Design Considerations for Building a Scalable Digital Version of a Multi-player Educational Board Game for a MOOC in Logistics and Transportation

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Abstract. With more flexible and large-scale learning environments, new design requirements for games emerge. Massive Open Online Courses (MOOCs) are one of the most important innovations in the learning field. Still, it is a challenge to motivate learners and to keep them motivated in such huge learning environments. To address this challenge, we redesigned a board game targeting at an integrated view on disruption and communication management in an intermodal transportation situation. From the redesign, we have learned that an online game works better with fewer roles, requires immediate feedback, and an engaging way of challenge to keep players motivated. Our findings can inform the design of games for large groups of players in an online environment.

1 Introduction

MOOCs or Massive Open Online Courses represent a new dimension of 21st century learning environments. MOOCs enable long distance learning to an extensively distributed audience and are widely discussed to be alternatives to traditional classroom learning [1]. In traditional classroom settings, only a few people benefit from the learning environment offered, whereas MOOCs are able to reach a diversity of learners, especially those who are not able to attend high-quality formal learning courses, because of location, time and costs. Although MOOCs have unique advantages such as the ability to reach a broader audience, provide easy accessibility, high flexibility, open and often free course materials, they are often affected by high dropout rates [2]. One reason for this could be seen in the fact that most MOOCs are still based on basic text-based materials, video lectures and interactions in forums [3]. MOOCs face the

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challenge of designing learner-centered online courses, rather than just providing open access to static educational resources [4]. As they provide a huge opportunity for self-organized learning, there is a clear need to support learner's motivation and engagement by innovative and sophisticated instructional design, personalization and adaptability of the course [2]. We therefore propose a gamification of MOOCs in the sense of an integration of game elements and complete simulation games in the online learning process. The integration of simulation games is considered to have the potential to improve learner's motivation [2]. However these ideas are theoretical, and there are onle a few examples of simulation games successfully implemented in MOOCs yet [2, 3].

As an answer to this challenge, we started to develop a new MOOC called "Innovation in Logistics". This MOOC will represent a 5-weeks course targeting at students on a master level as well as professionals from the transportation domain. Innovative logistical concepts like automation, synchromodality, and management of big data will be discussed. Up to now, it is only a small group of students who are able to follow teaching programs dedicated to Transport and Logistics all over the world, while the societal and economical role of this domain is still growing. The new MOOC will support explorative learning approaches to motivate and engage a large group of learners. Simulation games and game elements will form an integrated part of this learning experience within the MOOC. As one element of this new course, we redesigned an existing and evaluated board game known as the "Container terminal disruption management game" that was focused on the development of Situational Awareness (SA) in integrated planning of container terminal operations. SA is considered to be a pre-requisite for good decision making [5, 6]. The game is built on simulation gaming methods to research and train problem solving capabilities in relation to SA [7, 8]. The board game has been successfully designed, tested and implemented in classroom settings and professional institutions [9, 10]. For the integration in the new MOOC, we redesigned the board game into an online version. The redesign of the game was based on lessons learned from a first prototype of a mobile version of the game.

The key contribution of this paper is to analyze the design process that started with a board game, which was then transformed to a scalable mobile game and finally redesigned towards an online game to be integrated in the MOOC. We provide insights in the lessons learned from this transition process, and into advantages as well as pitfalls that come with the technology change of the game.

2 The Container Terminal Disruption Management Board Game

Container transportation is a multi-modal system of transporting goods bundled into steel containers aimed at cost-effectiveness, safety and quicker service times [11]. Container terminals are crucial hubs in the global transportation network of goods that act as coupling and decoupling points for the transfer of containers from sea to land and vice-versa. The storage area of the terminal is called the yard, where containers are stored in stacks, thus facilitating the decoupling of seaside and landside operations [12].

Planning and aligning all functions in a container terminal is a difficult task [13]. All planning activities of e.g. berth location and timing of deep-sea vessels, and the sequence of containers to be (un)loaded, are interrelated, and changes in one plan have a big influence on other plans [14]. Moreover, container terminals are often affected by a wide range of disruptions like common equipment failures, sudden demand shocks, weather conditions, conflicts and political unrest, or even terrorism [6]. Each of the disturbances, disruptions or risks, described for instance in [15, 16] can have debilitating ripple effects on the container terminal, causing financial, operational, or collateral losses and in rare cases affecting human operator safety [17]. Therefore, important challenges for container terminals are related to integrated planning, effective disruption and information management. These challenges form the basis for the learning objectives of an educational board game to train participants in problem solving.

The Container terminal disruption management game, henceforth referred as the *game,* is a tabletop 5 player board game representing a setting of a container terminal. The game was designed based on the triadic game design approach of balancing the game aspects reality, meaning and play [18]. The game consists of five different roles (berth planner, vessel planner, control tower operator, resource planner and sales), each responsible for specific planning and operational tasks in the container terminal. They also need to maintain healthy levels of three main key performance indicators (KPIs) of the terminal namely Safety, Customer Satisfaction and Performance. See [9] for detailed description of the roles and rules of the game. As the game unfolds, disruptions start occurring that drastically affect individual operations as well as the operation of the entire organization. Three disruption scenarios each with varying levels of severity have been modelled in the game.

With each round of the game, the event complexity increases and the disruption situation escalates, unless some action by the players is taken. In order to make the 'right' decision and 'win' the game, participants need to manage information, communicate and coordinate if necessary, monitor the effects of disruptions and take the necessary actions at the right time to mitigate the negative effects. The game has three difficulty or complexity levels. In every successive level a new disruption unfolds in addition to the existing disruptions creating a more complex scenario for information exchange, coordination, effect control and decision-making.

The game was tested among several groups of 80 students and 25 professionals, all from the field of transport and logistics, to assess its usefulness as a learning method for disruption management in container terminals. The game play was observed along pre-described observers' guidelines and by the use of a post-test survey. An overview of the study including the analytical methods can be found in [9, 10]. From the survey data on the learning effect due to the game play, about 16% responded that it would be *very helpful*, 37% of the participants felt that the learning experience from the game would be *helpful*, and 38% felt that it would be moderately helpful, 9% answered slightly helpful to better prepare them to handle real world disruptions. Not even one participant responded that it would be not helpful.

Most of the participants (80%) stated that they learnt that communication and information sharing are extremely important for disruption management container terminals [9]. Descriptive answers from the survey highlighted learning aspects

imparted from the game by participants. Following this, the game represents a good exercise to understand the importance of disruption management in transportation and supply chains. It also shows that it is difficult to pre-determine a perfect or optimal solution to manage disruptions, and that decision-making during disruption management is more complex and inter-dependent than one thinks. Communicating the right information at the right time is very important, as well as integrating the different pieces of information to make good decisions.

The results from the above mentioned sessions demonstrate that helpful learning experience in the field of disruption management of container terminal operations has been created with the use of the board game. While these positive results are encouraging, we observed several obstacles to adopt the board game as a scalable teaching tool as described below. First, the board game always requires an experienced human game master to be present in order to control the complex game processes. Secondly, the distribution and scalability of the game is limited to a small group of participants. Thirdly, in the board game only the human memory is available for debriefing, thus the learning experience is also limited as not all user interactions and decisions are tracked. Fourthly, the board game requires all players to be present in a single room at the same time. While this fosters a common game experience, it imposes an unrealistic situation, as in reality the different persons would be distributed across the port [19]. Based on before mentioned limitations of the board game, we aimed at further developing the board game to a more scalable and distributable version. We chose to re-develop it into a mobile game, which will be explained in the following sub-section.

3 The Mobile Version of the Board Game

The mobile version of the board game was developed in a platform called ARLearn. Subsequently the game can be downloaded as an Android application in all Android supported smartphones [19]. The instructional content of the mobile game is similar to that of the board game but some modifications have been made in the redesign for the sake of playability. The 5 roles in the board game have been consolidated to 3 roles (berth planner, controller and sales) to reduce waiting times of players due to communication delays. Every participant can choose a role to play.

The ARLearn game engine automatically updates the game state, evaluates player decisions and distributes information. Game rules, processes, decisions and all other game resources are encoded as game design script in ARLearn [19]. The mobile devices provide a realistic scenario, as the players use communication means similar to their daily activities as the game interaction is based on mobile devices. Users receive messages and interact with question items. Players don't need to be in one location but can be mobile [20]. In spite of the promising nature of the mobile game with respect to scalability, our initial and internal tests taught us some lessons regarding the usability and feasibility of the mobile game as a teaching tool for a large audience. Although it addresses some of the limitations of the board game, the main reasons for not considering this version of the game for the MOOC environment are related to the mobile technology used. First, the mobile game is not versatile as it can only be installed on

Android supported mobile devices. Secondly, although the mobile version provides a more scalable version than the board game, it is not a good alternative for a MOOC where students have flexible learning times, and not always have access to smart mobile devices. Thirdly, students in MOOCs are distributed geographically and it is difficult for 3 students to synchronize their timings and organize themselves to play a game that is supposed to be a fun learning instrument and not a burden. Technology glitches, connection issues might also arise. Fourthly, the platform doesn't have a 'digital game master' that can assign students to groups of 3 players, so that if two groups are playing simultaneously they will be aware who they are playing against and in which group they belong. Fifthly, all the actions in the game are text based, which might not contribute to player motivation in a massive online learning environment.

Given the above reasons, we decided to completely redesign the board game into an online game by keeping in mind the special and novel environment of MOOCs to integrate simulation games.

4 Redesign Towards a Scalable Online Version for a MOOC

In order to support the learning process and to foster motivation of the students, design requirements for the online game have been drawn from the specific learning situation within a MOOC. For certain aspects, this meant to radically change the initial design of the board game, also based on the lessons learned from the development of the mobile game in between.

4.1 Design Requirements and Challenges

Before starting developing the scalable online version of the game, we especially discussed the game design requirements within a team of experienced game designers. Again the triadic game design philosophy [18] was used as starting point for the redesign. Starting from the lessons we had learned from the mobile game, we identified four main requirements for the redesign of the game. First, it should motivate communication between players, even in situations where players are distributed amongst space and time. Secondly, the game should provide immediate and clear feedback to player actions to keep them motivated within the MOOc environment. Thirdly, information about other players' actions should be given to enable social learning. Fourthly, the online game should include less roles than the board game for better playability.

The second set of requirements came from the feedback of the professionals in the field of transport and logistics who had played the board game. Their feedback was that, despite the limited choices in the game, it was realistic and a good representation of a disruption. Therefore, little adaptations had to be done for the digital version, resulting in following requirements. The game should allow for realistic actions, decisions and ways of communication as in the board and mobile game. Secondly, the game should be based on realistic scenarios, which are based on the board game scenarios and our own experience from working together with deep-sea container

terminals. A scenario where people are spotted in the yard replaced the scenario of the equipment failure from the board game, as this requires more communication amongst different roles. The resulting scenarios for the online version are a trucker's strike, an injury/fatality due to an accident, and people spotted near rails in a shunting yard.

Playing a game within a MOOC means additional implications for the design of a game, especially for the meaning part addressing the learning experience, and the way participants are involved in game play and feedback. We analyzed the requirements from the specific MOOC environment very carefully, leading to following design considerations. Due to the various backgrounds of students and their individual learning situations, the game should be playable on any computer or laptop, using different types of browsers (Firefox, Safari, Chrome). Due to the distribution of students in time and place, the game should not only be playable on separate locations, but additionally, an automated game master or game system should be included, which can guide the process of play. The game should also provide feedback after every level. Furthermore, we decided for a quasi-multi player game set up, with two of the roles played by the game itself. Players can choose any role, while the other two are automated. The participants need to change their role in every level, to experience the different decision making perspectives. As MOOCs are usually divided in short elements, the game play cannot take too long. The time for playing one level of a scenario is about 10 min. The look and feel of a game (as opposed to an exclusively text-based experience) should foster the motivation of the players. For the same reason, a clear in-game explanation of the learning context (SA, disruption management) and instructions of the game have to be included. The instructions should clearly explain the roles, objectives, rules and constraints, which are mainly the same as in the board game. For research purposes, game results should be logged.

Related to the aims of the redesign, all requirements contribute to immediate and clear feedback to the players, building a strong relation between learners and learning environment, getting information about player's actions and including multiple roles. The question how to motivate communication between players and between players and teachers, while the game being a single player activity, remains a challenge for the design.

4.2 Technical Specifications and Related Challenges

The game is built using Unity 3D, a game software creation tool that enables quick development and easy export possibilities. Because the game has a large amount of choices and information, the main system behind the game is a decision tree. The tree allows for scalability. Further disruption scenarios based on decision trees could be added quickly. One of the challenges in building the digital game was the creation of believable artificial intelligences (AI). The AI should make choices like real players would, which is necessary to give the player the idea that he or she is really communicating with other stakeholders of the disruption. The AI makes choices based on objective factors, but there is always a chance they make mistakes or communicate badly. The game will be published and hosted on the White box platform, developed by InThere, a Dutch game developing company. This system enables consistent user profile use and easy data collection.

4.3 First Design

For an internal test of the game, several mockup versions of the game interface have been developed that included the basic functionalities of the game. The design options were discussed with a group of 5 game designers and researchers from the field of game design and transportation research. Given the requirements for the game as defined above, we decided for an interface that should clearly show the roles involved, the information available and the choices a player can make. Tests with the first design of the game made clear that for a feeling of challenge, the decreasing time available to make a choice in the game should be as clear as the decrease in available communication resources of a player. A player is thus forced by the design to act quickly, as he or she would have to do in a case of a disruptive situation, and still care for the value of communication options and time, which is also important when managing a disruption. We found that the scoring system of the prototype still seemed not fair for every choice made. The right choice made, based on the right information, would sometimes give a lower score (a higher reduction of the KPI's) then the wrong score. In the initial version of the game, the player gets immediate feedback from the game. A general debriefing moment on how the player performed and the choices he or she made, is not yet included and has to be decided upon.

4.4 Second Design

Based on our observations, we decided to improve the interface design of the game as well as the feedback provided at the end of one game session. The player will get some feedback on his and her choices, together with an overview of the choices of the AI players. That should illustrate how the choices of the other actors influenced the result, too. The interface design shows different areas now, as illustrated in Fig. 1.

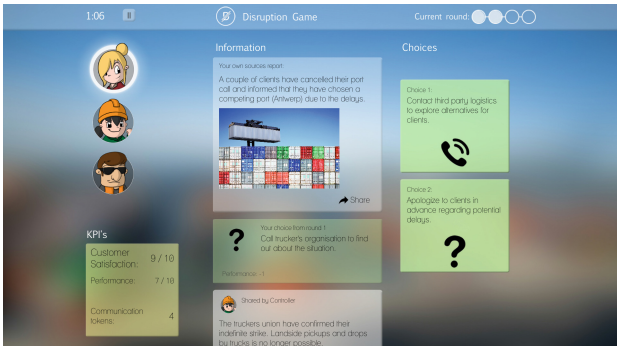

Fig. 1. Final interface design for the online game

The roles included in the game are illustrated by pictograms on the right. Below that, the player is able to view the key performance indicators (KPIs) for his role, in the example customer satisfaction and performance. Also the communication resources

available are shown. In the middle, information available is shown in a scrollbar. The player can choose whether the information was useful or not, and whether it should be shared with whom. Based on the information received, the player has to make a certain decision, e.g. contacting an external party for help, to finish the round. After that, feedback is provided on the decisions and their impact on the KPIs.

5 Discussion and Conclusion

From the redesign process starting from a board game involving a lot of direct interaction towards an online game in a massive online learning environment, we came across several challenges and collected lessons learned.

To start with, we have learned from the experts in the field of transport and logistics, that a realistic set-up is a prerequisite for a valid learning game, no matter whether it is low or high tec. Similar to the realistic actions and decisions in the board game, the scenarios in the online game are realistic, and developed together with subject-matter experts. The functional fidelity of both game versions is thus very high and appreciated by the target group. The dynamics of the game situation on the opposite is really different in the two game versions. In the initial board game, players have to communicate directly. There is a tension between individual and general goals, and the facilitator introduces surprising disruptions as well as provides feedback on player's actions and decisions. This holistic approach results in a high involvement of the players. For the online version, we wanted to design a similar experience of involvement. We decided for the design of a quasi-multiplayer game to guarantee the involvement of the players. All roles involved in the game are visible for the player. Feedback is provided by points, but also by more or less happy faces of the artificial roles in the game. Automated feedback is thus the mechanism we decided for to address the engagement of players. In addition to this, the roles also support the narrative of the game, which enhances the learning effect [21].

In general, the development of the mobile version of the game was a useful step towards the final design as it forced us to think about the decision tree already, which was again used for the online version. We also learned that the mobile version would be useful for more informal learning situations, but that an enhanced version with more possibilities for interaction and feedback would be needed in a MOOC setting.

For challenging the player, we introduced a certain time pressure into the game. This is one element that has still to be validated by the target group, as we are not sure yet whether this is realistic. Even in situations of disruptions, a quick decision might not always be the most desired one.

In summary, our experiences with designing a simulation game for a MOOC can throw some light on the requirements, possibilities and challenges related to integrating a simulation game in a MOOC. We observe that the same game design steps can be followed, however the boundaries of a MOOC already define some design choices, like distributed place and time independent game set up, preferable single player, short playing time. In our future work, we will explore how to design effective debriefing mechanisms for simulation games in MOOCs. Simulation games provide rich feedback in the form of interaction data that can be used for detailed analytics. They also provide

a supportive narrative context missing from bare simulations, making user decisions have consequences beyond simple grades [21]. We will soon test our design with students and our future work will inform the results of our simulation game design with respect to effectiveness of learning and levels of engagement.

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