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DOI
10.1007/978-3-030-63464-3_44

Publication date
2020

Document Version
Final published version

Published in
Games and Learning Alliance - 9th International Conference, GALA 2020, Proceedings

Digital Versus Analogue Simulation Games: Influence on Validity, Play(er) Experience and Learning Outcomes

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Abstract. The aim of this paper is to analyse whether the design decision in terms of the choice between a digital or an analogue simulation game does have an influence on validity, play(er) experience, and learning outcomes. Therefore, we analysed and compared a digital and analogue version of a simulation game for port management regarding their validity, play(er) experience, and learning outcomes. Our results showed that engagement is one of the key factors for learning, but that simulation games need to be realistic enough to also guarantee specific learning outcomes. Further research is needed to statistically evaluate our findings and the applicability of these results in other games.

Keywords: Simulation gaming · Digital games · Analogue games · Complex systems · Socio-technical systems · Learning · Immersion · Validity

1 Introduction

Societies have grown in complexity due to the increasing dynamics and different functional systems that are interconnected [1, 2]. A complex system can very broadly be defined as *"one in which there are multiple interactions between many different elements of the system […]"* [3]. Due to the characteristics as emergence, self-organization and adaptation [4], complex systems are difficult to analyse and to design. Simulation games open the opportunity to analyse the behaviour of (individual) actors within a social network and in relation with changes in the physical environment [5]. This creates an unique learning environment, while other instruments focus on solely the technical-physical aspects without taking into account personal choices or social network aspects [5, 6].

In general, it is said that simulation games work [7] and that they are suitable tools for learning. But what is the powerful element of such games? Why do they work? Simulation games can be understood as a special method for multilogue communication [8] and of participatory modelling which makes it possible to provide an environment that is structured and safe to (inter-)actively learn about complex problems [9]. Learning occurs on different levels and activates and generates different resources [10]. Simulation

I. Marfisi-Schottman et al. (Eds.): GALA 2020, LNCS 12517, pp. 441–446, 2020.
https://doi.org/10.1007/978-3-030-63464-3_44

games can be build upon these different learning levels and resources, so the process of understanding specific game dynamics and also of playing a game can be defined as (parts of the) learning (process) as well. Gee [11] stated that learning always takes place in well-constructed games, but how can we guarantee a proper design and development of such games. To the best of the authors' knowledge, there are just a few publications about the consequences different design decisions have. Theories and approaches related to the design and development of simulation games, such as Harteveld [12], focus more on the general level of gaming, but what is the difference between digital and analogue games especially for games with the objective to the analysis and design of complex socio-technical systems?

2 Digital and Analogue Games

From the 1980s, the use of computer simulations has increased and also the first computer games were developed. The idea was that by using computers more detailed and valid data could be given about the future. In addition, the idea was that graphics would increase the experience. However, the resources needed to develop these highly realistic digital environments also increases and it is not sure that the outcomes and impact of games are indeed better. Meijer [13] compared low-tech and high-tech games for innovation with each other and showed that *"[…] despite the higher precision, fidelity of high-tech simulators was not necessarily better than that of low-tech cases"*.

Another study was conducted by Kurapati et al. [14]. They explored the similarities and differences of learning outcomes after playing a digital and analogue version of a similar game. Therefore, they organized gaming sessions in different countries, let group of players play either the analogue or the digital game and analysed differences through a post-game survey that measured the learning experiences. Their results showed that the type of a game had just a limited effect on the learning experience, but more research in this domain is needed to derive valid conclusions.

Portelli and Khaled [15] stated that *"analogue games […] are more than capable of eliciting very real emotional responses in their players […]. They are also much simpler to design in a complete way in a shorter span of time; both in terms of concept as well as mechanics"*.

Fang, Chen and Huang [16] did a study in which they wanted to know if analogue games evoke different social interactions and reactions than digital games do. They let their participants play different versions (desktop, tablet, analogue) of Monopoly and Jenga and measured the emotional satisfaction of the players through a questionnaire. They found out that analogue games evoked stronger emotional reactions of the participants. In addition to this, analogue games improved the social interaction as well. This fact has also been given attention by Freese, Schier and Mühlhausen [17] who compared the gameplay of a digital and analogue version of an airport management game.

To conclude, digital as well as analogue games showed their effectiveness for understanding complex problems. However, one of the main question is still what the difference is between digital and analogue games and what this means for characteristics of a game(play), such as validity, play(er) experiences, and learning outcomes. So far and to the best of the authors' knowledge, research articles focused very often just on single concepts but not on the mentioned variables as a whole.

3 Analysis Based on Hands-on Experience

In the following, the focus will be on the description and comparison of a digital and analogue version of a port management simulation game. Although both games have some differences, such as a different number of players, we believe that both versions are comparable with each other because these are validated and evaluated games, they were played with students, so the target groups of the gameplay sessions can be compared with each other, and the same facilitators moderated the gaming sessions.

3.1 SimPort-MV2 Versus PortConstructor

SimPort-MV2 and PortConstructor both simulate the strategic decisions of the port planning of Maasvlakte 2 in the Port of Rotterdam. The first version of SimPort-MV2 has been launched in 2005, while PortConstructor is developed later, based on the success of SimPort-MV2, in 2018. The objective of both games is to develop Maasvlakte 2, the newest extension of the Port of Rotterdam, taking into account the objectives of the Port of Rotterdam.

SimPort-MV2 is a hybrid game, where a team of 3 to 6 players represents the board of the Port Authority, consisting of three roles building director, commercial director and general director. Each role is responsible for certain actions, such as building the port area, negotiate with clients and keep track on finance and performance. Decisions have to be added in a computer program and the effects of the decisions are visible on a beamer, representing the 'current' state of the port area. The game takes about 5 to 8 h to play, including briefing and debriefing [see 18 for a more extensive description of the game].

PortConstructor on the other hand is an online game. The player represents the general director of the port area and the other roles are presented as a non-player characters providing information about potential clients, placing clients to parcels, and informing the forecasts and news. In PortConstructor an infrastructure manager is added who can build infrastructure in the port area, an element which was not part of SimPort-MV2. The general director is often played by two players as team to increase communication about the decisions.

In both games, participants start with a strategy phase, where they have to decide about their objectives and have to define the Masterplan. After the strategy phase, the participants have to execute the strategy, by contracting clients, assigning the clients to the port, and trying to develop Maasvlakte 2 in the best way.

3.2 Methodological Approach

Sessions of both games have been played with professionals (Port of Rotterdam) and students from different educational institutes (TU Delft, Unesco IHE and in port management programs). These sessions have been evaluated with a pre and post survey. The students in this analysis followed a 'Project Management' course at the Faculty of Technology, Policy and Management at Delft University of Technology. The game SimPort-MV2 is played several years in a row and the game Port Constructor is played two times as this game is released in 2019. Therefore, the number of the respondents

is higher for SimPort-MV2. The post-game questionnaire consisted of some open questions, and statements with 5-point Likert scales (from 1 totally disagree to 5 totally agree). The statements involved questions about the quality of the game, the manner in which they have played the game, the use of the computers, and the acquired insights. For the descriptive analysis of the quantitative data from the questionnaires we use the analysis program SPSS (version 25).

3.3 Results

Students playing SimPort-MV2 and Port Constructor both had the feeling that it improved their learning ($M_{PortC} = 3.72$, $SD = .70$; $M_{SimP} = 3.86$, $SD = .75$). However, students of PortConstructor did not agree with the statement that the game was educative ($M_{PortC} = 3.26$, $SD = .86$; $M_{SimP} = 3.88$, $SD = .75$). In addition to this, students playing SimPort-MV2 said that this game better promoted communication ($M_{PortC} = 3.67$, $SD = .82$; $M_{SimP} = 3.86$, $SD = .76$) and integration of different disciplines ($M_{PortC} = 3.57$, $SD = .69$; $M_{SimP} = 3.72$, $SD = .80$), and a higher score of students playing PortConstructor highlighted the technical ($M_{PortC} = 3.72$, $SD = .78$; $M_{SimP} = 3.32$, $SD = .98$) and strategic complexity ($M_{PortC} = 3.98$, $SD = .61$; $M_{SimP} = 3.81$, $SD = .86$) and got a better understanding in terms of the effects of the decisions of the port ($M_{PortC} = 3.70$, $SD = .79$; $M_{SimP} = 3.40$, $SD = .91$).

Although the scores regarding elements of gameplay experience and validity for both games are high, the participants of SimPort-MV2 enjoyed more ($M_{PortC} = 4.02$, $SD = .61$; $M_{SimP} = 4.16$, $SD = .70$) and scored higher on the statement that the game was build up in an interesting and stimulating way ($M_{PortC} = 3.70$, $SD = .90$; $M_{SimP} = 3.40$, $SD = .80$). Participants agreed that the aim of the game was clear and that facilitation was good. They also agreed about the clearness of the instructions; however, these were lower for PortConstructor ($M_{PortC} = 3.38$, $SD = .61$; $M_{SimP} = 3.61$, $SD = .90$).

Both groups of participants agreed that the games are sufficient realistic ($M_{PortC} = 3.61$, $SD = .68$; $M_{SimP} = 3.57$, $SD = .84$). We see a difference in the reflection in the game, which is higher for SimPort-MV2 ($M_{PortC} = 3.56$, $SD = .77$; $M_{SimP} = 3.92$, $SD = .84$). The results also show that participants of SimPort-MV2 played more from the perspective of their roles ($M_{PortC} = 3.59$, $SD = .82$; $M_{SimP} = 3.81$, $SD = .74$) and also other players took a role ($M_{PortC} = 3.73$, $SD = .83$; $M_{SimP} = 4.02$, $SD = .62$), more than in PortConstructor.

4 Discussion, Conclusions and Future Research

The aim of the present paper was to analyse whether the design decision in terms of the choice between a digital or an analogue game would have an influence on the validity, play(er) experience, and learning outcomes. To answer to this question, a comparative analysis of a digital and analogue version of a simulation game for the complex system of a port has been done. The discussion and interpretation of the results is structured around the topics of validity, play(er) experience and learning outcomes.

1. Regarding the *validity*, we were not able to find huge differences in terms of the perceived type of complexity of both games, so further research in this area is needed.

An idea here could be to work on a set-up that makes it possible to test the same sample twice, so that biases based on the sample can be reduced. However, complexity can be understood in different ways. Our observations have shown that you can address technical complexity quite easily in and with a digital simulation game, whereas the more social-related complexity (such as communication-related aspects) can easily be addressed by an analogue game.

2. Regarding the *playability*, the results indicated that digital and analogue games generate a different style of playing a game. In analogue games, the focus is quite often on discussions which sometimes can have a negative influence on the gameplay itself, because the players need too much time for making a decision. In digital games, players very often follow the trial and error approach, meaning that they just do a certain action and directly see what the consequences are (but do not think about it). Secondly, *emotional experiences* play an important role. Here, a correlation analysis showed that identification with an in-game-role has a positive effect on learning ($R_s = .42$, $p < .001$), so the engagement players show is directly and positive correlated with general learning processes. This could be a point of interest for further research, too. As soon as you work with a role change and a good role description including the description of the tasks and areas of responsibility of this role or have an immersive game, it might have a positive influence on the engagement of the players and on the general learning as well. Thirdly, digital and analogue games generate different *social interactions.* We already discussed this briefly, but the analysis of social interactions in the digital and analogue version of the port management simulation games has confirmed this pattern. Often, digital games are less interactive as their focus is more on technical and/of strategical components and the understanding of effects, whereas the focus of analogue games is more on communication and integration. We want to highlight that the comparison of the two games in terms of the degree of the social interaction might be difficult due to the fact that their set-up was different. Interestingly, you can see this clearly back in the way of how people have played the game.
3. Regarding the *learning outcomes*, players learned (slightly) more about technical complexity in the digital game and about communication in the analogue game. In addition to this, the understanding of consequences on the port design was higher in the digital game, whereas the understanding of how you need to integrate things was higher in the analogue game.

To conclude, the results showed that engagement is one of the key factors for learning. If you are having fun, you feel like you have learned something. But a game needs to be realistic enough to also guarantee specific learning outcomes. The focus of this paper was mainly on the comparison of analogue and digital games, but it is also possible to combine aspects of each game type with each other. Generally spoken, analogue and digital games are both suitable methods for analysing and understanding complex systems and for learning as well.

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