Complexity in Simulation Gaming

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ABSTRACT

The paper offers another look at the complexity in simulation game design and implementation. Although, the topic is not new or undiscovered the growing volatility of socio-economic environments and changes to the way we design simulation games nowadays call for better research and design methods. The aim of this article is to look into the current state of understanding complexity in simulation gaming and put it in the context of learning with and through complexity. Nature and understanding of complexity is both field specific and interdisciplinary at the same time. Analyzing understanding and role of complexity in different fields associated with simulation game design and implementation. Thoughtful theoretical analysis has been applied in order to deconstruct the complexity theory and reconstruct it further as higher order models. This paper offers an interdisciplinary look at the role and place of complexity from two perspectives. The first perspective is knowledge building and dissemination about complexity in simulation gaming. Second, perspective is the role the complexity plays in building and implementation of the simulation gaming as a design process. In the last section, the author offers a new look at the complexity of the simulation game itself and perceived complexity from the player perspective.

INTRODUCTION

Complexity in simulation gaming is not a new or undiscussed subject, but there is still a lot to discuss when it comes to the role and place of complexity in simulation gaming. In recent years, there has been a big number of publications targeting this problem from different perspectives and backgrounds, thus contributing to the matter in many valuable ways. Understanding complexity, systems dynamics, decision making, building models and multi-agent systems representing reality, designing simulation games and social-psychological context are just some of them. The growing number of contributions is understandable form the point of view of the changing reality. Social, business, and political structures become more complex and the environment, in which they operate becomes more unstable and thus more complex in predicting its potential states and outcomes (Duke, 1974; Mayer, 2009; Otoiu, 2014; Lukosch & Bekebrede, 2014). Answering the call to the growing complexity and the need to transfer this into learning and modeling artifacts the way we design simulation games have all changed too. This change has been fueled by the expanding pool of knowledge on simulation and gaming design, and, on the other hand, by the technological progress, resulting in the growing number of platforms we can use to design and deliver simulation games.

The aim of this article is to look into the current state of understanding complexity in simulation gaming and put it in the context of learning with and through complex gaming systems. However, the term of complexity is well known to game designers and practitioners across the fields and implementation areas, than more careful examination brings us to the conclusion that approach to the role of complexity is very utilitarian and point-of-view related. Complexity is different to the game designer and it changes its role within the design process. User facing the complexity of the simulation game and real-world reference system also observes the complex problem and it is influenced by it through interactions. This paper aim at showing the changing role and place of the complexity form the start of the design process to the final delivery to the user.

Simulation games complexity plays a major role in learning through game systems. Games are one of the best methods to teach about complex systems and problems (Duke, 1974). On the other hand, game and/or task complexity reduces the effectiveness of learning, i.e. if the learner feels the task is too difficult or complex, they will be less likely to engage in the activity and feel motivated to learn or reflect. The so-called complexity paradox (Cannon, 1995) works as a counter-intuitive to games as a learning tools. We can observe this many times during simulation gaming sessions. People play games or undertake activities and make decisions even when they feel uncomfortable with the level of complexity they face, but they still learn, or simply play the selected game anyway.

However, there are many views and layers of complexity itself. One of the major issues is looking at this problem from different angles to see as many facets of the problem as possible. Game design is the first perspective and the author calls for better design tools for complex systems (Meijer, Reich & Subrahmanian, 2014). Complexity in systems design is well established in Klabbers' (2003, 2006) "design-in-the-small", and can be then taken further to be implemented in the society through the "design-in-the-large" process.

DEFINITION AND PURPOSE

Complexity does not have any one or single definition, although many scientific genres use this term. The simplest way to describe complexity is as an antithesis of simplicity. So if the state of having many parts is difficult to understand, then we can say that this state is complex. In the simulation and gaming discipline complexity is almost always associated with systems. "*A system is more than the sum of its parts. It may exhibit adaptive, dynamic, goal-seeking, self-preservative, and sometimes evolutionary behavior*" (Meadows, 2008; p.12). Looking at the systems thinking approach, complexity is "baked in", or "embedded" in the systems thinking, and we can only say that there are simple or complex systems. Therefore, we can use complex systems as equivalents of the definition of a system many times. However, complex systems can produce unexpected and spontaneous outcomes as a result of self-organization, interaction between two or multiple parts thereof, and/or collective behavior (Klabbers, 2006). Thanks to this key feature of complex systems, gaming is the most effective way to study complex systems and to transfer this knowledge to others (Duke, 1982, Klabbers, 1996). The main reason for setting complexity in the spotlight is twofold. The first such reason is the strong need to cope with complexity in reality, the way that simulation games can provide safe and risk-free environments to practice (Kriz, 2003) and if applied correctly, can give a meaningful impact (Duke & Geurts, 2004) on how we understand and deconstruct complex problems and structures. The second reason is how we treat complexity in the process of game design, which plays a very important role in the final quality of the game and how it behaves in real training situations. Both of these reasons correspond strongly with the "design-in-the-small" and "design-in-the-large" (Klabbers, 2006) paradigm. Choosing the right game and structural complexity of the learning experience for the particular game session is the essential core of the meaningful experience and thus ensuring learning transfer effectiveness. This process is a domain of practice and associated with analytical science focused mostly on analyzing outcomes in the specific setting or audience. Building a simulation game representing a complex system or phenomena constitutes different approach a problem and is mostly associated with theory-driven-science and design science. However, in the brad picture we need to bring both of the worlds together in one process from understating the world in its current state to the future simulation gaming solutions serving both educational and scientific purposes.

COMPLEXITY – A MANY-FACED GOD

Following the twofold perspective, we should analyze complexity within two different domains (see Figure 1). The first domain is the simulation games design domain (Klabbers, 2003). It is a process-oriented domain, and complexity is of instrumental nature. It provides a purpose of learning using with simulation games, and is shaped through a process based on the observation of the reality. The second domain is the domain of knowledge. Knowledge and its domain is the set of knowledge that we apply to understand the phenomenon of complexity and that we use to learn how to set the frameworks to particular areas of knowledge (Meijer, 2016) for process and role of simulation gaming as a contribution to the other areas of knowledge like decision making, policy management, organizational management, simulation of large systems, etc. The main reason behind it is that gaming simulation is a very interdisciplinary field and the way we design and use simulation games in training and research also varies through the fields of implementation (Patasiene, Rakickas, Skuncikiene, Patasius, 2014).

Using the model presented below (see figure 1), the author presents the role of complexity in both simulation game design as a process and related aspects of complexity as applied knowledge perspective. From the observer perspective of an entire process, it looks like it starts in chaos and ends in chaos.

PART ONE – REALITY

We do not have to study complexity as a phenomenon to be able to use it in the game design process. The most important skill is the ability to watch and analyze complex systems and/or problems effectively. At first, such systems seem to act and behave in a chaotic manner, but with progressing observation and a growing understanding of the system, we can deconstruct the system's behavioral patterns and feedback loops.

In the case of knowledge science, however, there are theories that help us understand complexity in social and human driven systems. This first comes from policy gaming and the complexity in policy gaming and directly connected with complexity of policy issues. Duke and Geurts (2004, p.223) follow Roelofs (2000, p. 174) typology, which consist of three dimensions of policy issues. The first one is cognitive complexity, which can be translated as depth of number of specialized knowledge needed for proper establishing of that particular policy. The second dimension is socio-political complexity, which represents all actors within the social network, as well, their interest and platforms of articulation. The third dimension is normative complexity, which represents the number of norms and values along with common understanding of that norms within the policy creating and executing process. This is very good example of filed specific understanding and dissemination of complexity at the level of game science.

The second and more comprehensive theory comes from Klabbers (2003:574-576), who offers a classification typology of complexity:

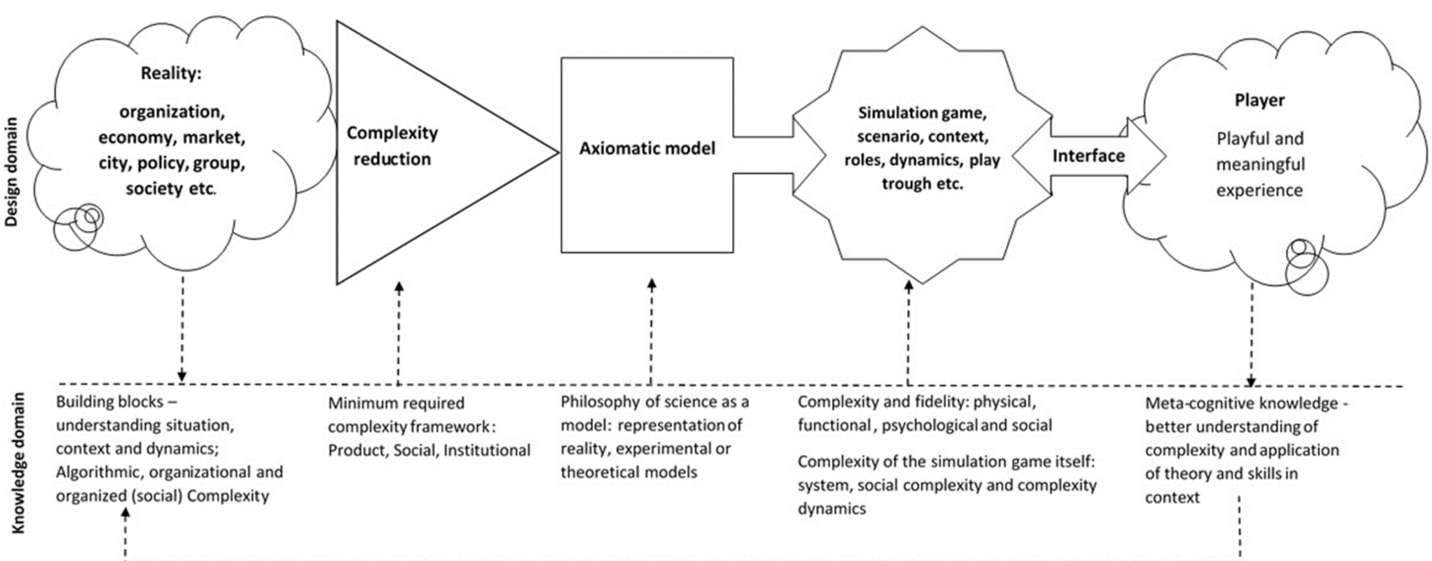
- Algorithmic complexity, which relates to both the calculability of the system (Stewart, 2001) and the quantity of information necessary to describe the system (Cohen & Stewart, 1995),
- organizational complexity, which relates to the ability of organizations to be dissipative, autopoietic, self-reproducing ecosystems and have evolutionary nature (Kaufmann, 1993; Stewart, 2001),
- organized complexity, which relates to the emerging complexity based on the self-awareness of its agents and their ability to act and negotiate in the environment of competing and/or cooperating groups of interest.

Those arts of complexity should be looked at more as dimensions of one and the same system rather than independent factors, and are strongly inter-correlated with each other. In different systems there are also different points of view of the system since algorithmic and organizational complexity can be analyzed from outside, but organized complexity requires an insider's point of view to be investigated properly (Klabbers, 2003). An example of such systems behavior of organized complexity can be the interaction between formal and informal social structures within an organization. It needs some experience, skill, and understanding of correct and effective dissemination of complex systems in order to be able to understand the proportions of all complexity dimensions and their roles. Thus, understanding complexity in both domains is crucial to effective problem solving with the use of simulation gaming.

PART TWO – COMPLEXITY REDUCTION

In order to grasp the idea and/or extract the problem we want to show or analyze through simulation gaming, we have to reduce the complexity of the observed reality and make sense of it. There is no one correct pattern to an effective reduction of a system's complexity in simulation game design without losing its main purpose or feature in focus. In the case of experience of many game designs we can see the process to be based mostly on a trial and error framework. However, in reference literature we find hints to the reshaping of the process of complexity reduction and to keeping the final outcome in control. The first perspective comes from aforementioned policy gaming perspective, which has a long and rich tradition of extracting very complex problems and representing their essence in the form of policy gaming exercises. Their quality is based on the results delivery on the basis of the 5 Cs (Duke & Geurts, 2004): Communication, Creativity, understanding Complexity, building Consensus, and Commitment to action. In this sense, the aim of complexity reduction refers to creation of a meaningful experience to the players and not to creation of a gaming artifact itself, we can also clearly see the connection of the 5C's with the understanding of policy complexity presented above. Building upon this approach, Meijer, Reich, Subrahmanian (2014) propose a more structured and organized framework for systematic design of large-scale simulation games for complex systems. The proposed design framework should be based on a collective and inclusive approach to both the problem and the design process itself. Representation of many perspectives, negotiation, mutual learning and identification of knowns and unknowns is an essential contribution to the quality of the final simulation game design and its ability to transfer knowledge (Kriz, 2003).

MODEL 1 - THE ROLE OF COMPLEXITY IN TWO DOMAINS.



They argue (Meijer et al., 2004) that defining the context of designing is both multi-dimensional in complex systems and difficult by design, as the nature of large scale complex systems is to behave in an unpredictable or even disruptive way. On the other hand, in order to offer a meaningful experience to players, the complexity of a given gaming artifact itself needs to be understandable to the players, who do not necessarily have to be experts in a given field. In this sense, they argue for a multi-dimensional minimum complexity framework that covers the needs for complexity reduction and secures the meaningfulness and relation to the real world systems. The three basic dimensions proposed by Meijer, Reich, and Subrahmanian (2014:157-161) are:

- Product space, which represents products and services, geared towards solving a given problem; it features three sub-dimensions:
- disciplinary complexity – the number of disciplines that are needed to create a given product and service, or involved in the problem together with the set of dependencies between them;
- structural or mereological complexity – decomposition of a given product/service/problem into functional parts together with the relations between them;
- knowledge availability – the amount of formal, informal, as wells as tacit knowledge crucial to the development of the

product or service together with knowledge localization (i.e. actors inside or outside organization). Also the requirement towards new or yet unavailable knowledge.
- Social space, which represents the social unit(s) that create(s) the product space in all specific aspects, from specification to implementation and adoption of the product. The sub-dimensions of social space are:
- inclusion – reassembles the openness of the system environment to new knowledge;
- number of perspectives – the number of points of view essential to effective discerning of the product, and definition and solution of the problem – from conceptualization to implementation;
- capabilities and skills – skills and abilities needed within the social space, accompanying the product journey both in terms of the process and skills in general, like creative thinking, communication skills or systematic analysis.
- Institutional space, which represents rules, norms, routines, and organizational structures, managing and regulating the processes essential to producing the product and addressing the problems within and beyond a given organization. There are three sub-dimensions of this space:
- ties – strength of interconnections between individuals and structures in the organization;
- knowledge accessibility – describes the formal and informal barriers to accessing knowledge within the organization and in larger networks, as well as from outside the organization;
- institutional structure –describes the structure of the institution that designs, produces, and implements a given product, or deals with a given problem.

The Product, Social and Institutional Spaces framework (henceforth referred to as PSI) lets one effectively manage the level of complexity together with interdependencies between the particular spaces. This gives one the ability to introduce the minimal complexity requirement (Meijer et al., 2014) without losing the bigger picture or leaving out critical dependencies and/or problems that need to be addressed.

PART THREE – AXIOMATIC MODEL

The reduced and distilled picture of the problem or organization is the basis for establishing an axiomatic model of a simulation game. Despite the large number of essays and publications on the topic of model building and the fact that models are the most common practice and tool for conveying theoretical knowledge, the ability to build a model is understood more as a craft than knowledge (Morgan & Morrison, 1999). Axiomatic models are rules and dependencies defined and written in a semantic or non-linguistic language together with rules describing the understanding of that language (van Frassen, 1980; Giere, 1988). Viewed as such, models can act as independent entities called agents in simulation gaming, and are built in the process of choosing and integrating a set of items which are considered relevant for the task at hand (Boumas, 1999). Moving through different descriptions of modeling, we explore the philosophy of science viewed in terms of model building approaches rather than functional modeling theories (Morgan & Morrison, 1999). The philosophy of science offers three approaches to model building, which are relevant to the topic of modeling for gaming simulation:

- models as a representation of reality – models' aim is to represent the reality as much as it is potentially possible,
- models as experimental entities – models' aim to create a version of reality extended by experimental elements that do not exist in the reality,
- models as a theoretical mediators – models' aim is to reproduce a theory in order to test its assumptions and logic.

The three trends in the philosophy of science of model building are in line with the philosophy of learning. Models as a representation of reality can be connected to the knowledge acquisition metaphor (Sfard, 1998) in which the learner is a passive observer and acquires knowledge by analyzing the observed reality. Models as experimental entities can be connected to the participation metaphor (Sfard, 1998) in which we actively engage with models to experiment and acquire knowledge by drawing conclusions based on the experimental model behavior. Models as theoretical mediators are a straightforward knowledge creation metaphor (Paavola, Lipponen & Hakkarainen, 2002), in which we build models to test theoretical assumptions and verify new theories through logic.

Although the basic language formalization of models at is base can be the same, the purpose of modeling is critical to the philosophy of the future simulation game functional node. The axiomatic model formulation position in the center of the proposed model symbolizes also a transition from the observer's perspective to the creator's perspective. In the case of the former, complexity is a multi-perspective and multi-dimensional feature of the real world system. However, in the case of the latter, complexity becomes a tool and a feature of the simulation game. The bridge between these two different perspectives is an axiomatic model based on the chosen philosophy that conveys the complexity of the real world systems into gaming simulation systems.

PART FOUR – SIMULATION GAME

The axiomatic model is a major contribution to simulation gaming, which in the process of the final game design turns into learning experience. Effective game design for learning purposes (Kriz, 2003) involves rigorous process to ensure the desired quality of the designed simulation game. The quality of simulation gaming is related to verification and validation (Pegden, Shannon, & Sadowski, 1995). Verification involves checking if the model works as intended, and validation is about checking if the simulation game teaches what we want it to teach and if the conclusions from the gameplay are in line with the conclusions driven from the real world system that it represents (Feinstein & Cannon, 2002). Verification and validation give us the chance and opportunity to model the game in order to reach the desired level of realism (Norris, 1986); model optimization, visual design, narrative, contextual setup, role-playing, debriefing phases, feedback loops, scenarios, game pace, and dynamics are the basic tools for reaching the goals described through the 5 Cs (Geurts & Duke, 2004). At this stage we do not deal with real world complexity anymore, but with simulation game complexity. Real world complexity becomes merely the benchmark for gaming complexity, and an input to the internal and external validation processes (Cook and Campbell, 1979). An important issue in modeling the simulation game complexity is fidelity, which can be defined as the level of realism that a simulation presents to the learner (Feinstein & Cannon, 2001), and it overlaps partially with the definition of validity. Although the relationship between the level of fidelity and the learning outcomes seems to be mixed (Lukosch & Backbrede, 2014), the dependency between simulation game fidelity and simulation complexity is quite clear and in most cases, a higher degree of fidelity represents a higher complexity. However, there are different types of fidelity in simulation and gaming (Lukosch & Backbrede, 2014:145-147):

- functional fidelity – represents the degree to which a simulation game recreates roles, tasks, and process of the simulated agents,
- physical fidelity – represents the degree to which a simulation game recreates the environment of the real world, such as objects, surrounding, sounds,
- psychological fidelity – represents the degree to which a simulation game recreates the emotional and cognitive reactions of the players,
- social fidelity – represents the degree to which a simulation game recreates the interactions and relations between the roles in the game.

Fidelity in simulation gaming is important because it is the main factor of the game interface design. The interface delivers the game content to the player who experiences the game, and so they also experience the game complexity. Despite the mixed results of the research on dependency between fidelity and learning effectiveness in simulation games, the majority of researchers agree that an appropriate level of fidelity and the right balance between reality and abstraction have a positive impact on team awareness, effective collaboration (Meijer & Lo, 2014), and the overall ability of a given game to create a 'multiloge' (Duke, 1974).

PART FIVE – PLAYER

Although game designers' best efforts, game players will take the game and play it in their own way, i.e. in the way we may not expect (Duke, 1974). Looking at the last part of the puzzle we can say that the process ends in chaos. An untrained eye looking at gameplay sessions of many simulation gaming exercises can walk away with the impression that simulation gaming events are of a quite chaotic nature (Otoiu, 2014). The main question arising from the paper is how players experience games' complexity. This question is very relevant because the purpose of simulation gaming and gaming in general is gameplay.

In order to look at the role of complexity in more detail, we should look at certain contradictory problems. The first one is connected to Cannon's so-called "complexity paradox" (1995), who argues that simulation games providing a realistic environment for experimentation with decision-making and receiving feedback are so complex that participants are not able to recognize the dependencies. Linking decisions to consequences through cause-effect relationships is one of the main learning mechanics of simulation, so any too complex and overly realistic simulation games can produce a lower learning effectiveness (Cannon, Friesen, Lawrence & Feinstein, 2009). Cannon (1995), who understands simulation game complexity as an information load and knowledge needed by players to make decisions, has proposed a simplification mechanisms that can be introduced to the game (Cannon, Feinstein & Firesen, 2010: 173):

- "*Strategic chunking – where players effectively reduce the amount of information they need to process by grouping, or "chunking", a set of related ideas into higher-level, more abstract ("strategic") concepts.*
- *Sequential elaboration – where players reduce the effective complexity by breaking complex thinking into smaller, less complex parts, spreading them out over time.*
- *Organizational specialization and coordination – where players reduce individual complexity by distributing components of complex tasks among different members of the simulated organization.*
- *Intermediate measures of performance – where games are structured to reward players for successful performance or achievement of a component task*".

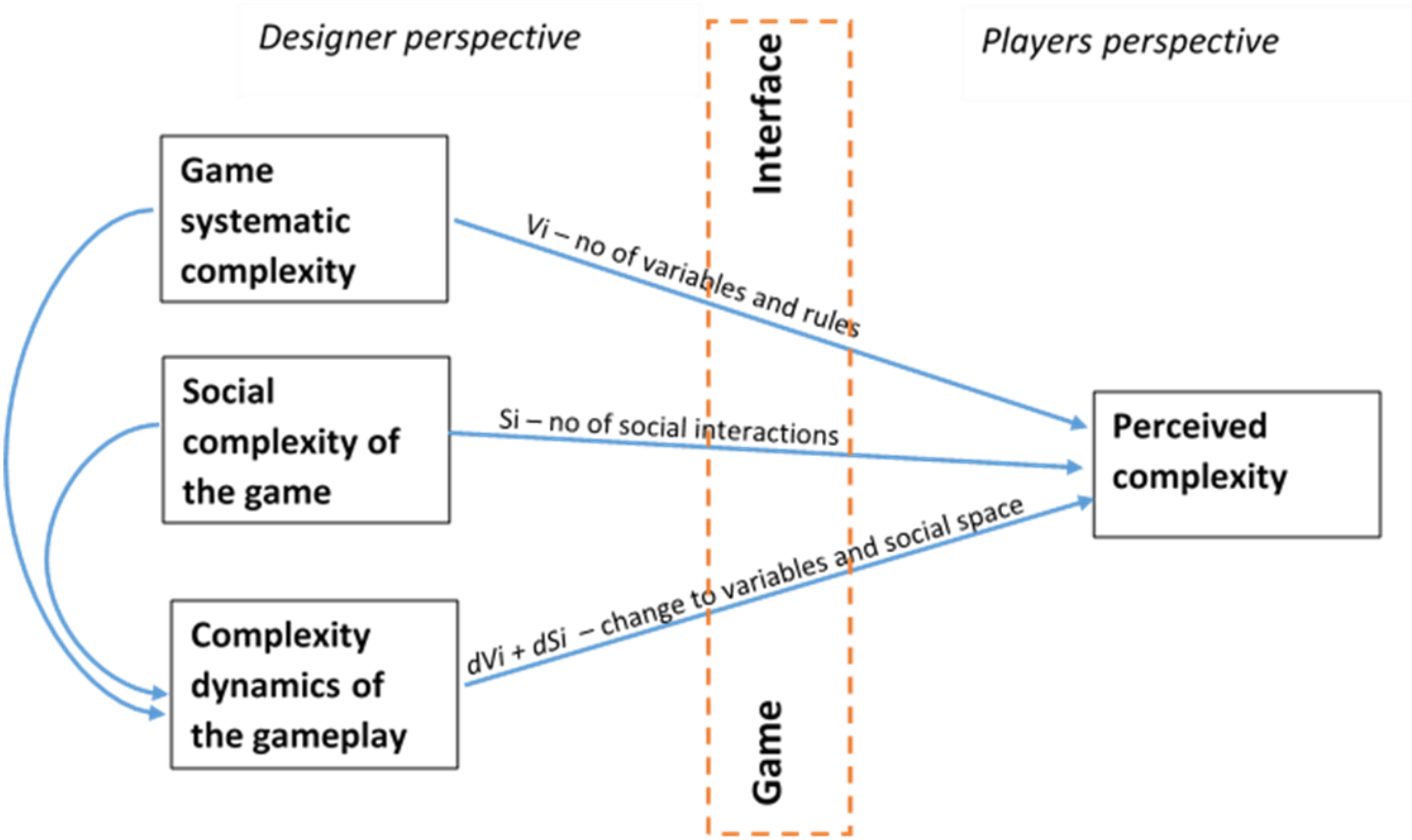
Cannon's framework seems to cope very well with simulation game complexity that can be seen as the number of decisions, functions, and concepts built in the game, where a larger number of them would lead to a greater level of game complexity (Burns, Gentry & Wolfe, 1990). Actually, it has created another type of simulation game complexity because many students can have problems with understanding abstraction and therefore perceive it as uncertainty (Cannon, Friesen, Lawrence & Feinstein, 2009).

Looking at this example we can see that studies on roles of complexity in simulation gaming are still an important and relevant problem in the field in question, and one that still needs new perspectives.

PLAYER'S PERCEPTION OF COMPLEXITY IN SIMULATION GAMING ENVIRONMENT

The complexity of a simulation game is transferred to players through the lens of the game interface (Whiton, 2009), which is a tool in managing interaction complexity and limit players in the way, in which the game communicates and transfers information to its players (Meijer, 2015). Players perceive the level of task complexity based on the game and gameplay. This level depends also on the profile of a given player, i.e. their experience with games, age, culture, level and type of education, etc. (see figure 2).

MODEL 2 – COMPLEXITY PERCEPTION MODEL IN A SIMULATION GAME.



Players experiencing complexity in the simulation game they play are influenced by three dimensions of complexity that interact with each other:

- Game systematic complexity – can be derived from the number of rules, variables, and interactions between them. This represents both how many decisions have to be handled, and the 'depth' of the decisions that need to be made, which is how much information and how many variables players have to take into consideration taking a given set of decisions.
- Game social complexity – simulation games are social systems (Klabbers, 2000) that have their own dynamics and structure. Complexity is represented as a number of interactions with different agents, parties and roles within the game.
- Complexity dynamics of gameplay – changes to the systematic and social complexity that requires player to adapt to a new situation or game configuration.

The first two dimensions are derived from the classical theories represented in the existing literature on dealing with complexity in simulation games, validity of games, and state-of-the-art game design (Klabbers, 2006a, 2006b; Girard, Ecalle & Magnan, 2012; Bekebrede, Lo, Lukosch, 2015; Meijer ,2015; Lankveld, Sehic, Lo & Meijer, 2014). The third one has been adapted from the dimension of dynamic decision making, and represents the body of knowledge analyzing human behavior when you have to take decision today altering the state of the system and influencing new level of decision making tomorrow (Dhiel & Sterman, 1995). They are pointing out that dynamic decision tasks vary in terms of dynamic complexity, which is a counterintuitive behavior of complex systems that arises from interactions between agents over time (Sterman, 2015). This is caused by misperception of feedback, time delays, stock-and-flow problems, and a tendency to look at the world from a narrow reductionist perspective. The simulation games mimicking the complex real-world systems are not free from the dynamic complexity, as we want to teach people to deal with complex problems with higher efficiency. If one of the constantly arising issues is the increasing complexity in real world systems, it leads to a change in the way we design simulation games adding more dynamics to both games and gameplay itself, organizing it in a more flow-oriented fashion (Wardaszko, 2016). One of the reasons behind it was the need of lowering the complexity threshold at the beginning of the game and avoiding the risk of shutting-off and random decision behaviors among players. In gaming we want to bring such complexity closer to players, and the players should be able to understand it, but the more real and sophisticated simulation games are offered to players, the greater the challenges related to the complexity of simulation game exercises we face. This builds a growing pressure to understand the issue of complexity in simulation gaming itself better, and to pursue a constantly learning of how to manage the process of handling the matter of the systems complexity in the process of design and how to use the existing body of knowledge to handle it more systematically.

CONCLUSIONS

The author of this paper aims to look at the problem of complexity from different angles and perspectives of design science and knowledge (Klabbers, 2003). This general idea was that for the presented issue to be manageable, the aim was to focus on a rather small number of relevant theories from a large range of areas and most recent publications. In the pursuit of these efforts, the author explored the most recognized and latest achievements in the covered disciplines concerning complexity in relation to simulation and gaming.

It seems clear that the growing complexity of the real world will pose a growing challenge to game designers, and is reshaping the way we need to look at game design even now. The challenge of using an interdisciplinary approach to the complexity issue in the lack of common ground among the practitioners and scientists. From the design point of view, complexity does not have to be studied for the purpose of simulation game design; it has to be observed and skillfully distilled into the essence of the gameplay. From the scientific point-of-view, researching complexity is an important factor in policy analysis, systems analysis, dynamic decision making and organizational studies. In both cases, however, understanding complexity and many roles it plays in simulation gaming is an essential contribution to the quality of the simulation games itself, learning experiences and knowledge creation (Duke & Geurts, 2004).

The proposed modeled solution propose two different models with different scope and level of detail. The general model 1 (see figure 1) aims at offering a more systematic view of the role of complexity in simulation game design and a bigger picture that can be easily lost when going deeper into particular problems that are multi-dimensional by nature (Meijer et al., 2014).

The second model (see figure 2) aims at building a new approach to the gap in the knowledge discovered during literature studies on how players actually experience complexity. It goes much more in detail but it also covers much narrow scope of interaction. Although, it also offers the level of comparison of simulation game complexity of different simulation games. This is, of course, an answer that will be the objective of the future studies and modeling attempts.

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