Gaming in Social Simulation: Why, when and how

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Abstract
Social simulation is gaining momentum in studying social complex phenomena in many domains. One important goal of social simulation models is the exploration of strategies to manage social complex systems, e.g. human interaction with the environment and social movements. Due to the many possible strategies to manage these systems, and the variety of stakeholders, experimentation with management causes an exponential growth in experimental designs. Yet many scientific communities rely on the experimental method in valuing scientific contributions. Gaming offers a method where stakeholders can interact with a simulation model, and may provide a viable method of studying the management of social complex systems, also using experimental methods. In this paper we explore how gaming might be used in research on management styles, practical management applications and in education. The paper concludes with an exploration of some of the requirements for an effective gaming approach in social simulation.

Introduction

Twenty five years ago Nintendo introduced its game console (NES), and millions of youngsters grew up playing with Super Mario and Zelda. Currently, this first generation of gamers that grew up playing with avatars in a virtual world has come of age, and many young professionals still are actively playing games. Whereas many people from the “older generation” consider gaming as a kind of entertainment, this young generation has experienced the power of interacting with a virtual world. Whereas it is obvious that Super Mario does not really contribute to our understanding of the real world, having a lot of experience with the increasingly complex and realistic games that have been developed over the last 25 years has awakened an interest in many people for exploring the possibilities of gaming in studying and training management skills in more serious environments. It is tempting to think about the possibilities to simulate social systems such as consumer markets, large crowds and social conflicts, and explore if and how these can be managed by operating this simulation in a gaming environment. However, does gaming really bring our understanding of how social systems can be managed to a new level, or is it just a “cool interface” that does not really contribute to what we already know. In this paper we want to discuss why, when and how gaming might contribute to our understanding and management of social complex phenomena.

Why gaming?

Whereas the social mechanisms underlying social complex phenomena have been identified in many social scientific studies, due to the complexity of all the different
interactions between people, statistical inference becomes problematic. In particular it is important to realize that the more turbulent a social system behaves due to these interactions, the more the manageability of the social system depends on how adequate management is capable to adapt to this complexity, but at the same time the less capable statistical methods are capable of predicting effects of management strategies. This for example may partly explain that, despite much practical marketing research, about 95% of new product introductions ultimately fail, and that the intelligence services were surprised by the recent political developments in North Africa. Hence, the more complex a system behaves (at a certain stage), the less predictable the outcomes are (using statistical inference (GLM)), but the more important management gets. It is precisely in turbulent situations where good management can result in favourable outcomes. However, bad management may result in disasters hitting the news, such as failing evacuation plans, civil war and power shortages. In developing models that allow for exploring the possibilities to manage such complex behaving systems, it becomes necessary to develop generative models that explicate the mechanisms at work (Hedström & Ylikoski, 2010). In particular when one is interested in identifying the causalities in more complex behaving social systems, the usefulness of statistical methods is restricted.

Studies taking a social complexity perspective have focused precisely on the question of how large scale social phenomena may originate from interactions at the local level. Here the principle of “emergence” explains how such large scale social phenomena may grow as a resultant of continuous interaction between large numbers of individuals (see e.g. Heylighen, 1997). The other way around, if a certain social phenomenon starts to emerge, e.g., a fashion or a transition, this will have an impact on the perception and behaviour of individuals, a process identified as “downward causation”. For example, when a small group of people adopts a particular opinion or behaviour, this may trigger certain other people to adopt as well, whereas others may reject the same opinion or behaviour.

The methodology of Agent Based Modelling (ABM) has proven to be a suitable approach in exploring the dynamics of social complex systems, and is gaining momentum in many disciplines (e.g. Gilbert & Troitzsch, 2005). In agent based models, agents are connected in a network and follow simple rules that are programmed on the individual level. In a model to investigate a particular social system, these rules can exist of more general behavioural theory and specific data originating from the field. Obviously it is possible to use the model to investigate individual choices of the agents. In addition it is possible to investigate variables on the aggregate level (e.g. opinion changes, diffusion, market shares), as well as developments over time. Furthermore it is possible to do experiments to investigate certain parts of the model or certain scenarios in more detail. For example it is possible to test how characteristics of the first adopters affect the chances of a new product, e.g. by influencing other agents through spreading information and imposing normative pressure. For the validity of the model it is essential that empirical data underlie the model formalizations of preferences and influences between agents.

Whereas empirically validated ABM’s clearly provide a relevant perspective in identifying the social complexities in many social systems, their application in experimentally testing the effects of management strategies remains problematic. A main reason for this is the variety of strategies that can be experimentally tested, the variety of
possible responses of other parties, the variety on the possible responses to these responses etcetera. For example, suppose we have an empirically validated ABM of a particular market, where a number of firms is competing for market share. Also assume that one firm, say X, is interested in testing the effect of a pricing strategy in combination with advertisement. First of all we have to realize that order effects may play a role, hence letting the advertisement follow by a price cut, may have a different effect than offering them simultaneously or in a reversed order. In the simplest case this results in 3 different marketing strategies. Now it is obvious that the other firms will respond to the strategy enforced by firm X. Again taking the simple position that the other (say 5) firms also have 3 possibilities to respond, we end up with 3(firm X) * 3*(5 other firms) = 729 experimental conditions. It is easy to realize that testing more marketing strategies, and the inclusion of responses to marketing strategies of the competition results in an exponential explosion of the experimental design. Realising that in many social complex systems several stakeholders are involved with managing the system, this exponential growth in experimental conditions causes problems in many simulated systems. For example, in opinion dynamics the messages provided by e.g. politicians and experts not only affect the agent population, but they also respond to each other. In land-use models several stakeholders are managing the system, but also here they respond on each other’s managerial activities. Hence we come to the conclusion that in situations where different parties are trying to manage the system, traditional experimental designs are not feasible in identifying promising managerial strategies.

Yet in valuing scientific contributions, experimental methods are understandably common practice, and as such it comes as no surprise that many journals evaluate agent based papers on the soundness of experimental designs (and obviously their empirical validation). In complying to these standards, scientific projects might face the risk of underemphasising the importance of managerial contributions of ABM work. Another risk is that a focus on classical experimentation may stimulate research in less social complex behaving domains, as here validation is easier than in highly turbulent domains. This might over time jeopardise the contribution of ABM in supporting managerial questions in domains where social complexity is a real issue, such as energy transitions, human interaction with and in the environment, political and social movements. Yet the scientific promise of ABM resides in its capability of simulating precisely the social complexity in such societal relevant domains.

Gaming may provide an answer of how to deal with this problem. Gaming has been identified by many scientists within the ABM community as a tool to explore and forecast developments in complex systems (e.g., Arai, Deguchi, Matsui, 2006; Guyot & Honiden, 2006). The essential difference between gaming and experimental designs is that in games the player has to respond to developments as they emerge, whereas in classical experiments the responses are usually defined as independent variables beforehand and have been organized in an experimental design. Leaving the implementation of strategies to real people interacting with the model thus has the advantage of creating a plausible managerial environment, as real people manage the system. In this respect, Horn (2011), a consultant affiliated with McKinsey, acknowledges that simulation games, which he addresses as war games, promise to be a powerful business tool. On the contrary, as each simulation run in a gaming setting will costs considerable time of the participating managers, only a very limited number of runs
can be performed, which limits the analytical depth of studies using gaming. The question that rises is what we can learn from games, which first leads us to the preceding question when games can be used in combination with social simulation.

**When to use simulation games?**

Originating from the mid seventies as a curiosity, today computer gaming is a very large and continuously growing industry. Whereas most games are being developed for entertainment purposes, games have also been developed for the purpose of learning, which is often addressed as “serious gaming”. Such serious games are increasingly being used in professional environments, the flight simulator being a prototypical example. Flight simulators are offering a realistic environment to practice flying skills, and are in particular offering the possibility to train pilots for all kinds of problems and emergencies that hardly occur in practice. Whereas this obviously is a very valuable property of serious gaming, still many people fly a flight simulator on their home pc just for fun. Hence the concepts of fun and learning should not be separated, but for a serious gaming application to succeed learning and fun should be combined.

Gaming is increasingly being used in explorative and training situations, for example the organization of fire fighting departments, military training, marketing games in managing product development and promotion, managing crowd streams in cities and stadiums (evacuation), and managing traffic flows. In developing games for managing societal issues, the field of social simulation could contribute with valid simulations of social behaviour. Whereas a flight simulator is basically being developed on the physical attributes of planes, simulating societal issues requires the modelling of (large numbers) interacting people. Here obviously the contributions in the field of social simulation could contribute to the development of serious games incorporating the dynamics of populations of people, and the management of population behaviour. First steps in this direction have been made in game like settings, for example in evacuation models. Most of these model humans as particles and use flow streams to simulate e.g. pedestrians evacuation behaviour or traffic flow streams (e.g., Helbing, 2010). In the field of social simulation many simulations have been developed that go beyond a particle approach in simulating processes of interaction, often in a non-spatial context. Here behavioural theory is often used in developing agent rules that capture processes as attitude change, informational exchange, (social) learning, normative influences and compliance, changing opinions and consumptive behaviour. Many societal problems, e.g. related to energy policy, sustainability, health and social conflict, deal with more complex interactions between people, and are often simulated using an agent architecture that employs behavioural theory. Yet these theoretically more advanced simulations are not commonly being used in gaming like settings. Some first developments in this direction can be spotted in simulations of land and water management, where policies can be implemented by stakeholders from the field, and the effects of these policies, including behavioural responses from the population, are provided as feedback. A state-of-the-art model has been developed in the GLOWA-Danube project (Ernst et al., 2008). This model is aimed at exploring the regional impacts of climate change and the management of future investments in e.g. in energy management, farming, tourism, industry. The
model is composed of various sub models, including a behaviour theoretical model on innovative behaviour of the population (Schwarz & Ernst, 2009). Scenario analyses are being performed to explore possible futures and how to cope with climate change.

The GLOWA-Danube project shows how stakeholders can be involved in modelling societal issues, and how they can learn about the efficacy of managing this system. Yet it does not offer a “gaming experience” in the sense that multiple players (stakeholders) are interacting through an interface with the model showing how the system evolves over time and responding directly to developments and actions of other stakeholders. If researchers and other stakeholders are interested in exploring the possible developments in a social (environmental) system and testing the efficacy of predefined management strategies a gaming approach is not required. However, if one also wants to study the managerial behaviour of stakeholders, e.g. the efficacy of managerial styles, it is important to create a simulated environment that provides a compelling “gaming experience”, and create a “flow” in the interaction between stakeholder and model. The more realistic the experience is, the more likely it is that the stakeholders are behaving in a natural way in managing the system. This realistic experience has been found to be of use in participative modelling exercises, as players reported the game to be realistic, were involved in playing the game, and their behaviour was realistic (see e.g. Naivinit et al., 2010). Whereas in these participative models behaviour was performed by the players, and exogenous to the model, games that capture many societal issues require an endogenous modelling of population behaviour. Hence gaming in social simulation can be understood as a participatory modelling approach, where the model includes a simulated social system, and the players have the ability to direct policy at changing behaviour.

Returning to the question of “when to use simulation games”, in first instance it can be said that gaming is useful if the stakeholders behaviour is exogenous to the model (participative modelling), if they have a varied repertoire of managerial actions (causing exponential growth in experimental designs) addressing the behaviour of a population (social simulation), and if the stakeholders may respond to each other’s actions (further adding to the complexity of the system). If these conditions apply to the situation, gaming might be useful. This usefulness may apply to three related areas: research, practical management and education. A clear distinction between the three areas is not possible, as the same game can in principle be applied to all three fields. However, since the main goals of games are different in the three fields, we like to pinpoint the main challenges and possible applications for these three fields separately.

**Gaming in research**

In the previous section it was concluded that experimental designs in simulation run into problems concerning the exponential growth of experimental conditions. In studying what management strategies are effective given a certain complex behaving domain, we propose to focus on a more aggregated level, denoted as the management style. A management style is a more generic style of interacting with a system, and originates from open systems theory (Johnson, Kast, and Rosenzweig 1964; Katz and Kahn 1978). This approach states that the long-term survival of a system depends on its ability to adapt its activities adequately to environmental changes. In particular, the timing and speed of response to environmental developments is critical (Thompson 1967, Katz and
Kahn 1978). Moreover, a distinction can be made between responses to the “autonomous behaviour” of the people in the system, versus responses to the actions of other, sometimes competing managers. In marketing this would translate as a customer orientation versus a competitor orientation.

This implies that in a simulation game we can experimentally test under what system characteristics more adaptive or fast responding management styles outperform more conservative strategies. Also it can be tested if and when an orientation towards autonomous developments versus towards other managers (other players in a game) performs better or worse given certain system behaviour. It can be hypothesised that in social systems where normative influences are dominating, lock-in effects are more likely to emerge, which necessitates a faster managerial response to unwanted developments, e.g. the success of a competing technology. In testing the efficacy of different managerial styles, it is possible to let samples of real people interact with the simulated system using a game. Here it is possible to identify their managerial style by tracking if and asking why they initiate managerial actions, and by tracking how fast and with what magnitude they respond to changes in autonomous developments and/or actions of other players, and asking for their reasons. This identification of their managerial style should be related to success indicators to be meaningful in the interpretation of effective policy. In most situations several indicators have to be accounted for, e.g. in an environmental model the environmental quality and quality-of-life of the population should be accounted for. Also it would be possible to measure to what extent participants are capable of developing a correct mental representation of the simulation model structure, which would be a proxy of what is commonly denoted as a “gut feeling” about the system and how it works. It can be hypothesised that more practical experience with the system would translate in a higher capacity to understand the simulated model, assuming the latter is a valid representation of the real system. Experiments using social simulation models in a gaming setting are thus expected to be capable of studying what managerial styles are the most effective in managing real world complex systems. In particular when the simulation model addresses a more social complex behaving system, classical experimentation may be used in identifying effects of managerial styles on system behaviour. For example, it could be expected that certain management styles (or command structures) are more effective in managing incidents in crowds. The importance of having a valid simulation model to conduct these experiments is without question, notwithstanding the many discussions on what precisely a valid model is.

Gaming in practical management
Simulations of real world systems involving social interactions can also be used in a gaming situation. This opens the possibility of stakeholders to interact with a simulated version of the system they are dealing with in practice, and confronts them with potential developments of the system and the possible effects of their management. In particular, a multiplayer environment confronts players with the responses of other stakeholders to system developments in general and their managerial actions specifically. For example, a policy maker aiming to promote energy efficient cars may discover that adapting a tax system to promote hybrid or electrical vehicles may result in an increase of sales of larger energy efficient vehicles, which limits the effects of the policy. The policy maker may
also experience that another player, producing cars, may respond by developing and producing larger models of hybrid cars. Using gaming in such a setting provides managers with a learning environment to obtain experiences with potential developments in the real system. This is expected to increase their sensitivity for developments in the real system, and ultimately may result in better management. A key requirement in such a gaming setting is that the underlying simulation model is valid, and that the players have trust in the realism of the model. This may require the involvement of the players in an earlier developmental stage of the simulation model.

Having such a valid simulation model opens the possibility for stakeholders to play games in exploring their management strategies. It would be very well possible to test different strategies in developing and adapting a policy aimed at a certain goal. Not only different strategies can be tested and compared, but most important is the possibility to explore the effects and countermeasures against the least predictable factor in many social systems: the response of other stakeholders, in particular those having conflicting interests. In the field of marketing it is known that marketing executives consider the potential response of a competitor to be a critical component in strategic decision making Coyne & Horn (2009), but at the same time a survey (Montgomery, Chapman Moore & Urbany, 2005) showed that fewer than 10% actually recalled having elaborated upon responses of the competitors. Gaming in a multi player setting would definitely increase the awareness of the players of these highly relevant interdependencies. Currently, in the field of marketing some multi player gaming tools are being used (e.g., LINKS (Chapman, 2010), Markstrat (Gatignon, Larrêché, Triolet, 1983) and the market simulation model of Unilever). However, these gaming environments are not equipped with a population of interacting consumer agents, and hence the social complexity of certain markets is not being targeted. This implies that policy measures such as targeting specific groups of customer agents (e.g., opinion leaders) are not possible, and important processes related to these interactions (innovation diffusion through word-of-mouth) cannot be captured.

Whereas in marketing studies the possible policies are usually quite clear in terms of product development, pricing and promotional activities, and multiple players are basically having the same policy options, in many other social domains the stakeholders differ considerably concerning their interests and policy options. This implies that – given that a valid simulation model of the issue is available – considerable effort is required in developing an interface for stakeholders to interact with the model that offers a realistic policy environment. For example, if a realistic crowd model has been developed, adding a policy component by adding police forces requires a correct implementation of the command structure of these forces. Here different players can be included, such as central police command and police units in the field. A realistic gaming experience here would first include different levels of system perception, e.g. central command having a more generic overview, versus units in the field having detailed local knowledge. Second, the communication between the different players has to match with reality as much as possible. Verbal interaction seems critical here, and would require an interface emulating communication channels. Third, it should be clear what policy options different players have, thus reflecting the command and operational enforcement possibilities of players. Many internet based multi player games already offer different types of interactive channels, and is seems practical that scientists in developing “serious
Games” explore which of these techniques can be implemented in making practical management games more realistic.

**Gaming in education**

Often it is said that practical experience is the best way to learn. However, practical experience is often hard to obtain. For example, dealing with an emergency situation in a plane is such a rare occurrence that learning from practice is not an option. In particular learning from mistakes would not be practical for pilots in training, thus further justifying the benefits of game. Also in the management of complex social systems mistakes can be made that may have serious consequences, such as evacuations that fail (e.g., the Loveparade incident in Duisburg, 2010), conflict situations where incidents may cause strong negative responses spreading though the population (e.g. armed forces in Afghanistan), or misinterpretations of market developments that may lead to (near) bankruptcy. Realising that most managers operating in domains where they encounter social complex phenomena have not been trained in dealing with this complexity indicates that educational programmes have a responsibility of training their students in the understanding and management of social complex phenomena. Besides a more classical approach in which the principles of social complexity and empirical examples are being taught in literature based classes, the use of educational games may further contribute to a valuable learning experience. Offering students an environment where they can practice their management skills, and make serious mistakes without facing real consequences, may provide a very rich learning environment. Instead of learning principles of social complexity only in a more abstract sense by studying books and case studies, they are being confronted with the effects of their own choices. Especially when things go wrong, this will stimulate them to reflect on their own decision-making process, which will increase the relevancy of the social complexity principles they learned before. Playing intensively with “serious games” may speed up the learning process, and allow managers to develop experience and a “gut feeling” more quickly. Also practical experiences can be related to earlier experiences they had with gaming, thus contributing to the practical learning experiences as well.

In the field of marketing learning games have been developed, such as LINKS (Chapman, 2010) and Markstrat (Gatignon, Larréché, Triolet, 1983), which provide a marketing game environment where students can interact via a web-based simulation tool with a market, where students (or groups of students) are responsible for the management of their company in a competition with other (groups of) students. However, these games do not yet incorporate a population of heterogeneous and interacting consumers, and thus are not suitable for gaming with social complex behaving markets.

In our view it is a challenge to develop “serious games” as a tool to offer students experience with managing social complex systems. Obviously, games can be developed for many types of realistic settings in different disciplinary domains. Whereas the games should provide a realistic setting, the empirical validation of the underlying simulation tool is not as critical as in the case of gaming in practical management, as the experiences of gaming will not directly translate in practical management decisions.

**How to develop gaming for social simulation?**
Starting from the assumption that we have simulation models available that are suitable to use in a gaming setting, the key issue in developing a game revolves around the interface of the game. This interface needs to provide a compelling and realistic view on the issue at hand, has to offer sufficient and realistic means of communication and control, and should be capable of creating a “flow experience” in the players.

Concerning the view of the system the interface should provide a clear view of what is happening in the system. Obviously this depends a lot on what type of system is being captured by a game. In a game where a crowd is being simulated over a few hours, much detail and a clear spatial environment are required, whereas in gaming with e.g. societal developments over decades more abstract information will be presented. Considering the complexity of the simulation models, which may provide detailed information on a multitude of actors, it is clear that not all information can be presented on a single system view screen. Hence in developing games it is important to develop a “view architecture”, which describes a routing to different types of information on the screen. This would enable to have a few main indicators on screen, which can be studied in more detail if needed. This view may also be related to the role of the player, thus reflecting the information a stakeholder is capable of viewing in practice. In a crowd management game a commanding officer would have a different view than units operating in the field. In getting a view of the system it is also possible to use existing methods in combination with the game. For example, if in real situations statistical analysis is being used as a tool, a realistic gaming experience should also offer the possibility to conduct statistical analysis on data from the game.

Concerning the communication and control, attention should be given to a realistic representation of the management system. In simpler games it is possible that a single player (or a group) is interacting with the game, and gets information on other players actions through the interface. The earlier mentioned marketing games use such an approach. However, in many complex domains control is exerted by a group of people, each having different roles, different information and often different interests. This requires more extensive communication between the players. Preferably (for recording purposes) all communication, including verbal & video messages, should be incorporated inside the gaming interface. The players will also have different controls depending on their role. Obviously it is a challenge to get the control options in a convincing and realistic way in the gaming context. This will require the incorporation of stakeholders in the developmental phase of a game.

Finally, the “flow” of the game is essential. If a game provides a convincing experience, and the interaction with the system through the interface is good, the players will become involved, and are likely to behave in a realistic manner. If however the game implies periods of waiting, or uninspiring tasks, it is likely that the players are becoming bored and lose their interest in playing the game. This “flow” characteristic is very important to keep players motivated to play the game, and will support the interest of people in using these kinds of games. However, the experience of fun while playing the game should not overrule the players’ conviction that they are interacting with a real-like situation. A game can be played during a fixed period of time, which may range from hours, but it can also be envisaged that a game will last for several days, where the players on regular times meet (virtually) to interact with the game. Many entertainment
oriented games can be played for extensive periods of time, and players can make appointments to meet and play, which is in principle also possible in a serious gaming context. Finally, the game setting can in principle also go beyond interacting with the interface. Players may have physical meetings, may conduct (statistical) analysis on the data obtained from the game, and may use external sources (literature) in playing the game. Hence the development of games knows many degrees of freedom, and will be very dependant on the domain for which a game is developed.

Conclusions

Gaming offers a new challenging perspective on studying, teaching and managing complex behaving systems. In particular when experimentation with complex behaving systems confronts us with an exponential growth of experimental designs, gaming may provide an alternative for learning about the dynamics of systems and in particular their management. For a viable application of serious gaming in social simulation it is required that the simulation tool being used is based on a sound theoretical framework capturing the processes of social interaction that are relevant, and that empirical data are collected that serve to parameterize the simulated population. It is essential that players have the experience of interacting with a realistic behaving system, including communication with other players. Next the game should create a flow in the interaction process, which contributes to a sense of realism and involvement in the players. Participative modelling approaches already demonstrated that games are capable of obtaining relevant information whilst providing a positive experience to the players. Whereas social simulation is to our knowledge hardly being used in gaming like settings, it is our expectation that gaming may provide a valuable tool in studying the management of complex systems, contributing to the actual management of real complex systems, and in teaching on complex system behaviour. In particular the experimental research of the efficacy of different management styles may provide valuable information concerning the management of relevant societal problems. As there is still little experience with gaming in social simulation research, it is recommended to study how the gaming industry has dealt with a number of related issues (realism, flow), and possibly investigate possibilities to share knowledge in developing serious games.

References


