learning for sustainability transitions such as the energy transition should include single, double and triple loop learning that includes adaptive, anticipatory and action oriented learning strategies. Hence, in our analysis we on the one hand assessed whether co-designers acquired new skills and knowledge (single loop), engaged with existing narratives and social or institutional practices (double loop) and proceeded to formulate and develop new social, spatial and institutional practices and developed common ground of understanding of the existing challenges (triple loop). On the other hand, we also assessed whether skills, narratives and social or institutional practices where not only recognized and understood (adaptive), but also whether they were being discussed and reflected upon (anticipatory) and actually being developed and tested during the process (action).

Table 1
Consolidated learning process are incorporating different modes of learning running through a sequence of more simple single-loop learning to complex triple-loop learning (Lozano, 2014); structured and illustrated by authors.

		Single Loop Learning Detecting & correcting errors to continue with existing policies, achieve goals	Double Loop Learning Underlying assumptions, norms, values, objectives are scrutinized, confronted with existing standards to ensure they are still relevant	Triple Loop Learning Developing new processes, methodologies an re-framing of existing concepts, models or discourse
Processes	Adaptive <i>Passive</i>	Increasing skills through schooling accomplish immediate task	<i>Proactive</i> Questions immediate assumptions, policies, models to find the root of a cause, relies on cognitive abstractions	<i>Not applicable</i>
	Anticipatory <i>Forecasting</i>	Learning skills in preparation for future tasks, events, problems process relies on cognitive abstraction	<i>Back-casting</i> Aims at challenging abstract models by creating future scenarios and comparing them with current real-world situation plan the changes that are needed to achieve the scenario, mental abstractions	<i>Discerning</i> Aims to develop new processes and methodologies that could be used for future problems, cognitive abstract
	Action <i>Coaching</i>	<i>Increasing skills through training accomplish immediate or future task, through real world experience, hands-on</i>	<i>Experiential</i> <i>Challenge models trough real life problem solving, linking cognitive and hands - on approach</i>	<i>Inquisitive</i> <i>Aims to develop new processes and methodologies through real life experience, problem solving and challenging of existing models</i>
Consolidation of Learning

3. Co-design process and methods

The co-design process followed a research-through-design approach, building on the main assumption that the act of designing has the potential to produce new insights, skills and knowledge to produce a better understanding of complex issues (Frayling, 1993; Stappers, 2007). The design process is also referring to Winn's (Winn, 2009) Design-Play-Experience framework (DPE) for serious games. Winn (2009) refers to four focus points for developing serious games: player experience, gameplay, storytelling and learning (see Fig. 1). Winn also indicates how each of these inspires the design of serious games. We followed this indication and firstly ensured co-designers we invited to contribute to improving player experiences by notably indicating how game visuals, competitions and interactions help players become motivated to engage with the game and its objectives. Secondly, co-designers were also able to manipulate and reflect on gameplay by being actively invited to discuss the prototypes game mechanisms and rules and to (re)design these. Partly this was meant to make the game more realistic and unbiased. Partly, however, it was also interesting as it could illuminate various (new) institutional responses. Thirdly, co-designers were asked to critically discuss and manipulate the existing narratives of the game. Mostly, they were asked to discuss or change the way in which certain choices or behaviors were valued or penalized in the game. This helped them to indicate if the game was realistic and fair and hence, reflected the regional narrative on the energy transition. Finally, with regards to learning, the monitoring of gameplay and debriefing after playing helped to establish if the co-designers were indeed learning about and (re)designing skills, social practices and institutional practices; i.e. following the framework of Lozano (2014).

3.1. Conceptual phase

The initial conceptual phase of the game design process (Mildner and Mueller, 2016) was used to gain a better understanding of the problem domain. Based on 12 exploratory

interviews (Groningen, Vienna, Hasselt) with planning professionals, facilitators of neighborhood offices and governmental representatives collected the experiences and barriers that stakeholders identify with participatory planning approaches and civic engagement, the methods and (digital) tools that they are already using, their gaming experience and their expectations on the performance and scope of games in such processes (published in Ampatzidou et al., 2015a, 2015b). The 'demand side' was investigated via an exploratory survey in Groningen's neighborhood 'Reitdiep', documenting the civic perspective on the aim and practices to turn energy neutral on local level (see Terpstra, 2016). The interviews were analyzed through content analysis (e.g. Gläser and Laudel, 2010; Mayring, 2015). A document analysis provided more awareness of current energy, transport and planning policies. These ranged from European Union, national to Regional policies that are important conditions for the game environment (for an overview see Spijkerboer et al., 2016).

The results of this phase (Ampatzidou et al., 2015a, 2015b; Terpstra, 2016) created the basis for the initial design goals (see Devisch et al., 2015) and were translated into a basic game prototype to embark the co-design process.

3.2. Exploratory co-design phase

The exploratory co-design phase was set up as an iterative process of workshops with in total 25 participants. Co-designers were identified to cover a broad range of different backgrounds, with alternative stakes and interest related to the regional energy transition. We deliberately chose more informed experts from a large variety of stakeholders. This allowed the co-design process to benefit from their expertise in critically discussing and (re) designing existing social and institutional practices. The co-designers included participants from research (also including game design researchers), public administration, local government, citizen based energy initiatives, SMEs (local energy enterprise) and civics. Notably by including various local governments and citizen-based initiatives, also knowledge and sensitivity to aspects such as

Fig. 1. Winn's design-play-experience (DPE) framework (Winn, 2009).

societal resistance and societal support for renewable energy projects were included. The game itself is planned to be played also by lay-citizens. Apart from the two game designers and two researchers, all involved co-designers were familiar with playing games but never have been involved in game design.

To embark the co-design process an initial, basic prototype was created. The decision to create an initial prototype was based on earlier experience in the project, where co-designers struggled with designly activities, because the pen-and-paper version was too conceptual and hardly associated with a 'game' by the co-designers. The co-design sessions followed a certain sequence: the co-designers were introduced to the project, aim of the session, and to the game prototype and the initial rule-set. Part of this was also to explain that some rules were not there or that some rules might be (re)designed if all co-designers (players) agreed on them. As such, ambiguity was indeed actively introduced in the prototypes. When playing the basic prototype with an incomplete rule set, the co-designers quickly encountered unclear situations and dead ends that needed discussions and negotiations how to interpret the situation. The co-design activity itself was not a standardized rule-based procedure, but set up as free-form, playful activity (Deterding et al., 2011). Hence, there was no standardized procedure how the co-designers, hence the designly activities could differ. Playing, creating and validating game components are interwoven activities in the co-design sessions (see Fig. 2). The activity stopped when the activity became notably repetitive or the co-designers started to reflect on the process themselves. During the game the researchers would actively take note and make pictures and so as to document the game flow (progress of game, game-play, suggestions, ideas, changes of the prototype) and the (re)design of new social or institutional practices. These were not only input for a later stage of consolidating the learning taking place in the redesign of the prototype to keep it playable. Also, these documented notes were input for the debriefing. The end of each co-design session was marked by this debriefing (Crookall, 2010), where the notes and the observations conducted during the session, were discussed with the co-designers. The debriefing was structured as a semi-structured discussion lead by the researcher. Apart from discussing notes and observations, the researcher would ensure with a checklist that all the research

criteria for evaluation the process of regional embedding and civic learning (see section two) would be addressed. Post co-design activity was a consolidation process of the co-design session where the researchers altered the prototype by including co-designers inputs and suggestion while ensuring the adapted game prototype remained playable and balanced, following Khaled and Vasalou (2014) transformative approach. The consolidated prototype then was the basis for the next co-design activity and iteratively further developed (see Table 2).

4. Findings and discussion

The researchers prepared the initial game prototype for the co-design phase based on the input collected during the conceptual phase (section 3.1). The prototype's game board (interface) is an abstract representation of the province of Groningen, divided in tiles of different colours. Each tile (area) represents a different type of energy project that can be realised (agriculture-biobased/green, energy production/red, energy saving/yellow, services/purple). On the game board, special zones are delineated such as development clusters around the major cities and industrial areas. The game-narrative (story telling) is based on the regional narrative of the energy transition. Groningen has high ambitions regarding the shift towards a sustainable energy system by using energy neutral villages, an energy port (Eemshaven) and a possible connection between its high quality agriculture and the chemical industries in the town of Delfzijl (see also Spijkerboer et al., 2016). Players are encouraged to implement different sustainable energy projects (project cards) and contribute to the energy transition. For each implemented project the players collect KW-points (representing the amount energy saved or sustainable energy produced) or coins (representing financial revenue). Players can set their own ambitions, focussing either on collecting KW points, coins or of a balance between those two. Nevertheless, they have a limited amount coins at the start and need to pay for an annually increasing fossil fuel energy bill at the end of each game round. Hence, participating in energy projects is crucial for collecting coins and avoiding going bankrupt. The game play is limited to five rounds. Through rolling the dice players are moving their token ('game-figure') over the game-board. Arriving on a tile the player can decide on realising the

Fig. 2. Co-designing the Energy Safari. The co-design process supported regional embeddedness and supported a realistic narrative. In the images the change and alterations of the game board are illustrated, from a very initial state (left) to a later one (right) already including externalities effect (blocked tiles/striped).

Table 2

Overview of the finalized game prototype Energy Safari created in the co-design process, structured in reference to the Design-Play-Experience framework by Winn (2009).

Components	Energy Safari
Anticipated experience	a) Experiencing shared concerns , values & that actors play a role in that concerns b) Experiencing achieving common objectives and perspectives c) Experiencing individual & collective civic learning and capacity building d) Experiencing different individual capacities within a group & that they can build up group capacities e) <i>Exploring new opportunities and possible social practices and institutions</i> f) Experiencing coalition and trust building g) Learning about externalities and impacts of different projects h) <i>Learning that projects also have a community value next to environmental and economic (People-Planet-Profit)</i>
Storytelling/Narrative	a) Goal of the region and city of Groningen is to become energy neutral b) Individuals and groups are exploring the region c) Nuanced valuation of different projects (KW, community , coins) and decision making d) Coalitions of players can implement different projects and create value e) Different energy projects created different intended and unintended effects and externalities
Gameplay/Game mechanics	
Collecting/Selecting Resources	a) Collecting resources to implement projects b) Collecting coins, community points and KW points Sharing & trading resources with other players (collaboration)
Sharing/Trading Resources	a) Rolling the dice for obtaining permits b) Rolling the dice for player movement c) Action Card at the end of each round d) Rolling the dice to determine the implementation costs of a project Coins, energy and community points for implementing different projects Balancing resources
Chance	Multiple choice quiz question, replacing ‘chance’ (rolling dice/permits) The game is limited to five rounds Policy Clusters (all players have to agree on a coalition) Players are competing
Rewards	
Resource Management	
Quiz- Question Answers	
Round Limit	
Progression	
Competition	
Player Experience/Interface	a) Board game, distribution of tiles b) Board representing the region, energy policies, risk maps c) Tokens (play-figure), Dice d) Different project cards , action cards and jokers e) Organization of the tiles, distribution and size of tiles

project indicated by the colour of the tile. Players need to draw a card with this colour, which directly informs them of the conditions and requirements that have to be fulfilled for implementing the project. These conditions and requirements mimic a limited set of institutional and social rules: (a) creating a partnership (coalition) of different players is a requirement, and the collaborating partners must contribute with at least a predefined number of coins to the seed funding for the energy project; (b) obtaining a permit (rolling a given set of numbers (e.g. 1 to 3) with the dice or alternatively answering a quiz question) and (c) paying the realization costs of the project (number of coins is the number rolled with a dice). Each realised project provides the instigator and the members of each project partnership with a certain number of coins as revenue and KW points after the round is done, representing the value of each project. It is inevitable that players are participating in the energy projects because those projects provide them with coins they need in order to pay their increasing fossil fuel energy bill. Thus, the players set their own game ambition, if they want to focus on the collection of KW points or coins, but they must invest into projects to avoid going bankrupt. The initial rule-set of the prototype was limited to some basic rules that ensured that the co-designers started to engage with the prototype. This encouraged the co-design process to subsequently alter the game rules of the prototype significantly.

4.1. Embedding in the regional context

The initial game narrative focused on reducing energy consumption and increasing the share of sustainable energy in the region, while taking into account the aforementioned regional ambitions. This narrative was embedded in the prototype via the different project types (agriculture/bio-based, energy production, energy consumption, services) and a differentiated valuation of

each energy project with KW points and coins. The co-designers recognized the basic narrative as being correct, including the different ambitions of the province and areas in which they had to be prioritized. Nevertheless, the co-design process also illustrated that in more detail important components for a meaningful and realistic game narrative were missing from the co-designers' perspective.

The co-designers substantially criticized the initial game narrative in the co-design phase. Among their main comments was that the valuation of energy projects only with KW points (energy) and coins (revenue) is mainly reflecting the current fossil-fuel based narrative and does not cover the social and societal meaning of sustainable energy projects. They argued that the depletion of the natural gas field urges the region to explore new and alternative narratives aside the dominant fossil fuel one. This was not only needed for maintaining a healthy regional economy. Also, providing those now negatively affected by the earthquakes were in need of financial and material support, urging energy projects to be linked to supporting community development. Furthermore, the rise of grassroots sustainable energy initiatives to support energy neutral communities signified a social desire for involvement. The claim was made for adding a 'community perspective' that reflects a new societal and social reading of energy. Thus, the co-designers developed the game component of 'community points', which should complement the valuation of projects with energy (KW-points) and revenue (coins). The integration of this perspective meant to facilitate a more realistic view on energy by addressing a people (community points) - planet (KW points) - profit (coins) perspective. Integrating the 'community points' was considered important to reflect more realistically the regional challenges and the importance to experiment with alternative narratives for the period 'post-gas' to come.

The initial set of energy projects was furthermore considered as

limited and perceived as too 'conservative' regarding the regions high ambitions. Thus, the co-designers created new energy projects (for project cards) they considered important for the future of the region. These included many regionally recognized opportunities such as 'warmte stad' ('heat city', based on geothermal heat), methane production (based on waste and agriculture), energy storage & cascading projects, heat towers, 'postcoderoos regeling' (postcode-regulation, an institutional toll to engage citizens in energy cooperatives), blue energy (using tides, waves and osmosis technologies), low heat conversion or i.e. high speed internet (in the rural areas as requirement for SMART services). The development of those projects also triggered a debate on the valuation of different energy projects leading to the conclusion that a more nuanced valuation is necessary to highlight the differences between the energy projects. Those differences are covering the conditions and requirements for realization (e.g. difficulty to obtain a permit, number of other player to join a project partnership) and the value of different energy projects (KW points, community points, coins). The co-designers based those changes on the argument, that in 'real-world' situations, the integration of projects is much more complex than it was reflected in the prototype. The (re) valuation of the energy projects and their requirements is linked to the co-designers' real-world experience that they are transferring here into the game.

In the initial prototype, energy projects were designed as 'stand-alone' that were not linked to their surrounding areas. Also fuelled by the importance of taking a community perspective, the co-designers critiqued that such sustainable energy projects should be interlinked with their surrounding neighborhood and community. Related, they criticised that in the prototype externalities are not considered. This was considered problematic, as these externalities are important triggers for societal resistance and conflict. In response, different effects of energy projects were included in the game rules: (a) multiplier effects (e.g. important community projects would double the community points of neighbouring projects), negative effects (e.g. odor pollution for neighbouring biogas projects, reducing your community points or paying a coin for upgrading the filter), (c) NIMBY effects (blocks the realization of an energy project, notably relevant for wind projects) or (d) external effects (e.g. bio-based projects with high land consumption, no other projects can be realised at the neighbouring tiles).

The limited initial rule-set of the prototype resulted in many unclear situations while playing the prototype. Hence, as hoped, co-designers needed to improvise on the spot by developing new rules and responses in order to proceed with the co-design session. In these unclear situations, the co-designers started to explore the opportunities of un-governed situations: "Can I step in for another person and cover the amount of coins needed for a project if I consider the project important?" In such situations practises and norms that were not set in the initial game prototype emerged, such as knowledge sharing (supporting answering quiz questions needed for acquiring permits), collaboration (lending coins, making deals for future support) or resource sharing (tipping in with coins). But also, unethical behaviour was integrated in one of the design session into the energy projects, allowing active bribery to obtain a permit. In the follow up session another co-designer considered the option, as realistic but demanded a penalty for such behaviour: "If you bribe, you get the project, but you should get less social or community points."

The co-design process thus lead to many changes to the initial prototype while altered prototypes were in subsequent sessions further altered and refined. The co-design phase showed that the initial narrative was too positive regarding the energy and revenue narrative of the game, even though it was preceded by a conceptual phase. Thus, the co-design phase was crucial to find a better fit with

the regional challenges. After five rounds of playing with altered prototypes, the amount of changes decreased, suggesting the co-designers increasingly accepted the game as being realistic. This was also confirmed in the debriefing. Where the first sessions lead to much debate on proposed alterations, later sessions more focussed on what the co-designers experienced with regards to how the prototype related to the 'real world'. Increasingly, co-designers indicated that they (a) recognized the game narrative as realistic and meaningful and (c) considered the representation of social conflicts as unbiased. The alterations occurring with the co-design process thus indeed helped in achieving these ambitions on regionally embedding the game. The second (b) ambition was to contribute to making the rule set as representing existing institutional and social practices. The (re)design of new institutional and social practices also decreased with the different co-design sessions, suggesting the co-design also made an important contribution. Nevertheless, these debates never really ceased. Notably, the current complexity and ambiguity of the 'real world' institutional and social practices seemed to constrain the prototype to represent them. Of course, this also suggests that the prototype thus continued to trigger debate, which is also exactly mimicking the contested 'real world' practice in the face of this ambiguity.

4.2. Consolidated civic learning in co-design processes

We illustrated that the co-design process was crucial to create a meaningful, regionally embedded narrative including new game components, such as energy projects. The playing and prototyping activities mostly triggered focused group discussions on the narrative, energy projects and un-governed situations. In these discussions, the co-designers reflected on their social practises and real-world experiences and contrasted the prototype with their experiences. Examples for this contrasting were the development of the community perspective and community value of energy projects, the more nuanced valuation of the energy projects or the critique on bribery and unethical behaviour that should mirror new narratives for the region. This reflection and discussion of the existing narratives and the proposition of new ones are indeed showing evidence that civic (Gordon and Baldwin-Philippi, 2014) and social learning with the means of prototypes (Sanders and Stappers, 2014) occurred. This is noteworthy, because other than Sanders and Stappers (2014) who are prototyping with 'real-world' systems, our co-design process targets a serious game, which is an artificial system. That fact illustrates that the boundary between the game-world and the 'real-world' is permeable. Hence, it is conceptually possible to transfer learning experiences, skills or knowledge from one system to the other and back again.

The kind of civic learning associated with the pursuit of sustainability and energy transitions would ideally involve all three loops of learning as discussed by Lozano (2014). While single and double loop learning was clearly identified, evidence for the occurrence of triple loop learning during the process of co-design is modest at most. Learning activities within the scope of single loop learning were explicitly addressed in the initial prototype by the quiz questions. The quiz questions targeted knowledge transfer, on topics such as regional energy policy, energy production/consumption, fuel poverty or energy costs, risk and externalities. Though the quiz questions were initially considered as entertaining way of knowledge transfer, the format of open questions was problematic, notably as the questions were also too difficult. Subsequently the format of the quiz questions was changed in the design process. The new format was a multiple-choice quiz with strongly deviating answers. The wording of the questions provides some crucial information (e.g. the total number of Dutch households for the question on how much money all Dutch

households could save when shifting to renewable energy) that allows approximating the correct answers. The notably deviating answer options support the group process of converging towards the correct one: “It turned out that together we know much more than we first thought we do”, commented a co-designer on the group learning experience. The example sheds light on the importance of collaboration and knowledge sharing. The quiz questions thus also link single-loop learning with double loop learning through social interaction and group discussions, reflecting on the narrative and real world experience and support the understanding of existing challenges. However, the learning events remain within the learning about the narrative and sustainable energy options and less about institutional practices. In the debriefing the co-designers once more reflected on their co-design experience and prototype and contrast it with their social practises, values and experiences and transfer experience from the game prototyping into a personal civic learning experience (e.g. Crookall, 2010; Gordon and Baldwin-Philippi, 2014; Lederman, 1992).

It was clear that co-designers also used their expositing knowledge and skills in the pursuit of their ambitions within the game and in their efforts to reflect on and (re)design the game rules and narrative. While this thus reflects the whole range of single loop learning (from adaptive, to anticipatory and action), with regards to double loop learning it was notably the adaptive and anticipatory learning that occurred. The fossil fuel narrative was clearly questioned and challenged, as was the initial limited degree of deviation from this narrative in the highlighting of only finances (coins) and energy (KW) in valuating projects. The relative lack of attention to the positive (community spin-off) and negative (externalities) with the social context of energy projects was explicitly challenged. The inclusion of a community perspective (community coins) furthermore highlights an action component by trying to better represent ‘real world’ conflicts in the game dynamics. It remains important, however, to understand that the addition of a community perspective in the game through community coins remains a rather generic and abstract solution that should not be conflated with actual ‘real life’ experimentation that Lozano (2014) also expresses as being action oriented double loop learning.

The degree to which the co-design triggered learning events in the spectrum of triple loop learning was overall much less evident. We already referred to the limited rule-set of the initial prototype that urged the co-designers to solve unclear situations. The group solved these situations by either exploring the ungoverned action space or tacitly accepting norms. Exploring the ungoverned action space happened for example when they had to answer the first quiz questions. When the correct answers were unknown, the co-designers started to look out for support. In the beginning the other individuals often hesitated but then discovered that there was no rule governing this situation and subsequently started to share knowledge and supporting each other. A norm that was tacitly accepted throughout the entire co-design process, was the ‘first come – first served’ approach, when it came to the forming of partnerships for the realization of energy projects. Rarely did single players take conscious decisions to include co-designers who for example did not do so well in the game. While accepting the norm in the co-design activity, in the debriefing it was often marked as “unfair”, “not working” and should be “replaced”. Only the discussion and feedback in the debriefing made it clear that in fact there was no rule or regulation set in place in the prototype that would have outlined a “first come first served” behaviour. One co-designer also reflected on the incomplete rule-set, asking “The incomplete rule-set, is that on purpose? So, it’s about the self-organization of people (?) – that’s a good one”. Thus, we can see that co-designers do identify room to develop novel institutional formats, such as self-governed initiatives or new collectives, but in

a much lesser degree engaged in this than they did with the narrative or energy projects. Nevertheless, the adding of community points suggests that the co-designers support a shift in policies towards looking beyond energy (KW) and finances (coins). Although also regional policies are to some degree promoting socially inclusive approaches, these often remain limited to the promotions and support of citizen based initiatives or financial compensation. The approach now taken seems to take things one step further and promotes a more thorough set of policies and evaluation criteria that explicitly see added social value as a key motive for pursuing or rejecting energy initiatives. While we might thus see some first signs of anticipatory triple loop learning in discussing new processes and methodologies (see Table 1), it seems too much to suggest it is practical and detail enough to mimic ‘real world’ problems. Hence, action oriented triple loop learning, which Lozano described as being an inquisitive development process, is also largely absent.

Overall it is evident that co-designing serious games with prototypes can trigger consolidated civic learning. Nevertheless, triple loop learning was modest at most and single loop learning also was not fully satisfied. Hence, the civic learning we encountered still falls short of the kind of civic learning associated with the pursuit of sustainability and energy transitions. What our co-design process does show is that also game prototypes, representing artificial systems, can evoke focussed discussion and reflection on civic actions and practises and real-world matters. We add to the methodological debate (Blythe, 2014; Sanders and Stappers, 2014; Stappers, 2013) that leaning and experimenting might profit from well-balanced prototypes: prototypes should be specific enough to trigger and facilitate focused discussion and reflection but at the same moment generic enough to inspire co-designers to ‘think and do outside the box’ and leave sufficient room for creativity and experimentation.

5. Conclusions

We argue in this analysis that co-designing games with prototypes offer a promising strategy to ensure regional embeddedness and create recognizable and meaningful narratives. Our example of co-designing the ‘Energy Safari’ suggests that well-balanced prototypes, balancing generic and specific, are supportive to evoke focused discussions and reflect on real world models and abstractions but also leave sufficient room to explore and experiment. We suggest, that this balance should be complemented by an inconclusive and ambiguous rule-set that should also remain in the future serious game itself. That might be surprising, since one of our ambitions of this article was to assess if the co-designers consider the rule-set representing existing institutional and social practices, which did not turn out in the way as it was expected. However, in the co-design process we learned that this ambiguity and inconclusiveness was helpful to evoke group discussions, trigger different learning experiences and explore possible action space regarding institutions. This might be especially relevant in the face of ‘real world’ problems, such as an energy transition, also showing a relatively ambiguous institutional landscape. Hence, also finalized serious games might benefit from explicitly allowing players to explore the action space in the face of this ambiguity. This finding is contrasting common gaming literature, which considers unambiguous rule-sets as fundamentally important for games and game-design because they describe and limit actions, interactions and responses (e.g. Adams, 2013; Juul, 2011). If civic consolidated learning is an ambition of a co-design process or a serious game, it might even be the case that this ambiguity is required to instigate more complex learning experiences in the spectra of double and triple loop learning.

Less successful was the experimental co-design process regarding consolidated civic learning. Though co-design process showed evidence for civic learning events in the spectra of single loop and double learning, learning events in the spectrum of triple-loop learning occurred in a modest fashion at most. The civic learning encountered thus falls short of the kind of civic learning associated with the pursuit of sustainability and energy transitions. This does not necessarily imply that co-designing serious games with prototypes does not have such potential. After all, the initial prototype and the structure of the co-design process were meant to allow for a playful (free-form) co-design process. Hence, we did not deliberately steer co-designers to also engage with triple loop learning or even single loop learning. While the playful, non-scripted approach worked very well for addressing the scopes of single-loop (knowledge, skills) and double loop learning, it mostly failed in the spectrum of triple-loop learning. For future studies on co-designing games for sustainability transitions, the suggestion is therefore to deliberately consider how the process of co-design and possibly even the initial prototype might be structured so as to trigger triple loop learning.

An important limit of our approach was the choice to specifically involve co-designers with an interest in advancing a sustainable energy system in the region. Also while co-designers covered different backgrounds, they were not explicitly dispersed over the different co-design activities. Hence, co-designers often were acquainted with each other and somewhat coherent in their ideas and suggestions. Hence, for the future the ambition would be to engage more mixed groups of co-designers with more varied stakes in the process. We would expect an elevated debate and reflection and therefore an even denser learning experience owed to the differences in stake, perceptions and interest of the co-designers. That might result in fuzzier co-design workshops that need more facilitation, but might result in sharper and perhaps more controversial discussions.

Although our research has limitations due to its experimental character, we see a potential in co-designing games as a method for city making and formats of experimental governance, such as living labs. Games, as artificial systems, allow co-designers to experiment and try things out with lesser restraint than they would perhaps do with a 'real-world' on the table. 'Its just a game' might offer the freedom to think outside the box, unbiased by everyday commitments and organizational responsibilities. Then, the game prototype would not be a precursor for a future game artifact anymore, but a means for individual and collective practices of exploring, learning, experimenting, creating and playing novel narratives and components in an artificial context that is still considered realistic. For research the method might be supportive to create an enhanced understanding of existing societal challenges. Notably, as this method allows for investigating how co-designers create and challenge narratives, see these being both institutionally and spatially manifested and contested.

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References

Abeele, V., De Schnuttner, B., Geurs, L., Desmet, S., Wauters, J., Van den Audenaeren, L., Van Broeckhoven, F., Annema, J., Geerts, D., 2012. A player-

- centered, iterative, interdisciplinary and integrated framework for serious game design and development. In: *Serious Games: the Challenge*. Springer, pp. 82–86.
- Adams, E., 2013. *Fundamentals of Game Design*. Design. New Riders Games, Berkeley.
- Adams, E., Dormans, J., 2012. *Game Mechanics*. Advanced Game Design. New Riders Games, Berkeley.
- Ampatzidou, C., Gugerell, K., Diephuis, J., 2015a. Lessons from game design: understanding participatory processes through game mechanics. In: Theona, I., Charitos, D. (Eds.), *Hybrid City: Data to the People*. University Research Institute of Applied Communication, Athens, pp. 189–196.
- Ampatzidou, C., Gugerell, K., Diephuis, J., Devisch, O., Constantinescu, T., Jauschne, M., Berger, M., 2015b. The mechanics of playful participatory processes. In: *Design, Social Media and Technology to Foster Civic Self-organisation*. University Hasselt, Hasselt, pp. 185–197.
- Beaulieu, A., Wilde de, J.H., Scherpen, J.M.A. (Eds.), 2016. *Smart Grids from a Global Perspective. Bridging Old and New Energy Systems*. Springer International Publishing, Berlin. <http://dx.doi.org/10.1007/978-3-319-28077-6>.
- Berger, M., Jauschne, M., Gugerell, K., Platzer, M., 2013. Willst du mit mir fahren? zoll+ Österreichische Schriften. für Landschaft und Freiraum, p. 22.
- Blomkvist, J., Holmlid, S., Sandberg, F., Westerlund, B., 2012. Workshop: exploring participatory prototyping of services. In: *Proc. 12th Particip. Des. Conf. Explor. Pap. Work. Descr. Ind. Cases - Vol. 2-PDC '12* 151. <http://dx.doi.org/10.1145/2348144.2348195>.
- Blumink, J., Hämäläinen, R., Manninen, T., Järvelä, S., 2010. Group-level analysis on multiplayer game collaboration: how do the individuals shape the group interaction? *Interact. Learn. Environ.* 18, 365–383. <http://dx.doi.org/10.1080/10494820802602444>.
- Blythe, M., 2014. Research through design fiction: narrative in real and imaginary abstracts. In: *Proc. CHI 2014* 10. <http://dx.doi.org/10.1145/2556288.2557098>.
- Bulkeley, H., Castan Broto, V., 2013. Government by experiment? Global cities and the governing of climate change. *Trans. Inst. Br. Geogr.* 38 <http://dx.doi.org/10.1111/j.1475-5661.2012.00535.x>.
- Cass, N., Walker, G., Devine-Wright, P., 2010. Good neighbours, public relations and bribes: the politics and perceptions of community benefit provision in renewable energy development in the UK. *J. Environ. Policy Plan.* 12, 255–275. <http://dx.doi.org/10.1080/1523908x.2010.509558>.
- CEC, 2010. *Europe 2020: a European Strategy for Smart, Sustainable and Inclusive Growth*. Brussels.
- Crookall, D., 2010. Serious games, debriefing, and simulation/gaming as a discipline. *Simul. Gaming* 41, 898–920. <http://dx.doi.org/10.1177/1046878110390784>.
- Cumming, G.S., Olsson, P., Chapin, F.S., Holling, C.S., 2012. Resilience, experimentation, and scale mismatches in social-ecological landscapes. *Landsc. Ecol.* 28, 1139–1150. <http://dx.doi.org/10.1007/s10980-012-9725-4>.
- Dahlgren, P., 2009. *Media and Political Engagement: Citizens, Communication, and Democracy*. Peter. Cambridge University Press, New York.
- de Boer, J., Zuidema, C., 2016. Stimulating co-evolutionary behaviour of renewable energy systems: the integrated energy landscape as vehicle for the energy transition. In: *Spatial Planning in a Complex Unpredictable World of Change – towards a Proactive Co-evolutionary Planning*. inPlanning, Groningen, pp. 170–184.
- de Boer, J., Zuidema, C., 2015. Towards an integrated energy landscape. *Urban Des. Plan.* 1–16 doi:jurdpl.14.00041.
- Deterding, S., Dixon, D., Khaled, R., Nacke, L., 2011. From game design elements to Gamefulness: defining “ gamification”. In: *Envisioning Future Media Environments*, pp. 9–11. <http://dx.doi.org/10.1145/2181037.2181040>.
- Devisch, O., Diephuis, J., Gugerell, K., Berger, M., Jauschne, M., Constantinescu, T., Ampatzidou, C., 2015. Game mechanics for civic participation in digitized cities. In: Partanen, J. (Ed.), *Complexity and Digitalization of Cities – Challenges for Urban Planning and Design*. AESOP, Tampere. <http://dx.doi.org/10.1017/CBO9781107415324.004>.
- Devisch, O., Poplin, A., Sofronie, S., 2016. The gamification of civic participation: two experiments in improving the skills of citizens to reflect collectively on spatial issues. *J. Urban Technol.* 732, 1–22. <http://dx.doi.org/10.1080/10630732.2015.1102419>.
- Dewey, J., 1938. *Experience and Education*. Kappa Delta Pi, New York.
- Dominguez, R.G., 2012. Participatory learning. In: *Encyclopedia of the Sciences of Learning*. Springer, pp. 2556–2560.
- Dörner, R., Martin-Niedecken, A.L., Kocher, M., Baranowski, T., Kickmeier-Rust, M., Göbel, S., Wiemeyer, J., Gebelein, P., 2016. Contributing disciplines. In: Dörner, R., Göbel, S., Effelsberg, W., Wiemeyer, J. (Eds.), *Serious Games. Foundations, Concepts and Practise*. Springer International Publishing Switzerland, pp. 35–82.
- Ekman, J., Amnå, E., 2012. Political participation and civic engagement: towards a new typology. *Hum. Aff.* 22, 283–300. <http://dx.doi.org/10.2478/s13374-012-0024-1>.
- Erhel, S., Jamet, E., 2013. Digital game-based learning: impact of instructions and feedback on motivation and learning effectiveness. *Comput. Educ.* 67, 156–167. <http://dx.doi.org/10.1016/j.compedu.2013.02.019>.
- Farla, J., Markard, J., Raven, R., Coenen, L., 2012. Sustainability transitions in the making: a closer look at actors, strategies and resources. *Technol. Forecast. Soc. Change*. <http://dx.doi.org/10.1016/j.techfore.2012.02.001>.
- Foxon, T.J., Reed, M.S., Stringer, L.C., 2009. Governing long-term social – ecological Change: what can the adaptive management and transition management approaches learn from each Other. *Change* 20, 3–20. <http://dx.doi.org/10.1002/>

- Frantzeskaki, N., Wittmayer, J., Loorbach, D., 2014. The role of partnerships in "realising" urban sustainability in Rotterdam's City Ports Area, The Netherlands. *J. Clean. Prod.* 65, 406–417. <http://dx.doi.org/10.1016/j.jclepro.2013.09.023>.
- Frayling, C., 1993. Research in art and design. *R. Coll. Art. Res. Pap.* 1, 1–6.
- Gee, J.P., 2005. Why are videogames good for learning? *Spectrum* 32, 25–32.
- Gee, J.P., 2003. What Video Games Have to Teach Us about Learning and Literacy, Computers in Entertainment. St. Martin's Griffin. <http://dx.doi.org/10.1145/950566.950595>.
- Gläser, J., Laudel, G., 2010. *Experteinterviews und qualitative Inhaltsanalyse*. VS Verlag für Sozialwissenschaften.
- Gordon, E., Baldwin-Philippi, J., 2014. Playful civic learning: enabling reflection and lateral trust in game-based public participation. *Int. J. Commun.* 8, 759–786.
- Gupta, A.K., Smith, K.G., Shalley, C.E., 2006. The interplay between exploration and exploitation. *Acad. Manag. J.* 49, 693–706. <http://dx.doi.org/10.2307/20159793>.
- Guzzetti, B.J., Snyder, T.E., Glass, G.V., Gamas, W.S., 1993. Promoting conceptual change in science: a comparative meta-analysis of instructional interventions from reading education and science education. *Read. Res. Q.* 28, 117–159. <http://dx.doi.org/10.2307/747886>.
- Hämäläinen, R., 2011. Using a game environment to foster collaborative learning: a design-based study. *Technol. Pedagog. Educ.* 20, 61–78. <http://dx.doi.org/10.1080/1475939X.2011.554010>.
- Hamari, J., SHERNOFF, D.J., Rowe, E., Collier, B., Asbell-Clarke, J., Edwards, T., 2016. Challenging games help students learn: an empirical study on engagement, flow and immersion in game-based learning. *Comput. Hum. Behav.* 54, 170–179. <http://dx.doi.org/10.1016/j.chb.2015.07.045>.
- Hourcade, J., 2008. Interaction design with children. *Hum. Comp. Interact.* 4, 277–392.
- Huizinga, J., 1999. *Homo Ludens: a Study of the Play-element in Culture*. Routledge Chapman & Hall.
- Jones, C.R., Richard Eiser, J., 2010. Understanding "local" opposition to wind development in the UK: how big is a backyard? *Energy Policy* 38, 3106–3117. <http://dx.doi.org/10.1016/j.enpol.2010.01.051>.
- Juul, J., 2016. The art of failure: an essay on the pain of playing video games. MIT Press Ltd.
- Juul, J., 2011. *Half Real: Video Games between Real Rules and Fictional Worlds*. MIT University Press Group Ltd.
- Keller, I., Sleeswijk Visser, F., van der Lugt, R., Stappers, P.J., 2009. Collecting with Cabinet: or how designers organise visual material, researched through an experiential prototype. *Des. Stud.* 30, 69–86. <http://dx.doi.org/10.1016/j.destud.2008.06.001>.
- Khaled, R., Vasalou, A., 2014. Bridging serious games and participatory design. *Int. J. Child-Computer Interact.* 2, 93–100. <http://dx.doi.org/10.1016/j.jccci.2014.03.001>.
- Kirby, D., 2010. The future is now: diegetic prototypes and the role of popular films in generating real-world technological development. *Soc. Stud. Sci.* 40, 41–70. <http://dx.doi.org/10.1177/0306312709338325>.
- Kleinbans, R., Van Ham, M., Evans-Cowley, J., 2015. Using social media and mobile technologies to foster engagement and self-organization in participatory urban planning and neighbourhood governance. *Plan. Pract. Res.* 30, 237–247. <http://dx.doi.org/10.1080/02697459.2015.1051320>.
- Lederman, L., 1992. Debriefing: toward a systematic assessment of theory and practice. *Simul. Gaming* 23, 145–160.
- Loorbach, D., 2010. Transition management for sustainable development: a prescriptive, complexity-based governance framework. *Governance* 23, 161–183. <http://dx.doi.org/10.1111/j.1468-0491.2009.01471.x>.
- Loorbach, D., Rotmans, J., 2010. The practice of transition management: examples and lessons from four distinct cases. *Futures* 42, 237–246. <http://dx.doi.org/10.1016/j.futures.2009.11.009>.
- Lozano, R., 2014. Creativity and organizational learning as means to foster sustainability. *Sustain. Dev.* 22, 205–216. <http://dx.doi.org/10.1002/sd.540>.
- Luederitz, C., Wiek, A., Lang, D.J., Bos, J.J., Burch, S., Davies, A., Evans, J., Farrelly, M.A., Forrest, N., Frantzeskaki, N., Gibson, R.B., Kay, B., Loorbach, D., McCormick, K., Parodi, O., Schneidewind, U., Stauffacher, M., Stelzer, F., Trencher, G., Venjakob, J., Vergragt, P.J., Westley, F.R., 2016. Learning through evaluation – a tentative evaluative scheme for sustainability transition experiments. *J. Clean. Prod.* <http://dx.doi.org/10.1016/j.jclepro.2016.09.005>.
- Magnusson, P.R., 2009. Exploring the contributions of involving ordinary users in ideation of technology-based services. *J. Prod. Innov. Manag.* 26, 578–593. <http://dx.doi.org/10.1111/j.1540-5885.2009.00684.x>.
- Magnusson, P.R., 2003. Benefits of involving users in service innovation. *Eur. J. Innov. Manag.* 6, 228–238. <http://dx.doi.org/10.1108/14601060310500940>.
- Mayring, P., 2015. *Qualitative Inhaltsanalyse: Grundlagen und Techniken*. Beltz.
- Milam, D.M., Howell-Moroney, M., 2010. Ordering stakeholder relationships and citizen participation: evidence from the community development block grant program. *Public Adm. Rev.* 70, 601–609.
- Mildner, P., Mueller, F., 2016. Design of serious games. In: Dörner, R., Göbel, S., Effelsberg, W., Wiemeyer, J. (Eds.), *Serious Games. Foundations, Concepts and Practise*. Springer International Publishing Switzerland, pp. 57–82.
- Mohammed, I., Pruyt, E., 2014. Speeding up energy transitions: gaming towards sustainability in the Dutch built environment. *Top. Saf. Risk. Reliab. Qual.* 24, 223–237. http://dx.doi.org/10.1007/978-3-319-02493-6_15.
- Muller, M.J., 2003. Participatory design: the third space in HCI. *Hum. Comp. Interact. Dev. Process* 4235, 1051–1068. <http://dx.doi.org/10.1145/1153571.255960>.
- Neef, R., Verweij, S., Gugerell, K., Moen, P., 2017. *Wegwijs in Living Labs in Infrastructuur en Ruimtelijke Planning. Een Theoretische en Empirische Verkenning*. Groningen.
- Neuens, F., Frantzeskaki, N., Gorissen, L., Loorbach, D., 2013. Urban Transition Labs: Co-creating transformative action for sustainable cities. *J. Clean. Prod.* 50, 111–122. <http://dx.doi.org/10.1016/j.jclepro.2012.12.001>.
- Osborne, S.P., Strokosch, K., 2013. It takes two to tango? Understanding the co-production of public services by integrating the services management and public administration perspectives. *Br. J. Manag.* 24, 31–47. <http://dx.doi.org/10.1111/1467-8551.12010>.
- Pasqualetti, M.J., 2012. Reading the changing energy landscape. In: *Sustainable Energy Landscapes: Designing, Planning, and Development*. CRC Press, Boca Raton, pp. 11–44.
- Piaget, J., 1962. *Play Dreams & Imitation in Childhood*. W. W. Norton & Company.
- Poplin, A., 2014. Digital serious game for urban planning: "B3-Design your Marketplace!". *Environ. Plan. B Plan. Des.* 41, 493–511. <http://dx.doi.org/10.1068/b39032>.
- Prensky, M., 2006. "Don't Bother Me Mom, I'm Learning!": How Computer and Video Games Are Preparing Your Kids for Twenty-first Century Success and How You Can Help! Minnesota Paragon House, pp. 27–51. <http://dx.doi.org/10.1016/j.jijnfomgt.2006.07.008>.
- Pretty, J.N., Guijt, I., Thompson, J., Scoones, I., 1995. *Participatory Learning and Action: a Trainer's Guide*. IIED, London. IIED Parti. ed.
- Raphael, C., Bachan, C., Lynn, K.-M., Baldwin-Philippi, J., McKee, K.A., 2010. Games for civic learning: a conceptual framework and agenda for research and design. *Games Cult.* 5, 199–235. <http://dx.doi.org/10.1177/1555412009354728>.
- Salen, K., Zimmerman, E., 2004. *Rules of Play. Game Design Fundamentals*. MIT Press, Cambridge, Massachusetts, London, England.
- Sanders, E.B.-N., Stappers, P.J., 2014. Probes, toolkits and prototypes: three approaches to making in codesigning. *Codesign-Int. J. Cocreation Des. Arts* 10, 5–14. <http://dx.doi.org/10.1080/15710882.2014.888183>.
- Sanders, E.B.-N., Stappers, P.J., 2008. Co-creation and the new landscapes of design. *CoDesign* 4, 5–18. <http://dx.doi.org/10.1080/15710880701875068>.
- Schuler, D., Namioka, A., 1993. *Participatory Design: Principles and Practices*. Laurence Erlbaum Associates, Hillsdale, NJ. <http://dx.doi.org/10.1016/j.janclin.2007.12.004>.
- Senge, P., 1990. *The Fifth Discipline: the Art and Practice of Learning*. NY Doubleday.
- SER, 2013. *Energieakkoord Voor Duurzame Groei*. Den Haag.
- Simmie, J., 2012. Path dependence and new path creation in renewable energy technologies. *Eur. Plan. Stud.* 20, 729–731. <http://dx.doi.org/10.1080/09654313.2012.667922>.
- Sleeswijk Visser, F., Stappers, P.J., van der Lugt, R., Sanders, E.B.-N., 2005. Contextmapping: experiences from practice. *CoDesign* 1, 119–149. <http://dx.doi.org/10.1080/15710880500135987>.
- Sotamaa, O., 2007. Perceptions of player in game design literature. Situated play. In: *Proc. DiGRA 2007 Conf.*, pp. 456–465.
- Spijkerboer, R., Trell, E.-M., Zuidema, C., 2016. Rural resilience and renewable energy: in search of synergies. In: Grabskie-Kieron, U., Mose, I., Reichert-Schick, A., Steinführer, A. (Eds.), *European Rural Peripheries Revalued: Governance, Actors, Impacts*. Lit Verlag, Münster.
- Stappers, P.J., 2013. Prototypes as a central vein for knowledge development. In: *Prototype: Design and Craft in the 21st Century*, pp. 85–97.
- Stappers, P.J., 2007. What are "design" and "research". In: Michel, R. (Ed.), *Design Research Now: Essays and Selected Projects*. Birkhäuser, pp. 81–91.
- Stremke, S., Koh, J., 2011. Integration of ecological and thermodynamic concepts in the design of sustainable energy landscapes. *Landsc. J.* 30, 194–213. <http://dx.doi.org/10.3368/lj.30.2.194>.
- Tan, E., 2014. *Negotiation and Design for the Self-organizing City*. TU Delft.
- Terpstra, A., 2016. *Tegen De Fossiele Stroom in*. University of Groningen.
- Verbong, G., Loorbach, D., 2012. Governing the Energy Transition, Governing the Energy Transition: Reality, Illusion or Necessity? <http://dx.doi.org/10.4324/9780203126523>.
- Vines, J., Clarke, R., Wright, P., 2013. Configuring participation: on how we involve people in design. *Proc. ...*, 20, 429–438. [http://dx.doi.org/10.1016/S0142-694X\(98\)00026-X](http://dx.doi.org/10.1016/S0142-694X(98)00026-X).
- Walker, G., Devine-Wright, P., Hunter, S., High, H., Evans, B., 2010. Trust and community: exploring the meanings, contexts and dynamics of community renewable energy. *Energy Policy* 38, 2655–2663. <http://dx.doi.org/10.1016/j.enpol.2009.05.055>.
- Wendel, V., Konert, J., 2016. Multiplayer serious games. In: Dörner, R., Göbel, W., Wiemeyer, J. (Eds.), *Serious Games. Foundations, Concepts and Practise*. Springer International Publishing Switzerland, pp. 211–242.
- Whitmore, E., 2009. Participatory learning and action. *Innov. Soc. Sci. Res. Methods* 1.
- Winn, B.M., 2009. The design, play and experience framework. In: *Handbook of Research on Effective Electronic Gaming in Education*, pp. 1010–1024. <http://dx.doi.org/10.4018/978-1-59904-808-6>.
- Wittmayer, J.M., Schöpke, N., 2014. Action, research and participation: roles of researchers in sustainability transitions. *Sustain. Sci.* 9, 483–496. <http://dx.doi.org/10.1007/s11625-014-0258-4>.
- Wittmayer, J.M., Schöpke, N., van Steenberghe, F., Omann, I., 2014. Making sense of sustainability transitions locally: how action research contributes to addressing societal challenges. *Crit. Policy Stud.* 8, 37–41. <http://dx.doi.org/10.1080/19460171.2014.957336>.
- Wüstenhagen, R., Wolsink, M., Bürer, M.J., 2007. Social acceptance of renewable energy innovation: an introduction to the concept. *Energy Policy* 35,

- 2683–2691. <http://dx.doi.org/10.1016/j.enpol.2006.12.001>.
- Yang, K., Callahan, K., 2007. Citizen involvement efforts and bureaucratic Responsiveness: participatory values, stakeholder pressures and administrative practicality. *Public Adm. Rev.* 67, 249–264.
- Zuidema, C., de Boer, J., 2017. A resilient energy landscape; a spatial quest. In: Trell, M., Restemeyer, B., Baakema, M., Van Hoven, B. (Eds.), *Resilient Energy Landscapes. Governing for Resilience in Vulnerable Places*. Routledge.