Serious games for crisis management: What can we learn from research on animations?

P. Wouters, E. van der Spek, H. van Oostendorp, Department of Information and Computing Sciences

Utrecht University, PO Box 80.089, 3508 TB Utrecht

Serious games can be potentially effective. We present 3 design guidelines from animation research that can support players to overcome the problems resulting from limitations in human cognitive architecture. We will provide evidence from research of our own and research of others that pacing, attention guiding and inserting information gaps will make complex serious games more effective. In our presentation we will show a game for training responsible officers in crisis management in which the guidelines were implemented.

Keywords: Serious games, animations, representations, design guidelines.

Introduction

The use of games in learning and instruction, often referred to as serious games, has been propagated by many researchers. In this paper we define serious games as learning environments in which learners are engaged in a goal-driven, competitive activity (against the computer, another player, or oneself) within a framework of agreed rules. While acting in the game world players constantly receive feedback enabling them to monitor the progress towards the goals they have set. Typically, but not always, games are embedded in a narrative including players, a setting, a conflict or obstacles, dialogues, events etcetera.

Reviews have shown that claims about the effectiveness of serious games are not always justified. Recently, we have conducted a review from a learning outcome perspective comprising cognitive, motor-based, attitudinal and communicative learning outcomes. We observed that serious games potentially improve the acquisition of knowledge and cognitive skills. We also concluded that the use of serious games is promising for the acquisition of fine-grid motor skills and to accomplish attitudinal change (Wouters, van der Spek, & van Oostendorp, in preparation). From a cognitive perspective it can be argued that without support novice game players can easily become overwhelmed by all the information that has to be processed. However, our review also revealed that design guidelines in serious games intended to support these players were not always effective. In this paper we propose animation-based design guidelines that can be used to make effective serious games.

In our studies we focus on the training of responsible officers in crisis management. Performance during disasters always requires making decisions under time-pressure in dynamical and chaotic situations. Information may come to these officers visually (e.g., seeing how a fire develops), auditory (e.g., an increasing pitch indicating a danger for explosion), verbally (e.g., information provided by other officers), and tactilely (e.g., a shockwave after an explosion). An adequate performance during a disaster requires officers to construct a dynamic mental model representing the major actors, events and the relevant information (Kintsch, 1998). This dynamic mental model will enable the officers to assess the situation and predict the direction in which it may develop. Serious games can be used to support officers to construct such mental models. Not only will serious games support them in learning about facts (e.g., the symbols for hazardous materials), procedures (e.g., the procedure to find a safe location for victims) and problem solving skills (e.g., decision making skills), but the high level of realism also enables them to develop situational awareness in dynamic situations.

Playing a serious game is a complex task. Players have to visually attend different locations on the screen and coordinate this with mouse or joystick movement. Moreover, different cues may occur (either visually, auditory, verbally or tactilely) whose relevance for the task has to be decided upon. Finally, they have to solve problems that occur during the game, often under time-pressure. In

combination with the perceptual constraints of human cognitive architecture (cf. Anderson, 2000) this complexity may pose problems to officers in training. Firstly, they may become overloaded with information and hence fail to discern between relevant and irrelevant information. Secondly, the transitory nature of games implies that players will only develop a good understanding of a crisis situation when all parts of the game are adequately processed. Once players miss a crucial part of the game (e.g., because the information is presented too fast) all subsequent information is likely to become incomprehensible. This may especially be true for the external multimodal representations in sophisticated 3D games. This means that the effectiveness of a serious game is contingent on the ability of designers to overcome the problems resulting from the limitations of human cognitive architecture.

Design guidelines

On a number of characteristics serious games resemble animations. For example, both use multiple types of external representations and both are transitory. Based on this resemblance we contend that some design guidelines that have proven to be effective in animation research can also be used for the design of serious games. However, an important consideration regarding this claim is that these guidelines should not jeopardize the nature of these games (e.g., its narrative nature). The guidelines that we will propose are used in a serious game that we developed for training medical first responder emergency personnel to perform a triage after an explosion in the subway (for an impression see figure 1).

Figure 1: Screenshot from the game CODE RED: Triage!. An impression from the chaotic station hall where the player starts

A triage is a process of prioritizing patients based on the severity of their condition so as to treat as many as possible when resources are insufficient for all to be treated immediately. The task of the player (as a trauma physician) is to diagnose and classify the victims under time pressure. The narrative of the game is as follows. First the player has to find a way to the platform through the chaotic station hall (see Figure 1). Before descending to the platform the player is notified that an unexploded bomb has been found. Specialists will try to dismantle the bomb. The player can observe the countdown mechanism on the screen. The victims lie scattered across the platform and the player has to decide how to deal with this situation. The performance of the player is reflected in a ‘life

meter', which the player can monitor continuously. Halfway the player has to resolve a conflict with another trauma physician. At the end an incident forces the player to enter the train to help victims who are trapped.

We think that three guidelines of animation research are promising: Pacing, attention guiding and inserting information gaps. We will substantiate this claim with research of our own as well as research of others. *Pacing* involves the control over the continuation of a serious game, which can be exerted by either the player or the computer. The opportunity to pause, continue, accelerate or deaccelarate enables players to adapt the serious game to their cognitive needs. Evidence was found in a study about nautical tie knotting in which it was observed that learners who could manipulate the pace of a video performed better on a test, especially when the knots became more difficult (Schwan & Riempp, 2004). A more advanced type of pacing is to strategically slow down or speed up the rate of presentation to make relevant information better observable (Fischer, Lowe, & Schwan, in press). Take for example a serious game for training firemen to deal with hazardous materials. Incidents with hazardous materials are dangerous, because of the quick, spontaneous and unpredictable reactions that can take place. This may hinder novice players to perceive what is happening and consequently act in an appropriate way. When players could initially slow down the tempo in which these reactions take place, they could perceive what exactly happened. Consequently they may be more likely to understand how certain events caused the reactions and how they can act in these situations.

As mentioned before players with little prior knowledge may easily neglect high relevance low salience information due to competition for attention from high perceptual salience information that has lower relevance. In particular when visual search is high *guiding attention* to relevant parts by using cues can support learners to discern relevant from irrelevant information and thus improve learning (Jeung et al., 1997). However, research also suggests that guiding attention should be applied with care. To start with, Mautone and Mayer (2001) found that cues in multimedia learning were only effective when both the verbal explanations and the animation were signaled. Secondly, the cue should be directive enough; global gestures of a pedagogical agent to a location on the screen may be ambiguous and therefore ineffective (Craig, Gholson, & Driscoll, 2002). Finally, Schwan, Garsoffky and Hesse (2000) have argued that film-cuts on places with important information can facilitate the cognitive processing of this information as they make these more salient. Because less effort is needed for visual search, more cognitive resources are available for building a mental model. In the triage serious game, attention guiding can be applied by making the injuries of victims perceptually more protruding or by having victims explicitly point to a part of the body.

In our own research, we have shown that omitting particular information on the display vs. showing it, in a puzzle game, did not affect the efficiency of the game adversely but did improve learning, especially of the underlying rules of the game (van Nimwegen et al., 2006). When inserted at an appropriate location and moment such *information gaps* may incite players to activate prior knowledge in order to make the new information meaningful (cf. McNamara et al., 1996). These information gaps apply to all types of external representations, that is, visual information can be omitted as well as spoken or written utterances. It is obvious that these information gaps must match the level of prior knowledge. Moreover, we believe that these information gaps should be in line with the story logic. Therefore we have developed the *Game Discourse Analysis* (GDA), which describes the structure of the story in terms of discourse components (i.e., actions, events, internal elements etcetera), the relations between these components and how these components may trigger scripts, that is, generalized schemas of how to act in specific situations. Eventually, this analysis will enable us to determine the appropriate places and moments for information gaps.

Conclusion

In this paper we argue that design guidelines that have proven to be effective for animations may also be effective for serious games. In this respect we propose three guidelines: Pacing, guiding attention and information gaps. It is clear that empirical evidence is required to substantiate these claims. Future research should also take into account possible interactions between design guidelines (cf. Lowe, 2005). Another issue that we would like to emphasize is that the design guidelines should not interfere with the characteristics of games such as its narrativity. We think that our GDA provides a

structural description of the nature and flow of the information in a serious game enabling the implementation of design guidelines without compromising the game characteristics.

In our presentation we will show the CODE RED: Triage! game. With this game we will exemplify how we implemented the 'animation-based' design guidelines. We will also illustrate how the Game Discourse Analysis can facilitate the implementation of these design guidelines.

Authors note
This research has been supported by the GATE project, funded by the Netherlands Organization for Scientific Research (NWO) and the Netherlands ICT Research and Innovation Authority (ICT Regie)

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