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# Targeting social learning and engagement: What serious games and gamification can offer to participatory modeling

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ABSTRACT

Serious games and gamification are useful tools for learning and sustaining long-term engagement in the activities that are not meant to be entertaining. However, the application of game design in the participatory modeling context remains fragmented and mostly limited to user-friendly interfaces, storytelling, and visualization for better representation of the simulation models. This paper suggests possible extensions of game design use for each stage of the participatory modeling process, aiming at better learning, communication among stakeholders, and overall engagement. The proposed extensions are based on the effects that different types of game-like applications bring to the aspects of social learning and the contribution of gamification to engagement, motivation, and enjoyment of some activities. We conclude that serious games and gamification have a high potential for improving the quality of the participatory modeling process, while also highlighting additional research that is needed for designing particular practical gamified applications in this context.

## 1. Introduction

Participatory Modeling (PM) is a well-established method with more than thirty years of practical applications in business and policy-making. Jordan et al. (2018, p. 2) define PM as "a purposeful learning process for action that engages the implicit and explicit knowledge of stakeholders to create formalized and shared representations of reality". Although this most recent definition is quite universal, there are variations among researchers in defining the ultimate goal and the outcomes of PM. Besides learning (Jordan et al., 2018; Voinov et al., 2018) or mental model alignment (Huz et al., 1997) some emphasize more specific results such as consensus-building (Van den Belt, 2004; Videira et al., 2009), assistance in decision-making (Rouwette, 2011; Stave, 2002), 'generating commitment with a decision' (Andersen et al., 1997, p.5; Huz et al., 1997; Suslov and Katalevsky, 2019), change of attitude towards policy (Andersen et al., 1997; Rouwette, 2011) or, more broadly, systems improvement (Cavaleri and Sterman, 1997).

Nevertheless, most of these researchers agree that the quality of the process is a critical issue, and its effectiveness is based on how well the stakeholders are motivated to involve themselves in the cognitively and emotionally demanding tasks of model building with a group of others. Stakeholder or client engagement has always been a significant issue for the simulation modeling community (Mayer, 2009). This could partly be explained by the overall practice-oriented focus and relativist nature of the models and, consequently, the need to explain the logic behind the model to the client and stakeholders. Such engagement has been achieved through incorporating user-friendly interfaces, storytelling, and visualization techniques. It has also led to the development of a diversity of interactive applications like management simulators, policy exercises, and serious games (Maier and Größler, 2000). However, to the best of our knowledge, little effort has been put into gamifying various stages of the PM process to create a more engaging experience for the stakeholders and improve learning and communication during the process.

According to Voinov and Bousquet (2010), there are five main stages: (1) preparation, (2) conceptual model development, (3) quantitative model development, (4) development of solutions and testing scenarios, (5) dissemination of results to a broader audience of interested parties. Each of the stages has its goals, particular procedures that comply with the specific features of the chosen modeling method and expected outcomes. A wide range of challenges that are associated with

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group communication, learning and overall engagement of stakeholders in the process might occur at every stage or stretch over the whole process. Jordan et al. (2018) summarizing the challenges of the PM process, among others mention difficulty in sustaining long-term involvement of stakeholders in the modeling process, difficulties associated with learning about complex problems including the need for recognizing and dealing with biases and barriers in group communication because of conflict of interest or power imbalance.

Although not all of these challenges can be possibly solved by the use of game design, from the existing literature we know that serious games appear to be particularly useful for social learning, while gamification has positive effects on engagement in some activities (Elsawah et al., 2017; Stefanska et al., 2011; Tsuchiya and Tsuchiya, 2000 and others). There is a distinction between serious games and gamification. Both of them are used for other primary purposes rather than sole entertainment (Deterding, 2015; Michael, 2006; van Daalen et al., 2014). However, unlike serious games that have all the formal and dramatic game elements, gamification implies application of only some game design elements in non-gaming contexts of real-life activity (Deterding et al., 2011; Fullerton et al., 2008).

In this paper, we aim to understand in which ways the PM process can benefit from existing advances in serious games and gamification. To achieve this, we review different types of game-like applications and gamification components. In addition, we reflect on the existing cases when they have been used during some stages of PM. Consequently, we suggest how gamified solutions and gamification can help to address the challenges of learning, communication, and overall engagement of stakeholders at each stage of the PM process.

This paper is our attempt to suggest ways in which PM as a method can develop further, benefiting from the advances in other disciplines, particularly game design and gamification. We believe that a better understanding of the positive effects of gamified applications for learning and engagement could help to design practical strategies for improving PM. More specifically, we focus on the particular features of game design that are needed to serve the PM process. This, in turn, could help researchers and practitioners who lead PM projects to create more engaging experiences for stakeholders and achieve the objectives of the modeling exercises more efficiently.

The paper is organized as follows: firstly, we define our overall methodology and review the diverse game-like applications and gamification as a separate concept as well as the existing applications in PM context; then we analyze the effects of serious games and interactive simulations on different aspects of social learning and contribution of gamification to engagement, motivation and enjoyment from the process; finally we suggest the ways in which PM could benefit from serious games and gamification at each stage and consider possible adoption barriers.

## 2. Method

This research is interdisciplinary in nature and includes elaboration on the concepts from simulation modeling, participatory modeling, game design and social learning fields. Such a perspective is essential for addressing the aim of the research; on the other hand, it makes it sometimes difficult to define the concepts and narrow the scope.

In this research we were interested in looking at stand-alone game-like applications and at gamification of the activities because both of these two types of game design use were applied in the context of stakeholders' involvement in decision-making (Mochizuki et al., 2018; Tsuchiya and Tsuchiya, 2000; Ampatzidou et al., 2018 and others). Therefore, both of them and the effects that they create could be beneficial for PM as a particular approach. Our first step was to define the main concepts from the game design field. There is no clear distinction between a variety of game-like application types and any existing typology is useful as long as it serves the specific purpose of the particular research (Maier and Größler, 2000). We suggested a typology that is applicable to the use of game-like tools in the context of stakeholders' engagement into decision-making and participatory modeling, in particular. In order to do so, we considered two aspects: (1) backing up the definitions by the existing literature, (2) focusing on those types of serious games and interactive simulations that are most frequently mentioned in the literature within the context of this research (see the next section on the methodology for selecting the scope of the papers). For example, interactive learning environment (ILE) is one of the types of interactive simulations (Maier and Größler, 2000), however, within the scope of the literature about interactive simulations in participatory setting such term has been mentioned as synonym of management simulator (Marrone et al., 1999), hence, we do not distinguish it as a separate type. The only exception from this approach is connected to the term 'explorable explanation', which we found useful to include into the typology although it has not been mentioned within the literature about stakeholders' involvement in decision-making. The reason for doing so is that it is an interactive tool that includes characteristics of both interactive simulation and serious game and, therefore, can be potentially useful for PM.

The core part of this research is connected to the analysis of the effects of game-like applications on social learning and the effects of gamification on engagement. The choice of these two particular concepts (social learning and engagement) is predetermined by the following reasons: (1) social learning is an important outcome of PM process (Jordan et al., 2018; Van den Belt, 2004; Videira et al., 2009; Voinov et al., 2018) and, according to existing literature game design can be efficiently used to promote social learning (Stefanska et al., 2011; Tsuchiya and Tsuchiya, 2000 and others), (2) engagement is a significant challenge of PM process considering the long procedure of conducting a series of modeling workshops (Jordan et al., 2018) while gamification contributes directly to engagement in an activity (Alsawaier, 2018; Sailer and Homner, 2019; Shpakova et al., 2017; Zichermann and Cunningham, 2011 and others) and indirectly to other aspects such as behavioral change, learning and so forth (Landers et al., 2018; Shpakova et al., 2017).

For choosing the scope of literature for the review we considered two inclusion criteria: (1) the game-like application discussed should be used in a participatory setting – by participatory setting we mean the context of workshops and/or other interactions with actual stakeholders aiming at learning about the problem, improving communication between the participants, developing solutions and collaborating for joint actions, (2) the publication should include at least some evaluation procedure of the effects from game-like application – we do not set strict criteria on the quality of evaluation because many of the papers in this context elaborate on particular cases with a limited number of participants that could hardly be considered as a valid case for extrapolation of the results to a bigger scope, however, the observations from such cases still give some useful information about the effects.

We conducted the search using the keywords 'management flight simulator', 'policy exercise', 'microworld', 'social simulation', 'serious game' together with 'participatory modeling', 'stakeholder engagement', or 'policy-making'. Initial search within Scopus and ScienceDirect revealed 65 and 57 results respectively. After more in-depth analysis of abstracts, checking for the presence of evaluation procedure and excluding duplicates we ended with 12 papers from Scopus and 4 papers from ScienceDirect. While conducting a broader review on combination of game design and participatory modeling and defining the research gaps in this field as well as analysing the references from previously found 16 papers, we included 25 more papers that satisfied the criteria. Consequently, the final scope of the scientific articles used for the analysis consisted of 41 papers. The choice of papers for analysis of effects of gamification on engagement has less specific criteria because the literature that includes evaluation of effects is limited in principle. Although many authors mention the positive effects of gamification on motivation or enjoyment of process (Deterding, 2012; Landers et al., 2018), there is just a few recent research papers that imply clearly defined evaluation procedures and elaborate on the contribution of particular game design elements to different components of engagement (Alsawaier, 2018; Sailer et al., 2017; Sailer and Homner, 2019 and others).

The next two sections present more detailed elaboration on the definitions of different types of game-like applications and gamification as a concept as well as the review of existing literature about their effects on social learning and engagement.

## 3. Game-like applications and gamification: definitions and use in participatory settings

Historically simulation modeling has benefited from the interactivity brought by game design and visualizations. PM, as a particular method dealing with group discussions, has also followed this path but at a relatively slower pace. In this section we look into the concepts and features of serious games, interactive simulations, and gamification, trying to distinguish one from another and to review their existing application in the PM context.

### *3.1. Better is the enemy of the good: does PM need gamification?*

PM, by definition, includes both social (participation of stakeholders) and technical (modeling) aspects. This makes it a powerful tool in dealing with complex problems, not only in theory but also in practice, such as for policy-making purposes (Antunes et al., 2006; Videira et al., 2016).

A lot is said about biases and cognitive traps when people are trying to untangle complex problems (Glynn et al., 2017; Vennix, 1996). PM contraposes this with its modeling instruments that visualize participants' mental models, forcing the participants to rely on logic and highlighting inconsistencies that might occur (Voinov et al., 2018). Unlike the verbal or descriptive ways of other participatory settings, models present the problem in a much more structured way, which leads to more transparency and better understanding.

Efficient communication between stakeholders is desired to develop robust solutions for complex problems. When dealing with complex problems, there is often no one correct solution, which makes it difficult for stakeholders to communicate and reach consensus (Vennix, 1996). Diverse psychological aspects of group dynamics, lack of openness to perspectives of others, and power imbalance in groups create interpersonal conflicts and prevent effective communication within a group (Van den Belt, 2004; Vennix, 1996 and others). PM again addresses this with the use of facilitation techniques and the competencies that an experienced facilitator brings to the process (Van den Belt, 2004; Vennix, 1996 and others). Additionally, in some cases it is useful to divide the responsibilities within the team, where the facilitator is responsible for the communication process, while a modeler is responsible for the technical interpretation of all discussed ideas (Vennix, 1996).

Indeed, the internal mechanisms embedded in PM provide responses to many challenges that occur when dealing with complex problems. At the same time, there is not much research reflecting on problems or pitfalls within the method. The paper of Jordan et al. (2018) is one of the few attempts at summarizing and reflecting on the long-term experience of applying this method in different contexts. Among the challenges, the authors mention (1) resource constraints - PM requires sufficient time and efforts from the modeling team and stakeholders to lead to meaningful results; (2) balance in modeling tools - conceptual models omit the dynamics while quantitative models are too complicated to communicate to communities; (3) implementation - although PM seems to be a useful learning exercise, it does not always lead to actual changes in actions/behaviors and the realization of arrangements in practice; (4) ethics and power imbalance during PM - whether the mechanisms embedded in PM process fully help to overcome such problems and which role the facilitator plays in it; (5) learning and biases - whether the PM process helps to fully address individual and group biases in regard to some problem or system (Jordan et al., 2018).

In addition to the perspective of reflecting on the challenges and pitfalls of PM as a method, some authors look at the development of the method from the perspective of its possible improvement through the adoption of the best practices from other disciplines and methods. Voinov et al. (2016)review a range of rapidly developing fields such as social media, crowdsourcing, and game design, to mention a few, and their implications on the participation of stakeholders in decision-making and learning about complex problems. They also provide some emerging evidence of applying these new technologies and approaches in a PM context (Voinov et al., 2016).

Considering these two perspectives, we decided to elaborate on possible intersections of the PM and game design fields. The specific focus on application of game design as opposed to other approaches or technologies can be explained by two considerations. Firstly, as mentioned earlier, many of the PM challenges are connected to the group communication, difficulties in understanding complexity of the problems by the stakeholders (Jordan et al., 2018) while game-like applications (serious games, management simulators and so forth) appeared to be effective in improving learning and cooperation within a group (Elsawah et al., 2017; Stefanska et al., 2011; Tsuchiya and Tsuchiya, 2000 and others). Hence, there are high chances that introduction of game design in PM process could lead to positive results as well. In addition to that, historically, games for learning and interactive visualizations played important roles in the simulation modeling field and they have always been recognized as powerful and engaging instruments for experiential learning (Maier and Größler, 2000; Mayer, 2009). Therefore, more in-depth investigation of how they have been used in the context of modeling with stakeholders as well as elaborating on the potential benefits and limitations of their broader use can be useful for further development of PM method.

### *3.2. Game-like applications: definitions and features*

Serious games are games that are 'designed and/or used for non-entertainment purposes' (Deterding, 2015, p. 9; Michael, 2006; van Daalen et al., 2014). Such games are used in a wide range of fields and became particularly effective in education and healthcare (Bredl and Bösche, 2013; Kavtaradze and Likhacheva, 2012; Nygaard et al., 2012). There is also a wide diversity of serious game types: simulation games, sandbox games, board, and video games, and quizzes, among others (Stanitsas et al., 2019). In the context of decision support and learning about complex problems, special attention is given to the games based on simulation models. There is no single typology of such game-like applications and no consensus whether they could be called 'serious games' or they should be categorized as some other sort of 'interactive simulations' (Maier and Größler, 2000; van Daalen et al., 2014). Both serious games and interactive simulations comply with the definition of a game, for example, the one that is given by Salen and Zimmerman (2003, p. 80) and defined as "a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome". Both of them are equally used in the context of learning and stakeholders' engagement (Elsawah et al., 2017; Tsuchiya and Tsuchiya, 2000; van Daalen et al., 2014). However, serious games are rarely used for actual decision-making, they are rather applied at the preliminary stages of policy-making for social learning, getting feedback from the stakeholders and other purposes (Magnuszewski et al., 2018).

For the purposes of this paper, we distinguish 'serious games' from 'interactive simulations' because we are interested in analysing their effects on social learning and the contribution of game design to it. Therefore, the core criteria for differentiating one concept from another is the extent to which the game design has been applied. From this perspective, we suggest that serious games imply a higher level of game design as compared to interactive simulations. According to Fullerton et al. (2008), a game includes all the formal elements from game design, such as roles, objective, rules, conflict, resources, player interaction patterns, boundaries and outcome. Interactive simulations, on the contrary, can include only some elements, such as roles, rules, and visual representations; additionally, as defined by Maier and Grossler (2000) such computer simulations have three components (1) underlying model (most commonly, science-based simulation model), (2) human-computer interface and (3) various functionalities (for example, naming of variables that is easy to understand for non-modelers, showing time-steps of simulation and other). In other words, larger variety of game design elements could be part of human-computer interface of interactive simulation but it is not considered as an absolute requirement.

There is a range of typologies of serious games (De Lope and Medina-Medina, 2017). However, considering the participatory modeling focus of this paper we suggest to differentiate, at least, 3 types of serious games: (1) model-based games, (2) social simulation games, and (3) non-model based games. Such 'model-centered' choice of types is rooted in two observations. Firstly, the engagement of the stakeholders into decision-making aims at helping them to learn about the problem, improving communication between the participants, developing solutions and cooperating for joint actions about real-life problems (Voinov and Gaddis, 2017). Therefore, the gaming exercise needs to imply a relatively high level of verisimilitude that could be achieved through using science-based models (Lane, 1995). Second, historically within the simulation modeling domain that is largely used for consultations with stakeholders and experts, a range of models were transformed into fully-fledged serious games (Sterman, 2014). Social simulation games in the context of stakeholders' involvement into decision-making also include either quantitative or qualitative models that represent particular problems (Schenk, 2014; Stefanska et al., 2011; van Hardeveld et al., 2019). However, the distinctive feature of such games is that it is a multi-player activity with a role-playing component (Rumore et al., 2016; Schenk, 2014). Finally, we allocate all the other games into a generic category of 'non-model based' games that are most commonly used for increase in awareness and behavioral change rather than more in-depth learning about the problem in participatory setting (Wood et al., 2014; Wu and Lee, 2015).

Within the scope of interactive simulations there are different types as well; microworlds, management 'flight' simulators, policy games, and learning environments (Maier and Größler, 2000). Such diversity of forms was produced by researchers applying simulation modeling in different fields and searching for ways of making models more understandable and usable by the experts and practitioners from other, non-modeling, fields. There is no agreement within research community on the definitions of these types and often many of them are used as synonyms (Maier and Größler, 2000; van Daalen et al., 2014). Considering the focus of our research that is associated with use of game-like applications in stakeholders' involvement in decision-making, we defined three types of interactive simulations that most commonly could be found in the literature within this scope (see Section 3 and Section 4.2 of this paper). These three types are (1) management (flight) simulator, (2) microworld, and (3) policy exercise. To define management simulator, we refer to the works of Chawla et al. (2006) and Maier and Grossler (2000) who suggest that it implies a combination of simulation model and computer interface (mostly including forms, graphs and spreadsheets) aiming at learning from experience in a single- or multi-user setting. As for the definition of microworld, we refer to the one that is commonly used in simulation modeling community and define it as a tool similar to management simulator but with higher level of freedom in experimentation and less explicit learning goal (Maier and Größler, 2000). Such interpretation of this term only partially comply with the initial definition given by Papert (1993) but it considers the context of microworlds' use that is relevant for the focus of this paper (in the context of stakeholders' engagement into decision-making mostly microworlds include science-based simulation model as the core of the tool (e.g., Grignard et al., 2018)). Overall, the main distinction between management simulator and microworld is that management simulator has predetermined actions or controls while microworld is more flexible in choosing the learning goal and path. Finally, the third type of interactive simulations that we consider in our research is a policy exercise. As per definition of Brewer (1986, p. 468) it is 'a deliberate procedure in which goals and objectives are systematically clarified and strategic alternatives are invented and evaluated in terms of the values at stake'. Policy exercise always implies the presence of multiple participants and, unlike management simulator or microworld, it goes beyond experiential learning as the main objective and is used as a preliminary stage of actual decision-making (Mayer, 2009; Tsuchiya and Tsuchiya, 2000).

Explorable explanations are among the types of game-like applications that are not mentioned in simulation modeling literature but, in principle, fall into the category of interactive simulations and are used for learning in participatory settings. Explorable explanations are an emerging concept that is widely used in practice but not as much in the scientific literature. They represent 'highly interactive, digital experiences with a mix of visual and textual content, leaning towards the visual side … and teach not only facts but also concepts and procedures as well as the relationships between said facts, concepts and procedures.' (Fogh, 2018, p. 23). Considering the above-mentioned definitions of different types of game-like applications, we summarized them in Fig. 1.

There are several features of serious games and interactive simulations that make them effective for learning and decision-making processes. Firstly, such game-like applications create an environment with feedback, where players can experiment with different strategies and experience the outcomes almost immediately (Rebolledo-Mendez et al., 2009). This characteristic is equally relevant for all kinds of games, but it is crucial for games where the main goal is learning. Serious games are a form of experiential learning where experience received from action reinforces the knowledge and feeds back to further actions and experimentation (Crookall, 2013).

Secondly, serious games create a low-risk environment that is especially relevant when they are used for policy-making purposes (Mayer, 2009). Decision-makers can experiment with diverse, even extreme strategies within a virtual world, while in a real-world setting such experiments would have been costly and sometimes not possible without the risk of irreversible consequences. Additionally, such low-risk environments give players the feeling of safety 'which is a prerequisite for experimentation and creativity' (Mayer, 2009, p. 1). Consequently, it could lead to deeper learning and better decision-making. The above-mentioned characteristics of serious games (environments with feedback and low risk) are equally relevant to simulations, although the level of user engagement in serious games versus computer simulations might differ a lot.

Thirdly, serious games, and especially role-playing or multiplayer games, add value through relational learning, which refers to the ability to understand the perspectives of others and collaborate with other participants in a group (Haug et al., 2011). In some serious games, players need to cooperate, to work in a team, or to take into consideration the strategies chosen by other players. Relational learning is important in the context of complex, transdisciplinary problems because they include the interests of diverse groups of stakeholders (Leicht et al., 2018). Finally, from a technical perspective, game design is very flexible and could be relatively easy to add on top of the computer simulation model which, in turn, could significantly improve the user experience (Mayer, 2009).

### 3.3. Gamification: definitions and applications

Deterding et al. (2011, p. 1) provide a generic definition to the term gamification, saying that it is 'the use of game design elements in non-game contexts.' Similar definition is given by Werbach and Hunter (2012), albeit in his later work Werbach (2014) suggests to describe gamification from the perspective of the process rather than focusing on its components or context. Specifically, he defines it as a 'process of making activities more game-like' (Werbach, 2014, p. 1). Meanwhile,

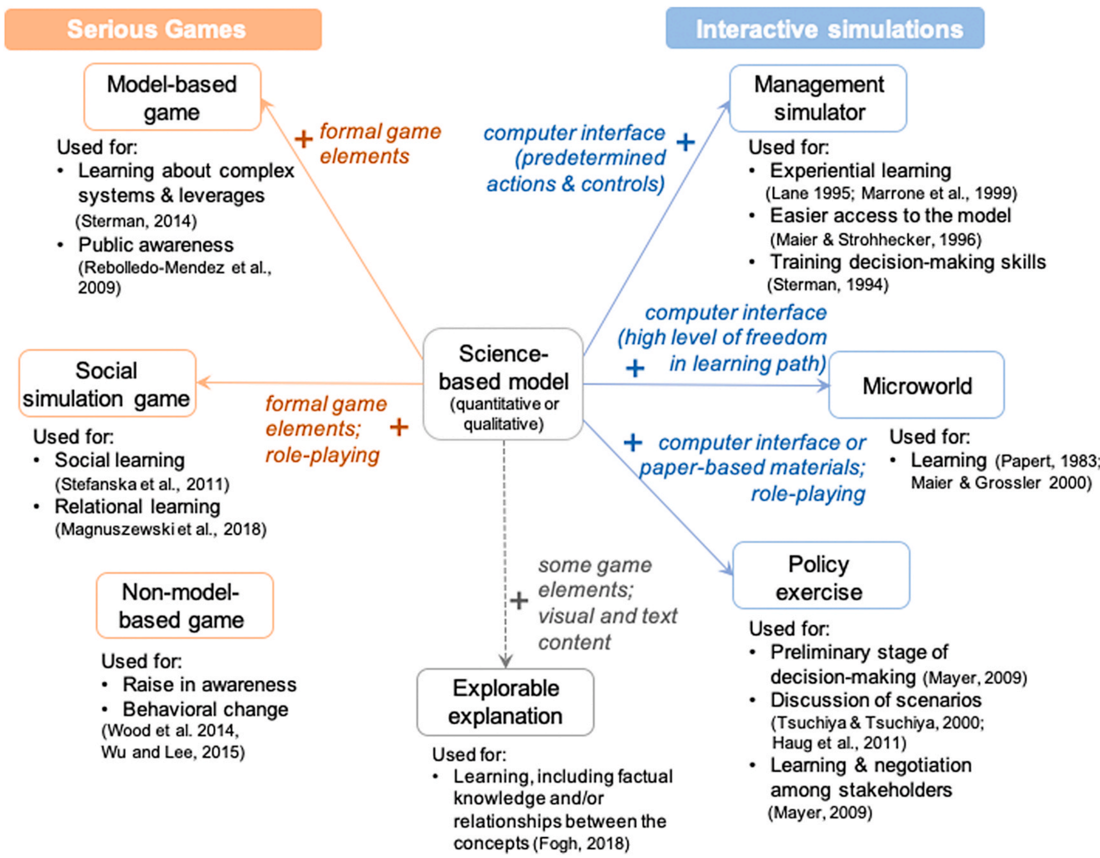


**Fig. 1.** Typology of game-like applications used in the context of stakeholders' involvement in decision-making.

other authors specify the definition of gamification based on its ultimate goal, which could be to influence human behavior (Landers et al., 2018), to develop skills (Shpakova et al., 2017) or to engage people with some activity (Shpakova et al., 2017; Zichermann and Cunningham, 2011). The definition given by Deterding et al. (2011) is most commonly used in the literature (Sailer et al., 2017). However, its use still leaves a chance to confuse 'gamification' with some other terms from the game science field, more particularly, with serious games, gameful design, and playful design.

Both gamification and serious games are used for non-game (non-entertainment only) contexts, but a serious game is a complete game while gamification implies that only some game design elements are included (Deterding et al., 2011; Sailer et al., 2017). Both gamification and gameful design include the use of game design elements in a context other than entertainment, but gameful design aims for game-like experience while gamification might not necessarily lead to gameful experience, and it could imply only a motivational component (Landers et al., 2018). In other words, gameful design is more similar to the experience of playing a serious game. Deterding et al. (2011) distinguish gamification from a gameful design by the difference in intentions; in the case of gamification it is a 'design strategy to use game design elements' and in the case of gameful design it is 'the design goal of designing for gamefulness' (Deterding et al., 2011, p. 3). The distinction between gamification and playful design is the most explicit one because it is grounded in the distinction between game and play, where play is an unstructured process of experimentation driven by curiosity as opposed to rule-based and goal-oriented nature of a game (Deterding, 2015; Sailer et al., 2017). Even though gamification does not explicitly aim for playful experiences or fun, these two components could be among the results of the process (Deterding, 2015; Landers et al., 2018).

Gamification is a relatively new and developing field within game science. Therefore, it is hard to say that there exists any universal approach on how to gamify some activity. Morschheuser et al. (2017) state that the gamification of activity is a complicated task because of several reasons. One needs to take into consideration the complexity of a game as a phenomenon that is hard to break into parts and apply separately in a different context (Morschheuser et al., 2017). Other authors also support this statement saying that 'game design is an activity too complex to be reducible to a formal procedure' or saying that iterative, agile approaches should be used instead of one complete framework (Mora et al., 2015, p.2). Additionally, in the case of gamification of some real-life process, one needs to take into consideration the psychological aspects (e.g., needs and motivation) and expected behavioral outcomes which add difficulty to the design process (Morschheuser et al., 2017). All these considerations have led to a situation where a large number of diverse gamification frameworks have emerged. Most of them include some or all of the following stages: (1) evaluate the context, (2) define the objectives, (3) design the process, (4) playtest, and (5) evaluate the results (Mora et al., 2015; Morschheuser et al., 2017).

Gamification frameworks differ in their focus. On the one hand, most of the existing frameworks are generic and, therefore, could be applied in different contexts. On the other hand, a certain level of customization of gaming interventions is needed to comply with the context of processes and users' profiles, objectives, and desired outcomes.

### *3.4. Game-like applications, gamification, and participatory modeling: existing cases of joint use*

Serious games, interactive simulations, and gamification have been widely applied in participatory workshop contexts, especially in the urban planning field. Serious games are useful for engaging broader audiences into learning or decision-making processes (Ampatzidou et al., 2018). Additionally, they could help in diminishing the negative effects of communication problems, such as conflict, power issues, and domination of particular viewpoints. Likewise, they could help with engagement problems such as the inclusion of vulnerable groups of stakeholders or sustaining the participation of stakeholders up until the end of the process (Ampatzidou et al., 2018). Interactive simulations based on augmented reality and visual projections have also been used as urban design and crowdsourcing tools. They proved to be effective for explaining the complexity of interconnections in urban settings, negotiating policy options, and building consensus among the stakeholders (Alonso et al., 2018; Grignard et al., 2018; Noyman et al., 2018, 2017). Social simulations have also been used as a tool for relational learning practices for stakeholders in a water governance context (Magnuszewski et al., 2018).

All these examples provide some evidence of the diverse effects on social learning and decision-making that serious games and interactive simulations could provide in a participatory workshop context. However, PM has specific processes, objectives, and constraints that are not present in any other participatory context. The most significant feature is that, during the PM process, stakeholders either develop a new model of a discussed problem or improve an existing one. The specific procedure of PM itself seems to impose restrictions on the wide use of serious games and game elements during the process, and there is a limited number of such cases.

The two most common ways of combining serious games and PM are the following: (1) at the initial stage - for data collection purposes and (2) at the final stage - to present the results (Voinov et al., 2018). There are several documented examples of such a combined approach. Fraternali et al. (2012, p. 2) mention 'games with a purpose' as one of the human-computing approaches for obtaining or structuring data in the context of water resources management. Zhou and Mayer (2010) present a case of the development of an interactive simulation tool for water management decision-making that helped to improve the negotiation process for choosing policy options within a group of experts. Ruud and Bakken (2003) used the results of the group model building workshop with experts for the purposes of developing a serious game for the training of air force defense professionals. As for interactive simulations, they are often used at the stage of quantitative model development and scenario analysis as a tool for visualization and testing assumptions through a user-friendly interface (Zhou and Mayer, 2010).

In regard to the gamification of the PM process, there are even fewer cases. Depending on the definition of gamification, one could say that companion modeling is one such example because it implies the use of role-playing and agent-based models for the discussion of the problem with stakeholders. Barreteau (2003) gives an overview of cases developed by other authors on how companion modeling was used for improving negotiation processes on topics such as urban planning at the local level, transportation and traffic organization, and building relationships within the local community. The method could be used for different purposes apart from the improvement of the negotiation process. One of the purposes of companion modeling is to observe the behavior and decisions of stakeholders during role-playing andenrich agent-based models based on these observations. Another possible purpose is to discuss the problem through developing a role-playing game about the problem with the stakeholders, then testing it and discussing the outcomes and underlying assumptions (d'Aquino and Bah, 2013). Companion modeling can also be used as an assessment tool for social interactions within a community where the behavior during role-playing sessions is compared to actual behavior in real-life. Overall, within companion modeling, role-playing is used for defining social relationships while agent-based models represent the behavior of agents in social situations and the cumulative results of such behaviors. Another recent example of the gamification of the participatory process was presented by Aubert and Lienert (2019), who gamified online surveys, aiming at extracting preferences as part of the multi-criteria analysis procedure. Although this example is not connected to participatory modeling per se, in principle it shows the possible applicability of gamification at the preliminary stage of PM when the modeling team might want to use questionnaires to get initial perspectives of the stakeholders.

Despite the active discussion around and development of diverse gamified tools for participatory settings in academia, there is not much evidence of the applicability of many of these tools in practice. Ampatzidou et al. (2018, p. 9) claim that lack of time, insufficient practical experience of the facilitators in using games in their work, as well as 'lack of adaptability of games for different occasions, cases, and audiences' are the main limiting factors in wider use of games on participatory analysis and decision-making. In addition to that, there is insufficient evaluation of the above cases and evidence that incorporating games into PM processes has led to the improvement of communication, engagement, or better outcomes in general. Finally, there are almost no examples where the entire PM process was gamified and gaming elements were applied at each stage. All these show that there is a need for additional elaboration on what are the exact benefits that game design could bring to the PM process and how game elements could be incorporated in a targeted and meaningful way at each stage of the process.

## 4. Effects and benefits of game-like applications and gamification for social learning and engagement

Based on the review of different types of game-like applications and gamification in the previous section, we can conclude that overall their application in participatory contexts could lead to positive results. At the same time, all the gamification frameworks emphasize the importance of being precise in setting the objective for gamification of some non-entertainment process. In other words, prior to designing gamification of PM, we need to define what exactly we want to achieve while incorporating game elements and engagement loops into the process. That is, which behavior do we want to stimulate among the participants and what are the expected outcomes of the gamification efforts.

In this section, we keep our focus on social learning and engagement as two components that are important for the PM process and have previously been demonstrated to be successfully addressed by serious games and gamification. We analyze which effects on social learning could be expected from using different types of game-like applications and by which means gamification creates an engaging experience for the participants. In later sections, we use this analysis to support our judgment about how PM can benefit from serious games and gamification at each stage of the process.

### *4.1. Why social learning and engagement?*

Stakeholders' learning and engagement are crucial components of the PM process. When talking about learning, researchers in the field either explicitly or indirectly mean social learning because PM implies a better understanding of the problem through reflecting on a person's own perceptions and considering the perspectives of others. Social learning is a particularly important concept to deal with complex problems where a diversity of technical, social, cognitive and other boundaries exist and, consequently, there is a need for a transboundary perspective to find the solution that satisfies major stakeholders (Medema et al., 2016). Reed et al. (2010) explore the roots of this term and refer to the works of Bandura (1977) who defined social learning as 'individual learning in social context' and to the works of Lave and Wenger (1991) who defined it as a learning that happens through interaction in participatory context. Although there is no one universal definition of social learning, most commonly it is associated with a situation 'when a change in understanding is achieved through interaction in collaborative and participatory settings' (den Haan et al., 2019, p. 4; Medema et al., 2016). Overall, social learning implies two elements that are change in knowledge or 'cognitive enhancement' and change in interpersonal attitude or 'moral development' (Haug et al., 2011; Webler et al., 1995). Baird et al. (2014) go further and define social learning through three types: (1) cognitive learning that implies acquisition of new knowledge or restructuring of existing knowledge, (2) normative learning that is connected to the changes in norms, values, and attitudes of a person or a group (this aspect has also been explored by Marini et al. (2018)), and (3) relational learning that depicts better understanding of others' perspectives and ability to build effective relationships with others (this aspect has also been explored by Lave and Wenger (1991) and Kolb (1984)). In this paper we refer to these three types because they help to conduct more detailed analysis in comparison with two-component definition of social learning by Webler et al. (1995).

Sustaining long-term engagement of stakeholders in the modeling process is also an important aspect because PM by its nature requires a series of separate sessions with time intervals between them (Jordan et al., 2018). Engagement is a broad concept that has been defined from the perspective of time ('quality and effort learners invest in an authentic activity') and the perspective of attitude ('enthusiasm and diligence in doing task') (Alsawaier, 2018, p. 7; Kuh, 2009). Engagement could be connected with many factors but motivation and satisfaction (enjoyment) with the process are among the core ones (Alsawaier, 2018). The motivation of the participants to involve themselves in PM sessions can be based on external goals, such as to understand the problem or to solve it. The motivation can also come from the desire to fulfill psychological needs for competence, autonomy, and relatedness, such as participating in discussions to get acknowledgement from peers or to feel that they are part of a bigger supportive community. On the other hand, in PM there is not much attention paid to increasing motivation; motivation is perceived as a side effect of the overall process. That is, participants contribute their time to create the model, they have a feeling of ownership over the modeling results and this feeling, in turn, increases their motivation to invest more time and effort in solving the problem. In addition, PM rarely considers enjoyment, or at least it is not seen as an explicit goal of the process. There are also many aspects that could undermine satisfaction in the modeling process, such as the high cognitive load of the modeling exercise, frustration from unknown modeling methodologies and software, emotional pressure from communicating with people with opposing views, and so forth.

### 4.2. Effects of serious games and interactive simulations on social learning

Similarly to PM, serious games and interactive simulations promote social learning through the game design mechanisms embedded in them. We extended the typology proposed by Baird et al. (2014) through adding a set of subtypes for each type of social learning, as shown in Fig. 2 and discussed in this section. The choice of subtypes was based on the effects of serious games and interactive simulations reported in 41 papers. For the cognitive aspect of social learning, we separated factual knowledge from knowledge about interconnections within a system because most of the interactive simulations have a focus on understanding how the system works rather than memorizing the facts. These subtypes are represented by quotes from papers such as ' … helped participants understand the rationale behind the ACT Government's policy to limit rebates only to the tanks connected to a water source' (Elsawah et al., 2017, p. 7) or 'player encouraged to see energy in a nexus context with other resources' (Wood et al., 2014, p. 7). A normative aspect includes subtypes that are either associated with changes in values and attitudes or connected to the way how these changes impact the behavior and actions of humans. These subtypes are backed up by such quotes as 'games are uniquely suited to get people … care about … climate issues' (Wu and Lee, 2015, p. 4) or 'many participants have expressed their intent to take the lessons learned back to their real-world jobs' (Tsuchiya and Tsuchiya, 2000, p. 14). The subtypes of the relational aspect imply multiple aspects of the communication process including the ability to understand the perspectives of others, conflict resolution, building trust, and so forth. These subtypes were formed based on such quotes from the literature as 'by having to act out roles that express very different assumptions and worldviews, they became more sensitive to other perspectives' (Krolikowska et al., 2007, p. 13) or 'FP succeeded especially on the 'soft' level of human interaction: citizens felt as partners in an 'eye-level' dialog with policy-makers and city administration' (Noyman et al., 2017, p. 9).

As explained earlier in the Method section of this paper, the choice of papers for the analysis was based on the presence of evaluation of the learning and other effects from the presented serious game or interactive simulation. It is important to mention that even within this scope of the research papers, many of them lack detailed evaluation procedures or are based on a limited sample of users/players. Based on the evaluation given by the authors of the papers, we assigned the connection between each type of game-like applications with their contribution to social learning. The outcome is summarized in Table 1.

Cognitive aspects of social learning could be most effectively addressed by game-like applications that include simulation models, such as management simulators (Bakken et al., 1992; Elsawah et al., 2017; Greiner et al., 2014; Keith et al., 2017), policy exercises (Haug et al., 2011; Tsuchiya and Tsuchiya, 2000), model-based games (Rebolledo-Mendez et al., 2009; Sterman, 2014) or social simulation games (Keijser et al., 2018; Rumore et al., 2016; Schenk, 2014 and others). To a large extent, such a conclusion was expected and it logically comes out of the purpose of using serious games and interactive simulations. Overall, these game-like applications are particularly good in presenting and teaching different types of problem complexities (physical-technical and social) (C2.1, C2.2, C2.4), as well as giving the users an opportunity to practice their decision-making and strategic planning skills (C2.3, N3).

Normative aspects of social learning haven't been considered much in the analyzed papers as compared to cognitive and relational learning aspects. In some potential PM contexts, such as in sustainability literature, it appears to be important for people to strive for self-reflection in order to influence their values, change attitudes and, consequently, come up with behavioral changes (Leicht et al., 2018). It could be explained by the overall notion that values, norms, and behaviors are the characteristics that require significant time to be changed. Therefore, they may not be influenced much through a sporadic experience of

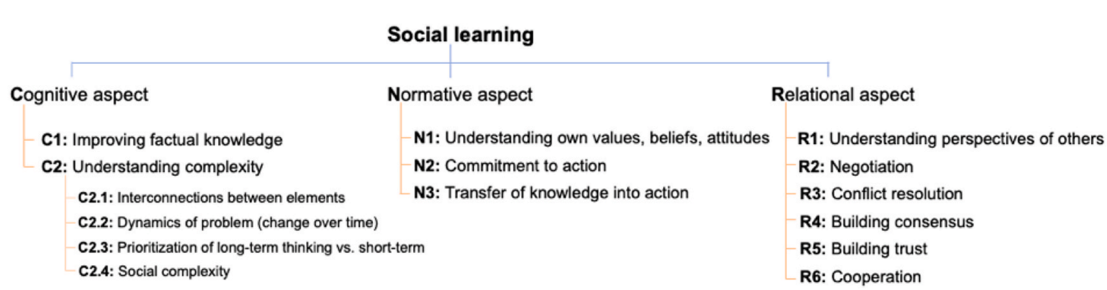


**Fig. 2.** The proposed set of categories of social learning for assessment of the effects/outcomes of different game-like applications.

**Table 1**
Effects of different types of game-like applications on social learning, as defined by the categories shown in Fig. 2.

| Types of game-like applications | Cognitive learning | | | | | Normative learning | | | Relational learning | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C1 | C2 | | | | N1 | N2 | N3 | R1 | R2 | R3 | R4 | R5 | R6 |
| | | C2.1 | C2.2 | C2.3 | C2.4 | | | | | | | | | |
| Interactive simulations | | | | | | | | | | | | | | |
| Management simulator | [8] | [8] [9] [18] [3] [11] | [8] [15] [18] [11] | [9] [11] | [11] | | | [3] | [20] | | | | | [20] |
| Microworld | | [12] | | | | | | | | [1] | | [2] | [23] | |
| Policy exercise | | [21] [35] [13] | [21] | [13] | [35] [13] | | | [35] | [21] [35] [13] | [35] | | | | [35] |
| Explorable explanations | [10] | | | | | [10] | | | | | | | | |
| Serious games | | | | | | | | | | | | | | |
| Model-based games | [27] [25] | | [34] [19] | [34] | [34] | [5] | [34] | | | | | | | |
| Social simulation game | [7] [38] [14] [29] [30] [24] [4] | [16] [22 [7] [41] [14] [6] [24] [37] | [14] [37] [4] | [33] [41] [6] [37] | [16] [41] [29] [30] [24] [37] | [22] [36] [29] | [29] | | [16] [17] [22] [7] [36] [41] [29] [24] [31] [37] | [17] [33] [22] [7] [36] [38] [4] | [16] [17] | [17] [24] [31] | [17] [7] [31] | [17] [33] [36] [29] [6] [37] |
| Non-model-based games | [32] [26] | [32] [39] | | | [32] | [40] | [39] | [39] [28] [40] | | [26] | | | | |

[1] (Afrooz et al., 2018).
[2] (Alonso et al., 2018).
[3] (Bakken et al., 1992).
[4] (Becu et al., 2017).
[5] (Costanza et al., 2014).
[6] (Craven et al., 2017).
[7] (den Haan et al., 2019).
[8] (Elsawah et al., 2017).
[9] (Vidal Flores and Muñoz, 2017).
[10] (Fogh, 2018).
[11] (Greiner et al., 2014).
[12] (Grignard et al., 2018).
[13] (Haug et al., 2011).
[14] (Keijser et al., 2018).
[15] (Keith et al., 2017).
[16] (Krolikowska et al., 2007).
[17] (Magnuszewski et al., 2018).
[18] (Maier and Strohhecker, 1996).
[19] (Marrone et al., 1999).
[20] (Martin et al., 2007).
[21] (Mayer, 2009).
[22] (Mochizuki et al., 2018).
[23] (Noyman et al., 2017).

[24] (Parker et al., 2016).
[25] (Poplin, 2012).
[26] (Poplin, 2014).
[27] (Rebolledo-Mendez et al., 2009).
[28] (Ro et al., 2017).
[29] (Rumore et al., 2016).
[30] (Schenk, 2014).
[31] (Speelman et al., 2014).
[32] (Stanitsas et al., 2019).
[33] (Stefanska et al., 2011).
[34] (Sterman, 2014).
[35] (Tsuchiya and Tsuchiya, 2000).
[36] (Van der Wal et al., 2016).
[37] (van Hardeveld et al., 2019).
[38] (Vasconcelos et al., 2009).
[39] (Wood et al., 2014).
[40] (Wu and Lee, 2015).
[41] (Zhou and Mayer, 2010).
Grey-colored cells - results that are supported by more in-depth level of evaluation.

playing a game. All in all, social simulation games appeared to be useful for self-reflection (N1) about the norms and values of the users (Mochizuki et al., 2018; Rumore et al., 2016; Van der Wal et al., 2016). Model-based games and social simulation games can also help in creating commitment to action (N2) among the participants (Rumore et al., 2016; Sterman, 2014). Meanwhile, management simulators, policy exercises, and non-model-based games may be better for transferring the skills gained in the game into real-life conditions (N3) (Bakken et al., 1992; Ro et al., 2017; Tsuchiya and Tsuchiya, 2000). In the case of management simulators, it is an expected outcome because many of them were initially designed to train particular skills, such as general decision-making under uncertainty, decision-making for particular markets (automotive or transport industries), or for particular policy fields (energy, climate change, or water management) (Keith et al., 2017). Additionally, some of the non-model-based games, such as serious games about energy efficiency, are initially developed to force change in particular behavior patterns of the customer (Ro et al., 2017; Wood et al., 2014; Wu and Lee, 2015). By default these games require long-term participation of the users, therefore, some transfer of knowledge from game to practice (N3) occurs.

Finally, relational aspects of social learning are mostly addressed in the game-like applications that include role-playing or multiplayer settings and, more specifically, policy exercises (Haug et al., 2011; Tsuchiya and Tsuchiya, 2000) and social simulation games (Magnuszewski et al., 2018; Mochizuki et al., 2018; Rumore et al., 2016; Zhou and Mayer, 2010 and others). Interestingly, microworlds with embedded augmented or virtual reality technologies and interactive projections could also contribute to the effective negotiation within the group (R2), building consensus (R4) and trust (R5) (Afrooz et al., 2018; Alonso et al., 2018; den Haan et al., 2019; Noyman et al., 2017). This could be partly explained by the fact that this type of simulators includes a physical 3D model with which stakeholders can interact and that makes the connection between the action and result transparent for everyone in a group. Mostly, these simulators are used for the problems where the geospatial domain is important, for example urban planning or management of water resources (Afrooz et al., 2018; Alonso et al., 2018; Noyman et al., 2017).

Different types of serious games and interactive simulations could help to address almost every aspect of the social learning phenomenon. The fact that they are stand-alone products by themselves and, if well-designed, can guarantee particular learning outcomes, makes them useful during the PM process. They could also be designed as 'ready-to-go' instruments that could assist learning in a participatory setting. The drawback though is that their case-specific nature might prevent them from being widely applicable in slightly different contexts within the same problem area. In this regard, gamification as a process of adding game elements to an already existing activity, seems to be more flexible and provide much more promise in terms of generalizability and ease of implementation.

### 4.3. Effects of gamification on engagement

Even though gamification is an emerging field, researchers have tried to understand and discuss the effects of incorporating game design elements to formal and informal learning processes (Alsawaier, 2018; Dichev and Dicheva, 2017; Hamari et al., 2014; Sailer and Homner, 2019; Seaborn and Fels, 2015). Typically, the main reasons for adding game elements to any process are higher levels of motivation and engagement, as well as the creation of gameful experiences. All these are the mediators that help to achieve the ultimate goal, which could be, for example, a change in behavior or improvement of learning. Therefore, understanding the mechanisms and drivers behind motivation, engagement, and enjoyment (fun) and matching them with game design elements could provide a base for the improvement of learning and other activities targeted for gamification.

Motivation (G1) is commonly described through self-determination theory as the desire to satisfy psychological needs such as autonomy (G1.1), competence (G1.2), and relatedness (G1.3) (Ryan and Deci, 2000; Walz and Deterding, 2014). The interpretation of motivation is especially important for gamification because, in many cases, gamification interventions fall into simple reward-based solutions or BLAP (badges, levels/leaderboards, achievements, and points) (Reiners, 2015). Reward-based gamification drives the extrinsic motivation of a user, and once the rewards are taken out of the system, the motivation to do some action decreases (Reiners, 2015; Walz and Deterding, 2014). Another problem with extrinsic motivation is that the users expect the rewards to increase over time in response to an increase in performance, and this mechanism works like a never-ending reinforcement loop (Zichermann and Cunningham, 2011). To sum up, application of BLAP without in-depth consideration of the context and users' motivation could lead to less effect as compared to what has been anticipated, however, such reward-based gamification could be still a good solution for short-term intervention, such as to attract attention to some newly launched products (Reiners, 2015; Walz and Deterding, 2014). Overall, most of the gamified interventions strive for long-term engagement and intrinsic motivation that is, in turn, based on the consideration of the basic psychological needs mentioned earlier. In understanding the nature of motivation, researchers also tried to connect particular game elements with the effects that may cause sustained or increasing motivation (Alsawaier, 2018; Baard et al., 2004; Rigby and Ryan, 2011; Sailer et al., 2017; Sailer and Homner, 2019). Points, badges, and leaderboards contribute to the fulfillment of competence needs, while avatars, stories/narratives, and social interaction (collaboration and constructive competition) help to satisfy the needs for autonomy and relatedness. These findings could be used as a guide for practical applications of game elements, though, following the debate about extrinsic versus intrinsic motivation, gamification is not limited to a simple application of these game elements.

Engagement (G2) is a characteristic that often goes together with motivation, almost as synonyms, though this is not entirely correct (Alsawaier, 2018; Appleton et al., 2006). As mentioned earlier, motivation is related to psychological needs satisfaction, while engagement is more associated with the observed behavior and attitudes towards some actions (Alsawaier, 2018; Brooks et al., 2012). The border between these two terms is still blurry and strong motivation could be a driver for engagement (Alsawaier, 2018). Engagement, like motivation, is a complex phenomenon, but some researchers state that the game elements, such as challenges and quests, could contribute to it significantly (Alsawaier, 2018; Reiners, 2015).

Enjoyment (G3) is often described in game science literature through self-determination theory and flow theory (Csikszentmihalyi, 1990). Following Deterding's (2015) interpretation, enjoyment is an experience of psychological needs (competence, autonomy, and relatedness) satisfaction, similar to the fulfillment of motivation. Csikszentmihalyi (1990) introduces the term 'flow,' which, to a large extent, includes the enjoyment component. Walz and Deterding (2014) paraphrase Csikszentmihalyi's explanation of flow as an experience of immersion and fun when a person deals with the 'optimal challenges' that results in the 'feeling of a lost sense of time' and blurry 'subjective distinction between the player and the activity' (Walz and Deterding, 2014, p. 116). Enjoyment could also be accompanied with the feeling of fun, although there are many debates among researchers, both on the definition of fun (since this phenomenon is very subjective) and on whether enjoyable activities (such as gamification) are required to be fun (Landers et al., 2018; Walz and Deterding, 2014). Another minor but important aspect is that enjoyment could be achieved not only through promoting positive emotions (G3.1) but also through managing negative ones (G3.2) (Anolli et al., 2010). Game design helps to incorporate mechanisms for preventing high levels of frustration from unknown environments, too complicated tasks, and drawbacks in the communication process. Overall, the game elements and mechanics that could increase the level of fun and enjoyment could include overcoming challenges, feelings of achievement, sense of exploration, and rewards for progress or winning (Alsawaier, 2018; Zichermann and Cunningham, 2011).

**Table 2**
Components which are in focus of gamification as an approach.

| Component | Aspect | Game elements | References |
|---|---|---|---|
| Motivation (G1) | Autonomy (G1.1.) | avatars<br>stories<br>non-player characters<br>teammates | (Rigby and Ryan, 2011; Sailer et al., 2017, 2017) |
| | Competence (G1.2) | points<br>performance graphs<br>badges<br>leaderboards<br>social interaction (collaboration)<br>feedback<br>freedom of choice | (Alsawaier, 2018; Baard et al., 2004; Sailer et al., 2017; Sailer and Homner, 2019) |
| | Relatedness (G1.3) | stories<br>teammates<br>avatars<br>non-player characters<br>social interaction (collaboration, constructive competition) | (Alsawaier, 2018; Rigby and Ryan, 2011; Sailer et al., 2017; Sailer and Homner, 2019) |
| Engagement (G2) | – | challenges<br>quests | (Alsawaier, 2018; Reiners, 2015) |
| Enjoyment (fun) (G3) | Positive emotions (G3.1) | challenges<br>achievement,<br>rewards for progress (points, badges, etc.)<br>sense of exploration | (Alsawaier, 2018; Anolli et al., 2010; Zichermann and Cunningham, 2011) |
| | Negative emotions (G3.2) | – | Anolli et al. (2010) |

We analyzed the existing research where different game elements were evaluated from the perspective of their contribution to motivation, enjoyment, and engagement; and summarized the findings in Table 2. Most of these studies were based on reviewing the empirical data published by a range of authors and have shown mostly positive or neutral effects on learning; however, some level of uncertainty still exists because of inconsistency in methodologies or small sizes of samples (Sailer and Homner, 2019).

The research about finding interconnection between game elements, their effects on psychological needs satisfaction, and other aspects of engagement provides some grounds for further attempts in gamification. At the same time, as noticed by some other researchers, simply adding game elements to some activity will not automatically lead to higher motivation, engagement, and enjoyment (Reiners, 2015). Particular game elements might be useful in one context and useless in another. There is a need for a more sophisticated and well-thought approach to gamification in general and gamifying the PM process, in particular.

## 5. Discussion

### *5.1. Opportunities for PM to benefit from game-like applications and gamification at each stage*

The success of gamification efforts is significantly dependent on the understanding of the context, motivation, and goals of the parties involved in the process, and the overall objective of the gamification. Considering that, it is not realistic to develop or customize one gamification approach that would fit the whole process of PM. It is unrealistic because PM is a multi-stage methodology, and each stage has its own goals, procedures, and expected deliverables. There is no universal list or sequence of PM stages. However, following Voinov and Bousquet (2010), we distinguish five main stages: (1) preliminary preparation, (2) conceptual model development, (3) quantitative model development, (4) development of solutions and testing scenarios, (5) dissemination of results to a broader audience of interested parties. Below, we further discuss how each of these stages could benefit from serious games and gamification.

> Stage 1: *Preliminary preparation.* At this stage, the first contact with stakeholders is established; therefore, it is vital to create a trusting (R5) and cooperative (R6) environment, so that they would be willing to join the actual modeling sessions. Such an environment could be built by allowing the participants to know each other better (R1) and show trusting behavior (R5) that could be done through relational learning activities. Based on the analysis described earlier in this paper (see Table 1), social simulation games, policy exercises, as well as microworlds that include projections and augmented reality, could be helpful in this case. They create a safe, playful environment where stakeholders could meet with each other for the first time and observe the behaviors of each other (R1) as well as learn more about the benefits of cooperative behaviors (R6) for finding win-win solutions. In practice, it could be done either through organizing additional gaming sessions for the prospective participants or through using online social simulations.

Additionally, at the preliminary stage, the modeling team might be interested in gathering data from the participants by conducting interviews and surveys, or expanding the scope of stakeholders beyond those initially contacted. Serious games could be used as a tool for collecting information about the choices and preferences of the players (N1). Such data should be considered carefully because the preferences in the game might differ from the ones under the conditions of real-life and real problems where stakes are high. Nevertheless, it could give the modeling team the clues about the stakeholders' perceptions of the problem and their preferences around solutions. A gamified online survey which includes a story, non-player characters, avatars, progress bar, and attracting visuals, could be helpful for sustaining the motivation (G1) to submit answers to questions. Such an approach was tested by Aubert and Lienert (2019). One might also motivate the participants to share the contacts of other relevant stakeholders through using constructive competition and tackling the fulfillment of psychological needs for relatedness (G1.3). In practice, it might be useful to consider developing an online communication platform with embedded motivational game elements for managing interactions with stakeholders and sustaining their interest in participation at the preliminary stage and further. Such a platform could help to create continuous gameful experiences due to the possibility to connect several engagement loops or to incorporate the system of progress and meaningful rewards as the user fulfills the tasks such as answering a survey, sharing data, assessing the ideas of other participants and so forth. Alternatively, it might also be possible to use existing online tools for managing group projects and incorporating game elements into them.

Stage 2: *Conceptual model development stage.* At this stage, most commonly, the stakeholders meet with each other for the first time or start to perceive themselves as part of the group, which will be working on the joint task for some time during a PM project. Trust (R5), cooperative behavior (R6), and, sometimes, lowering the level of conflict (R6) is desirable in such a setting. So, similarly to the preliminary stage, the PM session could start from a social simulation game on the topic relevant to the one being discussed.

At the second stage, participants often complete cognitively demanding tasks to define the problem (C1, C2) and its boundaries as well as building a conceptual model representing the problem (C1, C2.1, C2.4). When defining the problem, consideration of time boundaries (C2.3) matters a lot because the group of stakeholders is expected to concentrate on the fundamental roots of the problem rather than the symptomatic events observed in the short-term. In this case, management simulators, model-based games and policy exercises could be useful to explore the dynamics of a system over time (see Table 1). This could contribute to cognitive learning and help the group of stakeholders to prioritize one aspect of the discussion over another (C2.3) and find the focus for further modeling. Defining a problem scope can be very subjective, and each group of stakeholders might have their understanding of what is essential and what could be omitted. Therefore, it would be useful to provide the stakeholders with the tools to help them understand and consider the perspectives of others (R1) in order to stimulate more cooperative behavior (R6). Such relational learning could be achieved by using social simulation games.

Conceptual model development implies a brainstorming process where the participants propose elements to the future model and the interconnection between them (C2.1). There are a range of examples in the literature where the ideation process has been gamified through the use of the reward systems, constructive competition, and visualization techniques (Agogué et al., 2015; Tausch et al., 2014; Yuizono et al., 2014; Zimmerling et al., 2019). According to the standard rules of brainstorming, criticism is undesirable and open expression of thoughts is encouraged. Nevertheless, some participants, especially those representing vulnerable groups with lower decision-making power, might feel reluctant to share their opinions. In this case, game elements such as points, leaderboards, and badges could be used to reward the desired open behavior of the participants (G1).

Stage 3: *Quantitative model development.* There could be at least two critical challenges at this stage: (1) high cognitive load for stakeholders in understanding the logic and the formulas behind a quantitative model, (2) lack of data and discussion on how to model the driving factors of the discussed problem for which statistical data is unavailable. The use of game mechanics could be especially useful in this context to offer high levels of engagement (G2) and enjoyment (G3) throughout the modeling process. Although enjoyment sounds like an inappropriate word for such a serious task, it might be essential to manage specifically negative emotions (G3.2) such as frustration, anger from losing track of a discussion, and the fear of being incompetent in modeling. This could be done through rewarding participant contributions and dividing the process of refining the model into smaller steps with rewards along the way, so that the participants could get satisfaction from fulfilling autonomy (G1.1) and competence (G1.2) needs.

Stage 4: *Development of solutions and testing scenarios.* If at the previous stages of the PM process, the stakeholders had agreed on the roots of the problem and they perceive the developed model as valid, then, at the stage of testing scenarios, the chances of the constructive dialog are often quite high. Moreover, the scenario testing stage of PM has already been extensively addressed by using interactive simulations and model-based games, aiming at easier interaction with the model through 'playing with parameters' and experimenting with different assumptions. Nevertheless, when it comes to actual decision-making and not just experimentation with the model, this could be more challenging. For example, the negative effect of power dynamics in groups where more powerful stakeholders often push for scenarios in favor of their interests. The use of gamification techniques could assist in counter-balancing this behavior. Establishing the rules of communication and rewarding behaviour (G1) that strives for finding win-win solutions are among the possible options.

Stage 5: *Dissemination of results.* At this stage, the most critical objectives often are: (1) help the participants to transfer their shared understanding of the problem and solutions into practical actions (N3), (2) communicate the logic behind the solutions and proposed policies to a broader audience who might be affected by these policies or whose support is essential for implementation. As for transferring knowledge into action (N3), interactive simulations and serious model-based games could contribute through normative learning. In other words, while playing a game, users are reflecting on their values and attitudes towards the problem and vision of the desired future. As for the dissemination of results, the fun factor (G3) inherent in games and gamification could be used to deliver positive emotions, such as enjoyment (G3), satisfaction from accomplishments (G1.2), relatedness to other members of the community (G1.3), and managing negative emotions (G3.2), such as frustration from interaction with the complicated model or boredom. This could potentially increase the engagement (G2) of the involved audience (which could be crucial for behavior change, for example) and attract less motivated audiences to contribute to the problem.

Apart from the idea that game design could be useful for aiding the learning and communication process at each stage of PM, there is promise in a continuous gamified experience that covers the whole PM process. For instance, one could consider development of a reward system where the stakeholders collect points for particular actions during the whole process. They should also be given an opportunity to benefit from these points in a meaningful way, for instance, to exchange them for additional leverages during the voting process at the final stages of PM. Overall, incorporation of such game mechanisms into the process could help to sustain long-term involvement (G2) of the stakeholders and their active participation (G1).

### 5.2. Possible obstacles and limitations of PM gamification

The review of existing applications of gaming in the context of PM has shown that they could contribute significantly to crucial aspects of this process, such as social learning and engagement. Nevertheless, we also foresee possible obstacles and adoption barriers in gamifying PM. These are:

*Lack of case-specific games for particular PM projects*. The PM process is designed to untangle real-life problems, and each problem has its unique characteristics, which come from the diversity of stakeholders' interests and background of a particular situation. Despite the diversity of available serious games for different topics, a game that fully matches the purposes of a particular PM project may be lacking for other projects. This becomes an issue for the modeling team to decide whether it is worth spending limited stakeholders' time on the gaming exercise that might not fully match the problem. However, if the facilitator decides that such intervention is useful for a particular PM workshop, then additional efforts should be put in explaining its positive effects and convincing the participants in such necessity. Another possibility for the modeling team is to develop a game that serves the context of specific PM project. Mayer (2009) mentioned that models could be effectively incorporated into a gaming interface; still, it takes time and mastery to develop a serious game. Considering that time and efforts from the modeling team and stakeholders have already been perceived as a barrier for broader PM use, it seems to be problematic to extend the timeframe of a PM project for the development of a serious game (unless this is crucial for its success). However, even if there is no existing serious game that closely aligns with the topic of a particular PM project, there is still a chance to consider serious games as complementary tools for initiating discussion and aiding engagement.

*Gamification has no ready-to-go or universal solutions for PM*. Researchers and practitioners have made strides in developing diverse gamification frameworks for specific purposes, for example, marketing and customer engagement. Furthermore, the core logic of gamification is that the more it is specific to a particular action context, the more the probability that it would be effective. And although we can formalize the PM process in terms of its stages, we are also aware that each PM project is unique. The sequence of stages might change; the choice of the modeling method (system dynamics, agent-based modeling, and so forth) has a noticeable impact on the process; group dynamics and relations between stakeholders might differ from case to case and impact the design and implementation of the PM project significantly. All these lead us to the conclusion that even though gamification strategies for each stage could be developed based on generic assumptions, it is hard to guarantee that such strategies would be effective in all possible cases of PM. Nevertheless, the availability of gamification strategies for each stage of PM could provide aid to the modeling team in designing the sessions, and in some cases, they may require only slight customizations that are not time-consuming.

*For now, we still lack the tools to assess the impact of gamification interventions on the PM process*. As mentioned earlier in this paper, gamification is a relatively new concept, and like any emerging field, it takes time for it to establish standardized evaluation methodologies. Multiple authors have put effort into developing a rigorous procedure for the assessment of the positive effects of gamification (Sailer et al., 2017; Sailer and Homner, 2019). The research on the evaluation of gamification, particularly in the participatory context, has recently started to emerge as well. As one such example, Aubert et al. (2019) suggested a framework for the design and assessment of gamified interventions in water governance. The challenge of developing an assessment process, particularly for PM, lies in the fact that the PM methodology by itself contributes to social learning and engagement. Therefore, it is hard to measure and distinguish whether the social learning and engagement resulted from adding game elements or whether such positive outcomes took place because of standard PM procedures and efforts of the stakeholders. Additionally, the assessment that is usually used in game design, such as two group pre-test and post-test questionnaires, could not be fully applicable in the context of PM. This is because each group of stakeholders creates a unique output as a result of modeling exercise due to their unique expertise, backgrounds, and mental models. Therefore, any comparison of two experiments with and without gamification interventions should be performed with a certain level of caution.

The existing challenges of gamification adoption in the PM process are, to a large extent, associated with the lack of evidence and lack of practical cases to which we could refer to make a judgment. The adoption of any changes or novelties within a well-established method takes time both in terms of developing scientific grounds for the proposed interventions and from the perspective of testing and evaluating them under the conditions of multiple practical cases. Therefore, with an increase in available trials and evidence, some of the obstacles mentioned earlier might be resolved. We find a similar trend with gamification adoption in the field of education: the more it has been applied, the more evidence the researchers could get and, in turn, extend its practical applications even further (Alsawaier, 2018).

## 6. Conclusion

PM could be perceived as one of those methods that are not 'set in stone'; on the contrary, it is developing over time. Regarding the quality of the process and the possibility to improve it, we claim that PM can benefit from the developments in other fields, such as game design and gamification. To support this statement we analyzed three issues: (1) the existing applications of game design in PM reported in the literature, (2) effects of different types of game-like applications on cognitive, relational, and normative aspects of social learning, (3) contribution of gamification to engagement, motivation and enjoyment of some activity. Our main findings are the following:

(1) Depending on the type of game-like application different aspects of social learning can be tackled. Some types, such as management simulators or model-based games, work better for learning about the complexity of the problem. Meanwhile, other types, such as policy exercise or social simulation, are good for learning about the perspectives of others and building communication skills (see Table 1).
(2) Gamification is a more flexible approach compared to a complete serious game and adding just a few game elements into some process could be both simpler and just as powerful in terms of increasing engagement, motivation and enjoyment.
(3) The seeming simplicity of gamification does not exclude the need for thorough design of gamification interventions. More particularly, most gamification frameworks suggest that it is essential to consider the context of an activity, the goals of the participants, the objectives and desired outcomes from gamification.
(4) PM has been addressed by game design in a fragmented way, mainly through incorporation of visualization, storytelling and interactive interfaces in simulation models or role-playing tasks during the modeling process. However, the overall history of using serious games in the simulation modeling field is long and holds a lot of promise for further elaboration on the topic, particularly for participatory setting.
(5) Considering the fact that PM is a multi-stage methodology, and each stage has its own goals, procedures, and expected deliverables, it is unrealistic to develop a universal gamification strategy for the whole process. On the contrary, customization of game designs to the particular features of each stage is essential. We suggest that each stage of PM can benefit in some way from game design and suggest a range of ideas in the Discussion section of this paper.
(6) Although gamification is a promising avenue for enhancing the PM process, we should also be aware of some limitations associated with the fact that this field is relatively new and still in the

process of finding standardardized methodologies. Lack of scientifically validated evaluation methodologies for gamification is one of such constraints.

The exploration of positive effects from the application of serious games and gamification in PM contexts opens up a range of topics for further research. Firstly, gamification works better when it is customized to the particular context. Therefore, the generic trajectories proposed in this paper could be extended into precise gamification strategies that tackle particular behavioral aspects and goals of specific activities at each stage of PM. Second, there are plenty of different approaches within PM (group model building, companion modeling, and so forth) that imply diverse modeling techniques (system dynamics, agent-based modeling, fuzzy cognitive maps, and so forth). For this reason, it could also be useful to explore which gamification strategies could be universal and which of them work better only in the specific context of PM methods and modeling techniques. Third, evaluation of the effects from gamified interventions could be challenging in the case of PM context because this methodology, by definition, also aims at better learning and effective communication within a group. Hence, it could be useful to develop an evaluation procedure that helps to distinguish the effects of the gamified intervention from the overall outcomes of the PM process. Last but not least, the ultimate practical goal of PM exercise is to implement the solution on which all the stakeholders agreed. At the same time, the implementation part is always hard to accomplish, especially when the solution is connected to the need for behavioral change among some communities. Therefore, additional research could be focused on exploring how gamification can assist in fostering behavioral change at the results' dissemination stage of PM.

Overall, as in other fields where serious games and gamification have been used, the growth in the number of practical applications of gamification strategies under different conditions of PM projects is essential for further progress in this field. With the accumulation of experience and a build up of a critical mass of literature, it will become increasingly evident in which aspects of the PM process gamification can be particularly powerful, and where some other methods and technologies could be of better use.

### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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