

DESIGNING MIXED REALITY MOBILE GAMES FOR CRISIS MANAGEMENT TRAINING

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ABSTRACT

Games for crisis management offer an interesting complement to traditional training. Experiments on their usage show that games can be promising tools able to address some of the limitations of traditional training. Also our first assessment with a board game for panic management shows that this particular kind of game could be useful for soft skills teaching in crisis management. However the tested board game is not able to address all the elements characterizing crisis management, and in particular teaching field practices. For this reason we decided to add to the first board version, a mixed reality mobile game. With this game we want not only to train soft skills, but also to provide a more authentic learning experience. In this paper we describe the design challenges linked to this type of games explaining how we addressed them.

KEYWORDS

Serious Games Mobile games, Mixed Reality Crisis Management, Authentic Learning, Training for Emergency workers.

1. INTRODUCTION

Crisis management training through serious games has the potential to develop different skills: the ability to anticipate; an enhanced capability for teamwork; learning to cope with short response times; a better understanding of the value of/need for stress management; sharpened business judgment skills; enhanced lateral thinking and creative skills; greater sensitivity to weak signals of abnormality; and better acceptance of change. All these aspects are skills needed for crisis management (Roberts et al, 2002). Some already existing games for crisis management (see for example Incident Commander or Hazmat Hotzone) offer an interesting complement to traditional training. Though for none of them we have been able to find long-term evaluation of their impact, initial results of usage show they are promising tools addressing some of the limitations of traditional training. Also our first assessment with a game for panic management (Di Loreto, 2012) - a board game named Don't Panic - shows that this particular kind of game could be useful for soft skills teaching in crisis management, even having low development cost as a requirement. In addition, the experiment has shown a high level of acceptance of this kind of tool for the domain. However the tested Don't Panic version is not able to address all the elements characterizing crisis management. For example it's very difficult (if not impossible) to implement in this kind of games at low cost an adequate context or adequate actions able to teach work procedures in addition to soft skills. For this reason we decided to add to the first board version an augmented mobile game named MoDo. The main aim of this addition is to conceive different games that can communicate in a coherent way, allowing at the same time centralized management from the coordinators' part and interaction with the territory from the active workers part. In this way we can train different soft skills, using different games, but also teach on the field practices. Our main research question for this latter game is then trying to understand how to design a mixed reality mobile game (i.e. a game which merges real and virtual worlds to produce an environment where physical and digital objects co-exist and interact in real time) able to address soft skills and procedure teaching, and ensuring authentic learning. In the rest of this paper we describe the design challenges we encountered explaining how we addressed them in MoDo. In particular, next section analyzes the learning problems to be addressed during the design of such a game, Section 3 describes the game we designed to address such challenges, while Section 4 draws some conclusions and future works.

2. TOWARDS THE DESIGN OF A MIXED REALITY MOBILE GAME FOR CRISIS MANAGEMENT

To design a game able to address the above described situated training we decided to opt for a multilevel approach at the intersection of authentic learning, game based learning, and mobile learning. In the rest of this section we describe why these domains are needed in the design phase, while in next section we describe a game design which takes them into account.

2.1 Authentic Learning

Authentic learning is a pedagogical approach that allows students to explore, discuss, and meaningfully construct concepts and relationships in contexts that involve real-world problems and projects that are relevant to the learner (Donovan et al., 1999). In this approach the emphasis is based on the assumption that in classical learning information is stored as facts rather than as tools (Bransford, et al., 1990). A rather classical example is the driver with a physics degree attempting to dig the car out of sand instead of partially deflating the tires. Herrington and Oliver (2000) offer an interesting analysis defining the following critical characteristics of authentic learning:

1. Provide *authentic contexts* that reflect the way the knowledge will be used in real life
2. Provide *authentic activities*
3. Provide access to *expert performances* and the modeling of processes
4. Provide *multiple roles and perspectives*
5. Support *collaborative construction of knowledge*
6. Promote *reflection* to enable abstractions to be formed
7. Promote *articulation* to enable tacit knowledge to be made explicit
8. Provide *coaching and scaffolding* by the teacher at critical times
9. Provide for *authentic assessment* of learning within the tasks.

We will return on these aspects several times in this paper as we consider them criteria to meet when creating a game for crisis management.

2.2.1 Why to Use Authentic Learning for Crisis Management?

Crisis management is complex and we do not aim at its complete characterization, but rather outline general issues to consider when designing serious games. Let's use a simplified example to help us in this task. During a weekday, a truck transporting toxic material has an accident. If it gets in contact with air, the material could cause a major air contamination. The problem requires the coordinated intervention of multiple units: firefighters trying to avoid contamination; medical units taking cares of the injured; police trying to avoid traffic problems; Civil Protection activating evacuation plans and preparing sheltering for the population. As it is often the case, we are dealing with a wicked problem, i.e. a problem that does not have a univocal solution, but different solutions with associated costs and risks. In this scenario we can identify:

Predictable and Unpredictable elements: A complex interleaving of predictable and unpredictable events characterizes most crises. In our example, accidents involving vehicles transporting hazardous material are a well-known problem for which protocols of action are defined. However, nobody can predict when this will happen and the precise context, e.g. type of material, weather conditions, or population in the area. The involved units must manage the emergency as it unfolds.

Problem dissection: During a crisis, the main problem is broken down into manageable sub-problems, e.g. taking care of the injured, putting population in safe conditions, and so on. Generally, specific emergency units are allocated to each sub-problem.

Making plans: Once the main problem is dissected, action has to be planned. Each unit might define plans for sub-problem they have to handle, but with the need to coordinate the effort. Plans have to conform to approved protocols of action. They might act as maps or scripts depending on a specific situation and the role of the people involved, for example volunteers with low training have generally no authority to change a plan.

Local optimum vs. global optimum: Action leading to an optimal result locally is not always leading to the intended global result. For example, divert the traffic in one direction might reduce congestion in one area, but create problems to emergency vehicles parked in another road.

Communication and cooperation: Members in a crisis management team need to communicate to coordinate their action, e.g. keeping updated and negotiating changes in the plan, but also to cooperate to get the work done.

Roles: Crisis management is characterized by a clear definition of roles at the organizational, team, and individual level. Members of the emergency team can aggravate the situation if they do not accept leadership or refuse to act within their, possibly limited, action space.

Limited time for decision-making: In most crises, events can quickly deteriorate. In our example, the truck can start spilling out hazardous material and contaminate the air if the team is not able to act quickly.

Links to the territory: Crises do not happen in a vacuum, but are deeply grounded in specific social and physical contexts that influence their management, e.g. an event like the one in our working example happening in a highly populated area with schools nearby poses different requirements than if the accident happens in an isolated area.

Asymmetric information: Not everybody has access to the same information. Coordinators might have a better overall perspective, while workers deployed in the field might have more detailed and updated information regarding a specific area. No one can be sure to work with information that is complete, fully reliable, and accurate.

Quick convergence towards an objective: Though the time span varies with the specific situation, crisis management has the aim to quickly converge towards the “normalization” of the situation.

Coaching: Crises involve people with different levels of knowledge and experience. Actions that are almost routine for some of the workers might be extremely challenging for newcomers, both technically and in terms of emotional response. Though there is often limited time for discussion, and everybody has to act within their role and time constraints, there are continuous micro-sessions for informal coaching where workers support each other, providing suggestions and warnings.

Debriefing: After each event a debriefing session takes place to understand the critical aspects linked to the intervention. Debriefing sessions might significantly vary in terms of level of detail and people involved. For example, debriefing sessions might be conducted separately from each unit or together, if the focus is on coordination. Workers at all levels might be involved to use the session as an occasion of reflective learning at the individual and team level, while in other cases it might involve only top management to reflect of suitability of the defined protocols.

Actually, authentic learning is already used in crisis management. Learning from experience is promoted through structured debriefing sessions evaluating e.g. the application of existing protocols and team coordination. As a complement to real experiences, exercises that are simulating different crisis scenarios are regularly organized. These exercises can be seen as field tests that allow acquiring experience on specific events in a controlled and safe environment. Simulations generally involve different forces to manage an event, for example an earthquake. In this way, the simulation serves to test not only the responsiveness of a specific body, e.g. firefighters, but also the capability of different forces to coordinate their activities. Simulations are however very costly, requiring a large deployment of personnel and equipment. In addition, having situated learning is not always possible. For example most of the time using city centers for situated learning is avoided – in order to avoid panic spreading – cutting out the possibility to train in such environments. For this reason, computer based simulations have been proposed to facilitate training (e.g. Dobson, 2001 and Granlund, 2001).

2.2 Serious Games and Learning

The serious games movement started with the U.S. Army’s release of the video game America’s Army in 2002. The same year the Woodrow Wilson Center for International Scholar in Washington, D.C. founded the Serious Games Initiative, and the term “serious games” became widespread. The term itself is nowadays established, but there is no current single definition of the concept. Serious games usually refer to games used for training, advertising, simulation, or education, which are designed to run on personal computers or video game consoles. Corti (2006) considers that Game-based learning (GBL) and serious games have the potential of improving training activities and initiatives by virtue of, e.g., their engagement, motivation, role playing, and repeatability: failed strategies etc. can be modified and tried again. Digital game-based learning (DGBL) is closely related to GBL, with the additional restriction that it concerns digital games. Analyses have been conducted over the years, consistently showing that games promote learning in rather classical settings (see

e.g., Szczurek, and Van Eck, 2006) while in more applied field - like the health field - researches are still actives,(e.g. with the game L'affaire Birmain to teach children how to manage their diabetes and post stroke rehabilitation games, see Di Loreto et al., 2011).

2.2.1 Why to Use Serious Games for Crisis Management?

Training in crisis management is complex and it requires a combination of methods trying to reproduce as much as possible real life situations to teach best practices. However in crisis management training is important to support both aspects – specific procedures and soft skills: “The key to effective crisis management lies not so much with the writing of detailed manuals (that have a low likelihood of being used) and practicing location evacuations as with structured and continuous learning processes designed to equip key managers with the capabilities, flexibility and confidence to deal with sudden and unexpected events.” (Roberts, 2002)

One of the ways to address this complex scenario could be the usage of serious games. While simulation can help the crisis management team to find the optimal response to the crisis, serious games can help them, for example, in the art of optimizing the limited time that they have to develop creative responses to the crisis within the procedural constraints of the situation. The flexible rule structure can allow the learners to explore the game space, test hypothesis, and fulfill goals in a variety of unique, sometimes unanticipated, ways. However while there is a good potential to develop soft skills (e.g., communication styles during a crisis, team management and coordination, time management, stress management) and to transfer them in real life situations (see Charsky, 2010; Tang, 2012) it's not so evident that the hard skills learned through a game can be applied to a variety of real world situations. In particular if we look at the elements characterizing authentic learning described in previous section, we can see that the usage of classical electronic game simulations can allow for e.g., the usage of *multiple roles and perspectives*, while it's more difficult to insert *authentic contexts* and, above all *authentic activities*. In order to add them we will have the same problem real life simulations have: a high fidelity context, providing authentic activities with authentic reactions, means a very structured game or simulation, which on the other hand means high (development) costs.

2.3 Mobile Learning

In their paper “Towards a Theory of Mobile Learning” Sharples and colleagues (2005) distinguish what is special about mobile learning compared to other types of learning activity. An obvious difference is that it starts from the assumption that learners are continually on the move. We learn across space as we take ideas and learning resources gained in one location and apply or develop them in another. We learn across time, by revisiting knowledge that was gained earlier in a different context, and more broadly, through ideas and strategies gained in early years providing a framework for a lifetime of learning. We move from topic to topic, managing a range of personal learning projects, rather than following a single curriculum. We also move in and out of engagement with technology, for example as we enter and leave cellphone coverage. As we can see in this approach it is the learner that is mobile, rather than the technology.

2.3.1 Why to Use Mobile Technologies for Crisis Management?

In blurring the physical and scheduled personality of institutional-based learning, time-space implications of mobile learning open up opportunities for a wide variety of pedagogical patterns. Mobile technologies thus enable learning to occur in a multiplicity of more informal (physical and virtual) settings situated in the context about which the learning is occurring (Kearney, 2012). However apart from these theoretical considerations actual mobile learning still suffers from a prejudice linked to the content aspect. While in current mobile learning it's clear that the learner is mobile, the accessed content is still rather classical: the learner gets information through the mobile device. On the other hand mobile games use a totally different approach on the matter. In games such as *Can you see me now* and *Uncle Roy all around you*, the context is the content. The people playing the game and the place the game is played in are strongly part of the game dynamics (i.e., the actions the player can do). As we were looking for a low cost way to implement situated learning for crisis management we decided then to look into this kind of approach, designing a mobile game, augmented with smart objects. The design of this game and its advantages for crisis management teaching are described in next section.

3. MODO, A MOBILE MIXED REALITY GAME

To summarize previous sections, our main research question was: is there a way to address crisis management characteristics, in an environment that can allow for authentic learning through a mobile serious game? To answer this question we designed the mobile mixed reality game called MoDo which is described hereafter.

Game dynamics. MoDo is structured to be played in teams in a physical environment through the usage of mobile devices and technology-augmented objects (see Fig. 1 & 2). Each team has to complete its mission, to evacuate the people inside a zone or a building, before the other team does. This means that the teams have a limited amount of time to complete their missions using the resources (such as augmented hammers, chains, and the like) they are provided with. After this time they automatically lose the game. The game starts with a particular situation in the zone - for example a certain amount of wounded people, panicked people, collapsed walls, and so on - and the teams have to explore the territory in order to save people. However the players are able to see what the situation in a zone is, only by being in proximity of that zone (e.g., they will see the number of panicked people in a room only if they are near that room –see Fig.1). At the end of the game the teams will be ranked following the time used to complete their mission and the number of people they were able to evacuate. This means that each team has to “collect” and evacuate the maximum number of people in a limited amount of time. To do so the team has to bring the “collected” people back to the entrance point of the building/zone. The social aspect of the game includes then collaboration within the same team and competition between teams. The game is conceived so that only few key points are fixed: (i) the resources usable by the teams are limited; (ii) there is a limited time to complete the missions. All the rest of the game is linked to emergence dynamics (e.g., when and in which way the players use the resources, if they communicate/coordinate or not, and so on.) All the movements and events are tracked so that they can be used in the debriefing phase

Learning objectives of the Game. MoDo has multiple aims linked to soft skills and best practices. The missions inside the game are conceived to push local vs. global reasoning, problem dissection and making plans as dividing the game arena into zones and adding unpredictable events during the game which can create contrasting reasoning and priorities. The content of the game reflects real life information and events linked to crisis management. As the game is played in a real environment the players have to learn to use their competences taking into account also the other players and the environment they are playing in. All the teams are given a limited amount of resources and they have to use them wisely. Resources (typically physical objects augmented with sensors) are used to interact with the territory/building in order change a potentially dangerous situation. Finally not all the members of the teams have access to the same information (i.e. we implemented asymmetric information inside the game).

In addition MoDo addresses several aspects described in section 2.1.

1. Provide *authentic contexts*. The MoDo game is played in a real environment so that sensible areas in the city or of a building can be used for training. The game provides the narrative context for the situation in a real environment and the possibility to create tailored content for each group at low cost.

2. Provide *authentic activities*. All the actions that the players are able to use within the game were discussed with experts. Also the choice of which kind of tool to augment was decided following experts interviews (see next subsection).

3. Provide access to *expert performances* and the modeling of processes. This is the classical advantage of electronic games. As we can stock previous performances, novice players can compare their current performance with the ones from more expert players.

4. Provide *multiple roles and perspectives*. In MoDo Each team playing the game is composed by multiple roles: firefighters, first aid, and dog trainers. This mix allows simulating real life interchanges.

5. Support *collaborative construction of knowledge*. The mixed team structure and the game rules allow for intra team communication and collaboration in order to solve a common problem. The expertise shared has then the possibility to evolve - through time and through the usage of debriefing sessions -into knowledge.

8. Provide *coaching* and *scaffolding* by the teacher at critical times. This is a possibility left open by the game. If the teams are composed by more and less expert players, the experts can help the less expert in solving a problem.

A separate discussion will involve the points left behind as they can be characterized as post-game assessment more than in-game characteristics. We will return over them in the final section about future works.

Validating the gameplay through experts' interviews. In order to validate the game concept before the implementation (i.e., to validate if the elements we put in the design were really able to address the 6 points we analyzed) we conducted an expert evaluation with 4 crisis and emergency experts. Two of them were civil protection leaders, the other two came from the industry as sellers of emergency software and one of them in particular is a volunteer firefighter with a long experience. We used scenarios and low fidelity mock ups to discuss about the game. This expert evaluation allowed us to validate some game design aspect (such as the usage of the augmented objects) and to erase some other (like the kind of movement patterns the players have to follow in order to save the trapped persons).

They considered the whole game as a possible successful training means and the comments we got from the experts were directed towards little changes in the game dynamics while the scenario was easily accepted as realistic. In particular comments went into the direction of hints about *how to stick to real life procedures*. For example we were explicitly asked to add in the gameplay the necessity to bring people in a common room for a triage operation. Also the importance to find a way to keep track if the augmented object were used in the right sequence was underlined.

4. CONCLUSIONS AND FUTURE WORK

In this paper we described a mixed reality mobile game named MoDo. Our main research question was to understand if this kind of game can help learners through the usage of authentic learning. Experts' interviews conducted with crisis and emergency experts provided an initial validation of the game design for such a use. First of all MoDo is a low cost augmented game. Not only the game dynamics can be easily implemented on different platforms, but it is also possible to do hardware choices to keep the costs low (like in the solution we are using -everyday objects augmented through Arduino and barcodes). While it's true that this kind of game requires an initial setup, everything is mobile in the sense that everything can be used with little effort in different settings. Finally, the way the game is constructed -mixing real objects, mobile augmented reality, and real environment- seems to be a good low cost alternative to train emergency experts.

Currently we are developing a prototype of the game to evaluate it in use and understand its impact on learning. We are also investigating how to support the core aspects of authentic learning identified in (Herrington and Oliver 2000), see Section 2.1, that are not addressed in the current game design: 6. Promote *reflection* to enable abstractions to be formed and 7. Promote *articulation* to enable tacit knowledge to be made explicit. During our experts interview we got several hints about what could be useful to track during the current game session. The tracking can then help in structured debriefing sessions, but also to promote quick and long term reflection at the individual as well as at the group level. Finally we have the evaluation challenges. This is a more complex problem for this kind of domain, as this assessment can be done only after a real emergency. However we are planning to compare the results from the usage of our application with the ones from classical simulations to understand if the game at least is able to provide the same training.



Figure. 1 and 2. Storyboarding for the MoDo mobile augmented game

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