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The Role of Awareness for Complex Planning Task Performance:
A Microgaming Study

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ABSTRACT

This study introduces the concept of microgames to support situated learning in order to foster situational awareness (SA) of planners in seaport container terminals. In today's complex working environments, it is often difficult to develop the required level of understanding of a given situation, described as situational awareness. A container terminal represents an important, complex node in the multimodal transportation of goods. Many operations have to be planned in order to ensure a high performance of the whole system. To evaluate the relation between SA and planning task performance, the authors conducted tests with 142 participants. They evaluated the role of SA in integrated planning activities, and the playability and usefulness of the microgame. In conclusion, the authors can state that SA is very conducive to integrated planning tasks in container terminal operations. The microgame approach allows for an enjoyable game activity, while providing a meaningful situated learning experience towards SA.

KEYWORDS

Complexity, Microgames, Performance, Planning Tasks, Situational Awareness, Transportation

INTRODUCTION

A lot of working environments today show characteristics of complex socio-technical systems, consisting out of complex physical-technical systems and networks of interdependent actors (De Bruijn & Herder, 2009). These systems are characterized as increasingly interconnected, and their infrastructures composed of different technological layers inter-operate within the social component

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that drives their use and development (Vespignani, 2012). For example, a container terminal can be defined as a complex socio-technical system, being an important node in the worldwide transportation network, connecting different modalities of transportation and storing goods (Saanen, 2004). Related to these characteristics, the planning of operations in a container terminal is complex, dynamic and interdependent. Operations that have to be planned are e.g. the location and time of an arriving vessel, the loading and unloading of the vessel, and the further storing or transportation of the goods from the vessel. Current planning practice involves a decomposition of single planning tasks, conducting them in a sequential manner. This approach leads to sub-optimal results, while the container industry is highly competitive, and time, money and quantity of goods handled play an important role (Zeng & Yang, 2009). Such dynamic, complex, and technology dependent work environment requires employees with adaptive skills (Penney, David, & Witt, 2011), characterized by the ability to handle dynamic situations, to deal with stressful events, to manage crisis situations, and to navigate unfamiliar or unpredictable work situations (Pulakos, Arad, & Donovan, 2000). Furthermore, it requires a holistic understanding of what is going on within the container terminal, called situational awareness (SA) (Endsley, 1995). SA and multi-stakeholder decision situations (confronted with time restrictions and incomplete information such as emergencies) have been recognised as a relevant field for specific training approaches involving tabletop exercises (Dowell & Hoc, 1995), non-computerized tactical decision training games (Crichton et al., 2000), or multi-user mobile games for shared decision training (Klemke et al., 2014). In our study, we introduce a novel approach to learning in complex socio-technical systems called microgaming. We show how one microgame is used to support the development of SA of the actors involved in a complex system, and how this could influence planning task performance. In the following section, we briefly illustrate why SA is important for actors in complex, socio-technical systems, before we introduce our concept of microgames. In the fourth section, we represent our study with a microgame, before we end up with a discussion and conclusions.

Situational Awareness

Situational awareness (SA) is seen as critical for successful collaboration (Stanton et al., 2006) and system performance. SA refers to the understanding of others as context for own activities (Dourish & Bellotti, 1992). The application domains of SA currently range from large-system operations to everyday affairs like driving. SA provides dynamic orientation to the situation, the opportunity to reflect not only on the past, present and future, but also on the potential features of the situation. The dynamic reflection contains 'logical-conceptual, imaginative, conscious and unconscious components which enables individuals to develop mental models of external events' (Bedny & Meister, 1999). The most widely used definition for individual situational awareness is 'the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future' (Endsley, 1995). With these characteristics, SA means some key benefits for an individual. SA helps to generate an analysis of the complex and dynamic (work) environment as well as being critical for good decision-making under time pressure, and thus enhances decision quality.

Important features and mechanisms that individuals use to achieve SA include: attention and working memory, mental models, goals and goal-directed processing, preconceptions or expectations and automaticity (Endsley & Jones, 1997). However, in distributed or complex work environments like a container terminal, it is difficult to develop SA (Olson & Olson, 2000). SA is not a passive process, as the skills required for achieving and maintaining SA need to be taught and enhanced using specialized training programs. The learning process should also provide feedback to the individual allowing them to understand their mistakes and better assess the situation, leading to the development of more effective strategies and better ways to integrate information (Endsley, 1995). As awareness in work environments happens at many levels, from individual to team, to the awareness of what is happening in the whole organization (Gutwin, Penner, & Schneider, 2004), learning activities should

also address different levels of SA, namely individual, team, and system level. In our research, we have used one such specialized learning approach known as microgame based on situated learning, which is explained in the following section.

Situated Learning and Microgames

In complex and dynamic systems, where uncertainties will ever remain (Berkes, 2007), it is crucial for actors to gather as much understanding about the system as possible as background for well-grounded decisions and actions. Thus, in complex systems, knowledge sharing and learning have become critical competencies for individuals and organizations, leading to increased performance (De Vries & Lukosch, 2009). Nonetheless, the time span between the moment when relevant knowledge is required and when this knowledge becomes obsolete becomes shorter and shorter. Innovative, authentic ways of learning are required to facilitate learning at the workplace, and to update knowledge continuously (Thelen, Herr, Hees, & Jeschke, 2011). Research has shown that there is a huge gap between the knowledge that is needed at the workplace and the knowledge and skills derived from formal learning activities (Tynjalä, 2008). Cross (2007) states that while 80% of the knowledge that is needed in the workplace is obtained through informal learning processes, e.g. by sharing experiences at the coffee machine, using solutions derived from online forums, only 20% if the knowledge stems from formal learning activities, like formal educational courses. This is also stressed by the notion of 'situated learning', an approach that argues for a conceptualization of learning as a social activity within communities of practice (Lave & Wenger, 1991). Informal learning is learning that is predominantly unstructured, experiential, and noninstitutional (Marsick & Volpe, 1999). Organizations nowadays have to encourage learning on the job to enable people to make more informed decisions on what to learn and do (Marsick & Volpe, 1999). As an answer to this particular learning need, it is crucial to develop situated mechanisms that support learning closely to the workplace (De Vries & Lukosch, 2009).

In our work, we explore the use of short simulation games to answer the need for situated learning experiences that are engaging and motivating for an active learner. Such so-called microgames are a special form of simulation games. We decided for this way of supporting situated learning, as simulation games have the potential to provide a rich environment with many objects and the ability to approach complex systems from different perspectives (Bekebrede, 2010). With the possibility of team and multiplayer game modes, where a set of players can play simultaneously together, a shared experience from a scenario of a given context can be developed within a group of players, like studies on the impact of cross-training on team effectiveness show (Marks, Sabella, Burke, & Zaccaro, 2002). With the provision of a gaming environment where players can relate their actions within the game to their needs and interests in the outside world, like their work place, simulation games support situated and authentic learning (Yusoff, Crowder, Gilbert, & Wills, 2009). Simulation games, by virtue of being motivating and engaging, can help foster self-regulated, active learning (Lukosch, Littlejohn, & Margaryan, 2014). Unfortunately, not much development and research has been done so far in the field of so-called microgaming. In game design, the term is often used for describing mini-games that are part of a bigger game world. They are often used as incentive or bonus, and then do not always contribute to the overall aim of the main game. In our work, we refer to microgames as a learning experience, representing a stand-alone game with its own aim and meaning. Before we introduce our approach towards microgames, we briefly discuss related research in this context. We also show how our own study is positioned in relation to current work in the field.

Related Work

In a study within a high-school environment (Brom, Preuss, & Klement, 2011) could show that the use of microgames was at least as effective as traditional learning methods. Furthermore, the game group within the experiment was able to retain reinforced and integrated knowledge better than the control group. The microgames here were used as a brief activity between a traditional lecture and

a de-briefing phase. Related to our own approach, this experiment focused on high-school students, whereas we try to explore the use of microgames in the professional field and in higher education. Additionally, (Brom et al., 2011) define their microgames as "relatively simple computer games that do not require special skills to play", which is not applicable to the microgame we propose for the study and understanding of a complex system like a container terminal. The microgame exemplified in our research requires at least some expert knowledge and skills to reach a high in-game performance. For the understanding of the underlying system, a container terminal, our study can indeed show that the microgame is applicable for illustrating processes of the real system on a lower expert level. (Van Rosmalen, Boyle, Van der Baaren, Kärki, & del Blanco Aguado, 2014) illustrated the design and first experiences with mini-games based on the 4 Components Instructional Design (4C/ID) method (van Merriënboer /Kirschner, 2012). The mini-games in their study were meant to support students in higher education in acquiring knowledge about research methods. The evaluation showed that it is difficult to find a well-balanced design of the mini-games regarding the information provided – due to their characteristic of being a mini-game, a single game play should not take too much time, on the other hand, enough information has to be transported to play the game and to reach any learning effect. In our development process, we use a particular game design methodology to find the right balance of information transfer. The terms micro- or mini-game are often used in relation to mobile games, where they refer to the provision of small applications, that can also be used for learning or other serious purposes (Belotti, Berta, De Gloria, Feretti, & Margarone, 2004; Alsmeyer, Good, Howland, McAllister, Romero, & Watten, 2008). Our own approach towards microgames does not necessarily focus on mobile games, but follow the idea of providing games, which are easily accessible to foster flexible and situated learning.

This brief overview of related work shows that there is not much work being done so far on the use of shorter games to foster active, situated learning at the workplace. In this article, we illustrate crucial concepts the microgames are based on, and introduce first experiences we have made with game play sessions. In the following section, we illustrate our concept of microgames. Thereafter, test sessions with students in higher education of the transportation domain and the game design field are illustrated, leading to first results on the experiences with and the usefulness of the microgames. A summary and future steps are presented in the concluding section.

THE MICROGAMING APPROACH

In order to train skills needed in a container terminal, understood as a dynamic, complex socio-technical system, a microgame called Yard Crane Scheduler (YCS) has been developed. The microgame consists of a simplified representation of the quay side and yard side of a container terminal with the main goal for the player to conduct an interdependent planning of various terminal operations. The microgame approach is based on an instructional concept, called microtraining (De Vries & Brall, 2008; De Vries & Lukosch, 2009; Overschie, Lukosch, & De Vries, 2010; Overschie, Lukosch, Mulder, & De Vries, 2013). Microtraining represents an approach of short learning activities with a time span of 15-20 minutes for each learning occasion, being based on instructional design considerations like social constructivism, connectivism, and learner typologies (see in more detail De Vries & Lukosch, 2009). It addresses the need of contemporary complex work environments for the alignment of learning activities with increased specialization, new forms of organization, and agile transformation (Littlejohn & Margaryan, 2014). People nowadays have to be able to learn new practices to solve new problems appearing at dynamic workplaces (Hager, 2004). Learning opportunities are more and more incorporated within the workplace and co-exist with expert work-practice (Boshuizen, 2004.

Following the microtraining approach, microgames support situated learning, as they always start from a well-defined problem, which is translated into a short simulation game. For transferring complex systems into a simulation game, a game designer has to consider the game elements and systems like space, scenarios, rules, actions and goals of the game (see also Hendrix, Meijer, van der

Velden, & Iosup, 2011). At the same time, decisions have to be made, which elements, systems and procedures will *not* be part of the game. This question is especially important for the development of a microgame. Its brief set-up does not allow to include the whole complexity of the reference system. The game designer has to choose very carefully how to develop the game in order to design a valid learning experience.

In our case, the definition of the problem and the translation into a microgame are part of a structured, iterative design process. This design process is based on the Triadic Game Design philosophy (TGD) (Harteveld, 2011), and starts with a so-called game-storm session. In this session, the three components of a game design as proposed by (Harteveld, 2011) are defined together with the problem owner and the game designer (see Figure 1). The three components are reality, meaning, and play, and according to TGD, they should be well balanced in order to develop an effective simulation game.

The gamestorm sessions begin with defining the reality component of the game, namely making decisions on what aspects of the reference system, in our case, the container terminal, should be represented in a game. Also decisions are made on the fidelity, or the level of realism, the game should represent. This aspect refers e.g. to the audio-visual representation of the physical system that the game should illustrate. After that, the meaning component of the game is defined. This refers to e.g. the learning goals and the target group of the game. The meaning component describes for instance that the learning goal for the microgame introduced here is developing shared situational awareness in integrated planning tasks, targeting at planners working in container terminals. The third component, play, is the last one to be defined, and refers to all game mechanics that should be included in the game. It is for example important, and related to the meaning aspect, whether the game should include competition, and how challenging and difficult it may be for the user group envisioned. When all components are defined, game designers translate the results of the game storm session in a conceptual design of a game, which is again discussed with the target group. During this step, all three aspects of reality, meaning and play are considered not only as individual aspects, but also in their relation to each other and to the overall goal of developing a valid, meaningful and enjoyable learning experience (Harteveld, 2011). When an agreement on the conceptual model is reached, a first prototype of the game is developed, which is then evaluated by experts from the field, in our case, from container terminals (see for more details on the development process (Kurapati, Groen, Lukosch, & Verbraeck, 2014)).

Figure 1. Facilitating a gamestorm session

Following the above described development process, the Yard Crane Scheduler (YCS) microgame has been developed. The game focuses on the integrated planning of loading and unloading sea vessels in the container terminal. The game offers two different screens, the operational mode, where an overview of the container terminal is provided, including the vessels to be arriving, the quay cranes, the yard cranes, and the scoring. This part of the screen allows allocating the cranes to the vessels and the containers in the terminal with easy drag and drop operations, which is shown in Figure 2.

In this mode, game time runs, which has an immediate impact on the scoring of the player. When too many cranes are idle, the time of the idle equipment reduces the score of the player. When a vessel can leave the terminal early, the score of the player increases.

In the other, the planning mode, the time freezes, so the player has enough time for planning operations. The main task here is to plan where the containers in the yard and on the vessels have to be placed in order to handle the vessel as quickly as possible. This mode is illustrated in Figure 3.

The game's goal is to support the situational awareness (SA) of operational planners in container terminals. In the following, we will report on the outcomes of a case study conducted with game design students to evaluate the playability and the usefulness to develop SA of the YCS game.

CASE STUDY

Participants

Between October and December 2014, the YCS Microgame has been played with 142 students in higher education in The Netherlands, Germany, and the United States in total. The population consisted out of students from the logistics field as well as of game design students. 38 students formed the game design group. The first two tests with the game were conducted with this group in order to explore especially the playability of the game. Further tests are currently still being conducted with logistics students and with professionals from the field. The game design students were recruited from two classes, one from The Netherlands, from a technical university (N=20), and one from a university of media design in Germany (N=18). The rest of the students (N=104) belonged to the logistics and supply chain domain in The Netherlands and the United States. Though the overall sample size is 142, we were able to use only 107 data points, due to incomplete surveys. All the concerned university

Figure 2. The operational mode of the YCS game

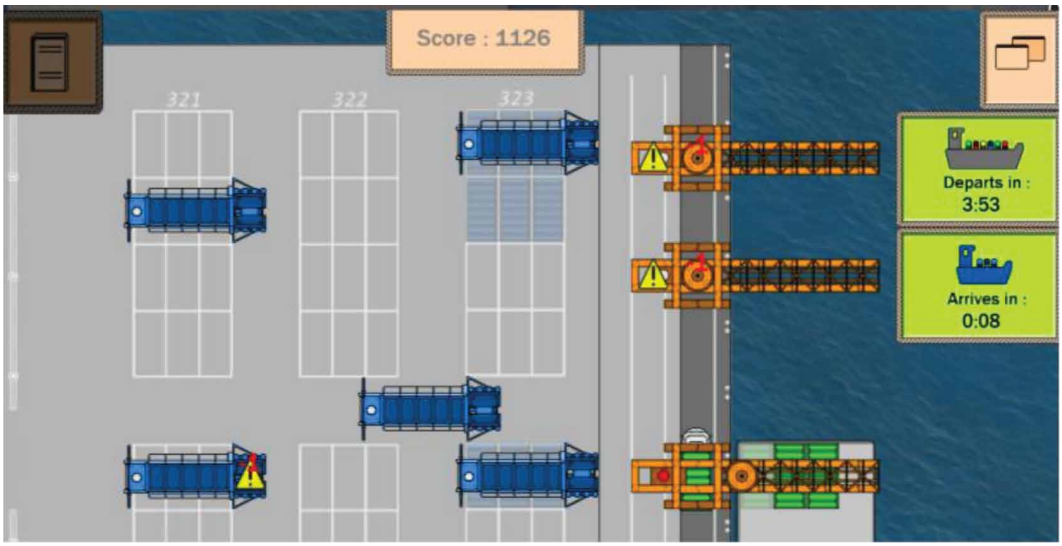
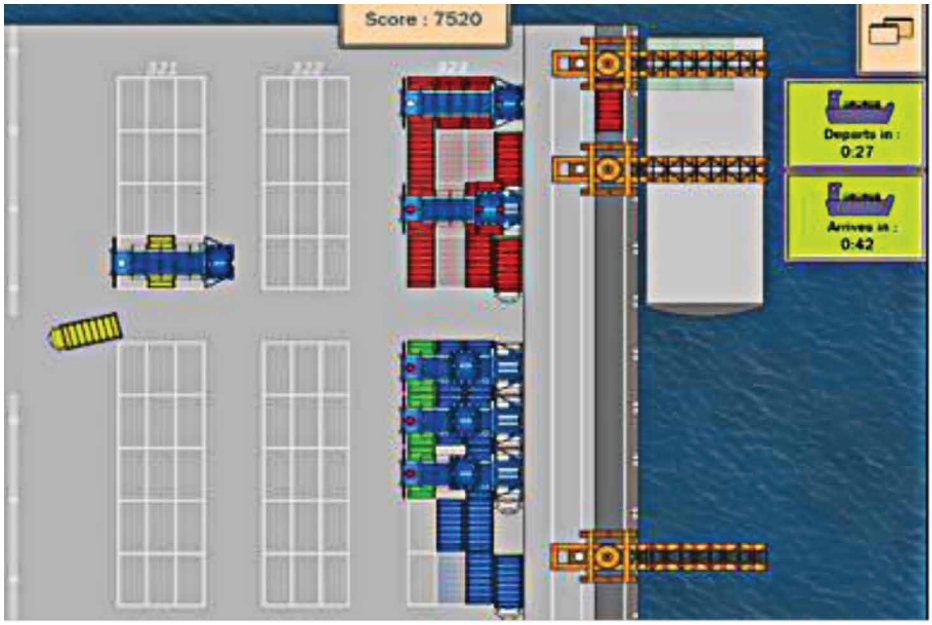


Figure 3. The planning mode of the YCS game



ethics committees approved our test sessions. We followed their strict guidelines for our sessions, so we could not make answers in the surveys mandatory. In this paper we will discuss the results on the playability of the game and its usefulness to develop SA in general for all students, and will derive more qualitative insights from the game design students with respect to game mechanisms, effectiveness as a learning tool and further improvements.

Experimental Set-Up and Materials

Within a structured experimental session, the students were asked about their prior experience with games, were given a brief introduction to planning operations in container terminals, and then played the game several times. The researchers took observer notes during game play. Before a de-briefing on the experiences and lessons learned closed the session, the participants were asked to fill in a survey. This survey consisted of 5-point Likert-scale questions, including a self-rating technique on SA known as the Situation Awareness Rating Technique (SART) (Taylor, 1990). The results derived from the post-test survey were calculated using Microsoft© Excel and IBM SPSS Statistics. With this set-up, we were able to combine a quantitative data collecting with qualitative approaches, in order to gather deep insights in playability and usefulness of the game. The experiments were conducted in a classroom setting at the two universities, where laptops were provided to the students for gameplay. Two ethical committees of the participating universities approved the experiments and the participation of the students beforehand.

Results from the Survey Responses

Quantitative Results

The SART measurement of SA consists of three aspects: (1) Understanding of the situation (U) (2) Demand of the situation (D), and (3) Supply of information (S). The overall SA is calculate using the formula:

Situation Awareness, SA = U-(D-S)

We analyzed the correlations between the performance in integrated planning tasks represented by the YCS microgame score and the SA measure. We found a significant positive correlation between them (Pearson's $r = 0.321$, $p<0.01$, $N=107$). This indicates that students that achieved better performance in the YCS game had higher Situation Awareness. Further, we would also like to report the group averages of individual components of the SA score. The results from the SA related questions imply that the game is able to support the understanding of the situation (m=4.7), while demand of the situation (m=4.7), and supply of information in the game are also high (m=4.4).

In addition to the SART survey, student perception on the usefulness of the game as a learning instrument for integrated planning tasks was measured in the form of a post-game survey, by providing the average ratings on a scale of 1 to 5. Results show that the majority of the students state that the YCS game is able to reflect on the need for coordination of various processes in container terminal operations (m=4.1), which is an important requirement for integrated planning operations. The game was also positively valued as providing better insights in the importance of integrated planning (m=3.9). The question whether the environment was familiar to the students, resulted in a low score (m=2.6). This is due to the fact that all the participants were students with limited working knowledge of the professional working environment of container terminals. Despite the unfamiliarity of the environment, the participants were still very well able to gather information from the environment (m=4.7). The players assessed the game as valuable training tool to enhance performance in integrated planning tasks (m=4.0), while the value of adoption of the game by container terminals to strategize integrated planning approaches was given a slightly weaker score (m=3.6), but was still positively evaluated.

Qualitative Results

In addition to the likert scale, a comment box was provided for all post-game questions. Hereby, all students were able to express their views in a detailed manner on the game experience. Not all students utilized this option, therefore the comments of the students are more apt for analyzing from a qualitative point of view. The comments on the various value characteristics of the game have been summarized below in 3 different categories of positive, neutral and critical. In addition, we also analyzed the comments and remarks based on their significance.

Positive comments:

1. The game showed how a real situation (inside a container terminal) might look like, for the first time in their study;
2. It provided insights into container terminal operations in a fun manner, although it was stressful to play;
3. The game was well organized;
4. The game is quite clear to understand and easy to follow;
5. It is a great and fun game to play (8 student responses);
6. Very good game to learn about planning tasks;
7. The game is intellectually stimulating.

Neutral comments:

1. It takes some time to realize the mistakes one is making in the game and to understand what one needs to do to become more efficient;
2. The objective of the game became clear only after playing 4 times;
3. The game is very nice, but more feedback would be appreciated;

4. It was a fun game but was hard to perform well in the game;
5. It is an interesting game, but the time for trying more strategies was limited.

Critical comments:

1. It is hard to focus on the objective on the game as a lot of attention needs to be paid to the game mechanics;
2. The goal is easy to understand, but hard to accomplish;
3. It is very complicated as it is difficult to handle the different situations;
4. The music of the game should be changed as it is very distracting;
5. More discussions about the relationship of this game and the field of supply chain and logistics are needed;
6. The game rules need to be explained more comprehensively;
7. During the game high scores were written on a board, which might bias the performance of some students who might feel anxious of high scores.

Further Remarks

The positive comments focused on the teaching/ training ability of the game as well the fun element of the game. Students felt very positive about the game since they gained insights into the planning tasks in container terminal operations in a fun manner. This also corresponds to the quantitative results from the survey regarding the insights gained into integrated planning tasks due to the game play. The game was deemed to be easy to understand and clear to follow. Students who felt very positive about the game also (unsurprisingly) achieved above average scores. Commentators who felt the game was easy to follow had above average game playing experience.

A large part of the neutral comments is focused on the ease of getting used to the game mechanics, and understanding strategies for high performance. Students felt that although the game was fun, it was difficult to achieve high scores, and the game session didn't allow them to try out different strategies due to the time limit. This is mainly due to the fact that the game session was a part of an experiment which was carefully designed within a specific time limit, so it was not possible for students to try out the game multiple times during the experiment. However students were given access to the game to tryout other strategies in their free time after the game session.

The critical commentators expressed their difficulty in playing the game due to its' complexity. Some opined that the rules needed to be more comprehensively explained. The game has 3 tutorials which elucidate the game mechanics and rules. A briefing lecture also explains the rules, but not all the minute details were explained. We also assumed that the tutorials were sufficient to explain the rules as a form of 'learning by doing'. Although it is a minority complaint, we could learn from this experience to make sure all students understood the rules very well in future game sessions. Surprisingly the music of the game seemed to have affected game performance at least in one instance. This was also observed during two game sessions when two students expressed their impatience with the music of the game. However many other students verbally expressed their likeness for the game music during our observations during game play. The debriefing on the relationship to the field of supply chain and logistics was unclear to a student. This is due to the fact that container terminal operations belong to a small sub-set in the field of supply chain and logistics, and the debriefing could not be generalized to the whole field. One student felt negatively about announcing the high scores during the game play. This was done to increase the spirit of game play and enrich the game playing experience. However we may need to take this aspect into consideration in our future session as a control variable.

Qualitative Results from the Observations during Game-Play

Comments on the game, and suggestions for improvement were observed and written down by the researchers accompanying the test sessions. Students were highly engaged during the YCS gameplay. The facilitator walked around to answer any questions regarding the gameplay by the students. In the first session students had problems logging in the online game portal due to long urls. This issue was immediately rectified by providing short urls for the subsequent sessions. Very rarely, the game froze due to technical errors and internet connection lapse, but students were instructed to restart the game when this happened. Students took 2 to 3 gameplay sessions after playing the tutorials to get fully familiarized with the game mechanics. Students enjoyed the music of the YCS game, while only one student reported that it was counter-productive for the performance. Students repeatedly questioned one aspect of the scoring mechanism, where idle resources loose points for every second they are idle. The motive behind introducing the negative points for idle resources is supported by the industry experts from the container terminal domain. However students found it counter-intuitive and unfair. This concern was raised in all the sessions in both continents. Therefore we are considering modifying this scoring mechanism in the future version of the game. Most of the students wanted to continue playing the YCS game, as we observed from our online portal that several students were actively engaged in the gameplay for several days and some even several weeks after the test session.

Qualitative Results from the Observations during the De-Briefing

The de-briefing of the game session consisted of a gathering of the perceptions of students on the usefulness of the game, playability, player strategies, and possible improvements. This was followed by a lecture by the facilitator linking the objective of the game to practical applications and real world problems.

Many students found the game very helpful to learn about integrated planning tasks in container terminals. A few students found the game too complex to learn and the actions non-intuitive. Players pointed out the importance of planning ahead. The majority of the players valued the game as well-designed and fun to play. Students suggested several improvements to the game, with respect to scoring mechanism as well as elements to be added to the game to further increase the element of 'reality' in the game. The suggestions will be considered for future versions of the game.

Summary of Results

In summary, the results briefly illustrated here indicate that the YCS microgame is able to address crucial skills needed in complex interdependent planning tasks. A crucial link between the YCS game score and SA measure was found, which backs the potential of microgames as training instruments for enhancing SA. The level of engagement of students expressed by the students during the game play as well as the debriefing session indicated that the microgame is not only a learning tool, but a highly engaging fun activity, which could further promote interest in learning beyond the game session. Even for students who are not familiar with container terminal operations, the microgame session was able to provide enough information to develop SA for the need of integrated planning approaches. The comments of the students during game play underpinned that they understood the importance of integrated planning. Nonetheless, also weaknesses of the game were mentioned, and improvements were suggested, which will be implemented in the future version of the game.

DISCUSSION AND CONCLUSION

Research shows the importance of SA for the performance of complex systems, like container terminals. Specialized training approaches are needed to acquire, maintain and enhance SA in such systems. Designing realistic training processes that are situated in the workplace for such complex and dynamic systems is very crucial but very challenging. In our work, we try to reduce this research gap

by exploring a novel approach known as microgames to enhance SA. We conducted 10 test sessions in Netherlands, Germany and the United States with 142 students to measure the effect of the microgame on SA and also to test its playability and usefulness. Given the significant correlation (Pearson's $r = 0.321$, $p<0.01$, $N=107$) between the microgame score and the SA level, as well as the observations from the gameplay and the reactions from the de-briefing session, we can conclude that microgames have a good potential to be training tools for situated learning to enhance Situational Awareness in complex systems such as container terminals. Students also opined both in surveys and during the debriefing that the microgame was a very useful to understand complex integrated planning tasks in container terminal domain in a short span of time. In general, the players also found it to be very fun and engaging. The debriefing provides an opportunity to reflect on their decisions in the game and think about ways to improve them, which is crucial to acquire and maintain SA. This also strengthens our claim that microgame can be used for situated learning in complex environments to enhance SA. Nonetheless, remarks were made about the complexity of the actions within the game as well as minor deficiencies in the scoring mechanism. For further development of microgames, we will take this comment very seriously. The problem addressed here relates to the trilemma between the reality, meaning and play aspects of a game (Harteveld, 2011). Whereas many experts require a highly realistic representation of the reference system in a game, while a predefined learning goal has to be achieved, we cannot forget that in a game, we also have to address aspects as fun and engagement of the learning activity. Especially for complex systems, it is difficult to simplify all relevant aspects, processes and relationships in a valid and meaningful way while still secure a joyful (micro) gaming experience. This process requires a participatory game design process including well-grounded design decisions.

In the future, we will explore how the YCS game should be improved in order to increase playability, while still being able to represent the integrity of the planning tasks. The improved version will also be tested with user groups from the transportation and logistics domain, with experience and knowledge about operations in container terminals. We will especially investigate how realistic microgames should be in order to provide a meaningful, but still enjoyable learning experience. This will lead to recommendations for design choices to be made when developing micro- or minigames, used for the support of situated learning and situational awareness in complex systems.

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