

Code Red: Triage

Or, COgnition-based DEsign Rules Enhancing Decisionmaking TRaining In A Game Environment

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Abstract—Serious games have a great potential for training and educating people in novel and engaging ways. However, little empirical research has been done on the effectiveness of serious games and, although early findings do point in a moderately positive direction, even less is known about why some games succeed in effectively educating while others don't. We therefore propose a serious game, *Code Red: Triage*, which is designed to empirically test a number of cognition-based design guidelines in the context of crisis management training. Our purpose is to come to a set of design guidelines through empirical experiments that enhance the instructional design of serious games and can be used in the development of future games.

Serious games; games-based learning; instructional design; design guidelines; Code Red Triage; virtual training; cognition in games

I. INTRODUCTION

Nowadays, games based learning and its potential to revolutionize pedagogy by being able to facilitate teaching novel instructional goals, as well as more traditional educational material in a manner that is actually engaging to the learner, needs little introduction (cf. [1], [2], [3]). For all the games that are being, or have been, developed, surprisingly little empirical research has been done that substantiates the claims of the potential benefits. In a recent review of serious games literature we found only 28 scientific publications with any empirical evidence pertaining to clearly stated learning goals [4]. Similar concerns about the lack of (quantitative) empirical research were voiced by Vogel, Vogel, Cannon-Bowers, Muse and Wright [5].

The empirical research that was published, some questionable methodologies aside, does give a relatively positive outlook on games-based learning as sound instructional media, with 58% of the total named learning goals met, 1/6th inconclusive and a quarter ending with no significant increase in learning [4]. However as Wilson *et al.* also noted, very little is known on why some games are able to achieve their learning goals, while others fail to do so [6]. As evidence is beginning to emerge that serious games can in fact educate the player in an engaging way—albeit with a lot of room for improvement, we contend that the real

question is now how to make serious games more effective instructional media. In order to achieve this, we are currently developing a game called *Code Red: Triage*, which trains medical first responders in categorizing the many victims of a mass casualty event (in this case a terrorist strike on the subway) according to urgency of needed medical attention (i.e. to perform a triage). With this game, we will empirically test a number of design guidelines, based on the workings of the human cognitive system, to see if these facilitate better learning while still letting the game retain its engagement. The result will be a set of guidelines that will help game developers enhance their instructional game design.

II. CRISIS MANAGEMENT

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, which is contingent on an adequate level of situational awareness [7]. From a cognitive perspective an adequate level of situational awareness requires the construction of a dynamic mental model representing the major actors, events and the relevant information [8]. This dynamic mental model will enable the officers to assess the situation and predict the direction in which it may develop. For two reasons games seem to be appropriate for training officers in acting adequately during crises (and consequently develop situational awareness).

To start with, games enable a high level of interactivity which enables a player (i.e., the learner) to act in the game and be confronted with the consequences of his/her actions in real-time. Moreover, other actors such as victims act and may change the game world in ways that will force the player to attend and comprehend the new situation. Secondly, current games can be made highly realistic by means of sophisticated visual graphics, sounds and even tactile sensations, unattainable by training on paper.

III. MITIGATING TASK COMPLEXITY

A. Games as complex tasks

Playing a serious game in the domain of crisis management is a complex task. We have discerned three closely related components that determine this task

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complexity. The first determinant concerns the inherent complexity of gaming. Typically, players have to visually attend different locations on the screen, each often with their own regime of change, and coordinate this with appropriate mouse or joystick movement. In addition, players have to learn and apply the rules and constraints that are part of the game. The second determinant considers the specific characteristics of the domain at hand. In the domain of crisis management officers have to deal with an abundance of information that may appear as quickly as it vanishes again. Based on this information players have to make decisions in often highly dynamic and chaotic situations. The third determinant pertains to the limited cognitive capacity of humans. In combination with the perceptual and processing constraints of human cognitive architecture (cf. [9]) the aforementioned game and domain 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 (i.e., a coherent mental model and situational awareness) 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 implies that special care has to be taken with the instructional design of the serious game, in order to guarantee that the game facilitates the necessary mental model construction within the player.

B. Helping the player

In trying to enhance the mental model construction of a player in a game world, we can discern factors that obstruct the construction of a mental model, and those that improve mental model construction. The first grosso modo pertains to problems with cognitive load, where the player is either

cognitively overloaded, as in the examples alluded to above; or underloaded, where the player isn't stimulated enough to fully focus on the subject matter. Therefore we contend that mitigating unnecessary cognitive load when the game is difficult (extraneous cognitive load as it is called in Cognitive Load Theory, cf. [10]) or increasing intrinsic cognitive load in the game when it is too simple, by e.g. guiding the attention of the player and information regulation respectively, could optimally load a player's cognitive capacity and lead to better knowledge construction.

One way to decrease extraneous cognitive load in serious games could for instance lie in the dual channel (or coding) theory, which states that we process information from our visual and audible system via separate channels, and can do so relatively concurrently. If too much information is presented on-screen at the same time, for instance a text chat while trying to navigate a 3D world, one could provide the text audibly and thus offload information into the other channel, reducing the cognitive load on the visual channel. Mixed results of dual coding information in a multi-user virtual environment were found by [11]. Another way to regulate the information is by progressively increasing the difficulty/complexity level of the task or by imposing a strict time limit, the latter plausibly leading to a heightened feeling of urgency.

Sometimes the most relevant instructional material at a given time in the game is less salient than other parts of the game. For instance, if a small gas leak is creating a large fireball, an instructor might want the student to notice and attend to the gas leak, instead of the much more salient fire itself. One can use a number of different guidelines to focus the player's attention. For instance, a pedagogical agent can be used in the form of a non-playable character (NPC) fireman that tells the player where to look and correct his or her actions when necessary. Another way would be to cue

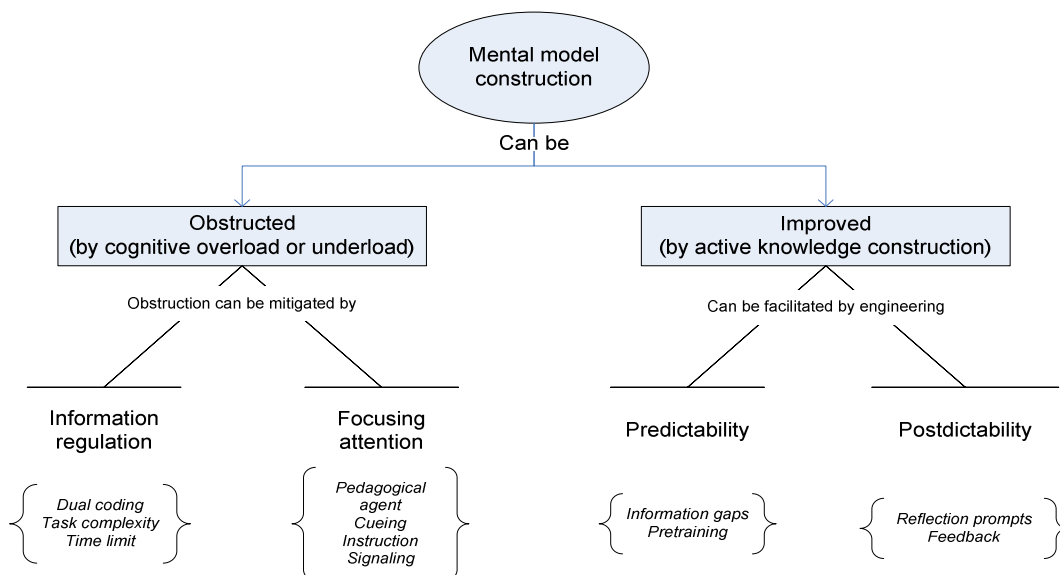


Figure 1. Framework for cognition-based design guidelines enhancing mental model construction

the player's attention to a certain area of the screen, for instance by having important objects noticeably reflect light. One could also do this less subtle and simply instruct the player, e.g. by a popup, to attend to a certain object. Last but not least, one can apply signaling [12], which entails stressing the parts of a text (or here: visual imagery of a certain to be learned mechanism) that are most important to understanding how different parts of a text relate to each other. For a more detailed look at some of these instructional design guidelines reducing cognitive overload in multimedia learning, see [13]. For a more detailed analysis of how these guidelines could apply to games, see [14] and [15].

To improve mental model construction, a designer can engineer what Kintsch [16] calls the predictability and postdictability of the game 'text'. Essentially these describe how well a person can predict what's going to happen next (predictability), or explain what has happened previously (postdictability). Predictability can be engineered to reach an optimal moderate level by actively introducing gaps in the information presented to a user, which will prompt the player to think ahead to fill in the information gap. It can also be done by pretraining, activating relevant prior knowledge during the game by some salient event. Postdictability can be engineered to be at an optimal high level by introducing reflection prompts, events in the game that encourage the player to think about his or her previous actions, or by giving corrective or explanatory feedback. A schematic overview of the framework for design guidelines enhancing mental model construction can be seen above in Figure 1.

IV. CODE RED: TRIAGE

A. Game setup

As mentioned previously, our game revolves around the training of medical first responders in a crisis situation. The game is currently being modeled with the Source SDK, a mod tool that comes free with VALVE Software's Half-Life 2 games. The player arrives in the central hall of the train station, after which he or she will need to find the way to the subway line that was struck by the explosion. We deliberately made the tunnels to the subway station maze-like as we hypothesize that this will give an objective measure of the player's proficiency with video games. We contend that experienced (First Person Shooter) gamers will breeze through the winding corridors, whereas novices may have considerably more difficulty with all the consecutive turning and maneuvering around objects. As well as being able to test the design guidelines more thoroughly on situational awareness and other path planning or decisionmaking objectives, a difference in gamer expertise could also interact with the effects of the design guidelines, where novice players may benefit more from explicit instruction, and experienced players from implicit cueing. A screenshot of the train station can be seen in Figure 2.

Arriving at the subway, the player will have to make a quick assessment of the situation, call for the estimated amount of ambulances, and then proceed with the triage task, a prototype of which can be seen in Figure 3. During the triages the game keeps a score of how well the player is

performing, and communicates this to the player. The score is constantly declining as some victims are said to die if not classified quickly enough. Some of the victims will furthermore change triage classification after they have been categorized (e.g. start out walking, but collapse to the ground behind the player), so that the player needs to keep an overview of the situation at all times. Afterwards the player will be given grades for handling a number of a priori set decisionmaking moments, as well as the score for the triages, to come to a final score that reflects how well they played the game. We will additionally use a pre-posttest design to see if there are any learning gains.

We contend that games should be goal-directed, a competitive activity and conducted within a framework of agreed rules, while constantly providing feedback to enable players to monitor their progress towards the goal [4]. The goal of our game is to teach the player to perform triages, the performance of which is communicated by a score, which in turn adds a competitive factor; we therefore believe our training is fully a game, instead of a simulation.



Figure 2. Trainstation in game (work in progress)

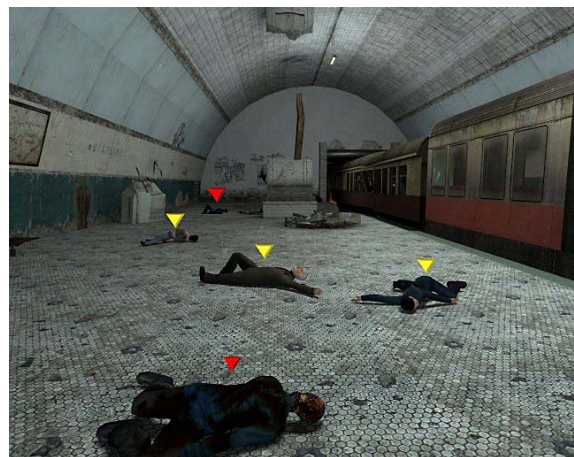


Figure 3. Triage categorization of victims in game (work in progress)

B. Cueing experiment

As an example of how a design guideline may work out in *Code Red: Triage*, we will focus on cueing, which will form the basis of our first experiment. That guiding a player's attention to relevant information can be done by cues and that this improves the learning of instructional multimedia material (but not games), has already been shown by Jeung, Chandler and Sweller [17]. Additionally, the effects of implicit (e.g. a far off mountain) and explicit (e.g. a signpost) visual cues on navigation and path finding tasks have been researched by Steiner and Voruganti [18]. However, it may be difficult to determine how well their findings can be generalized games-based learning.

With our game we will test each of the four major components of the framework in Figure 1, but we will first try to find out the effect of implicit vs. explicit cueing vs. a control group on mental model construction, decisionmaking skills and experienced engagement of the players, set out against their previous game experience. As an example of implicit cueing in the path finding section, one can think of subtle puffs of smoke emanating from the right direction, or objects being knocked over in the opposite direction by the people trying to flee the scene of the explosion. In the triage task, implicit cueing can be achieved, e.g. when the decisive part of the diagnosis should revolve around the arm of a victim, by having the victim reach for that arm while flinching from the pain, or alternatively by covering the arm in slightly more blood. Conversely, explicit cueing can be achieved by having fire or policemen stand at different areas of the subway tunnels to point the player in the right direction for the navigation task. For the diagnosis and triage tasks, explicit cueing can be implemented by painting the arm bright red. We hypothesize that explicit cueing will work best for novice players, but also decreases the challenge and thus engagement of the game. Cueing could potentially also be harmful, as the player may not process why the arm should be inspected. Because of this we will also include a control group that receives no cueing aid.

V. CONCLUSION

In this paper we argue that games are a promising instructional method for the training of emergency personnel. However, gaming is a complex task and the effectiveness for serious games is contingent on the ability of designers to facilitate players to deal with this complexity. Therefore, we propose a systematic approach of design guidelines for dealing with this complexity. For this purpose, we created a framework based on factors that obstruct or facilitate the construction of dynamical mental models. From this framework we have applied the cueing guideline in our *Code Red: Triage* game. There are also some caveats. To start with, we will focus on individual training in crisis management whereas team training and collaboration are paramount as well. The results should be interpreted with this in mind. Second, we would like to emphasize that the design guidelines should not interfere with the characteristics of games such as its narrative. For this we have developed the Game Discourse Analysis (GDA), which 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 [19].

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