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Design of a game-based pre-hospital resuscitation training for first responders

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Abstract. This paper reports about the design of a game-based training intervention for pre-hospital resuscitation training. Our underlying assumption is, that survival chances in cardiac arrest situations could be significantly improved, if bystanders would be better educated and prepared to help. Based on a discussion of problems of current training concepts and related educational theories a game-based learning intervention is proposed. The focus of the intervention is the improvement of procedural knowledge and self-efficacy of participants. The game is designed on the basis of the ARLearn platform. The game context and game-design is discussed. Last but not least we discuss short-term and long-term evaluation scenarios.

1 Introduction

Cardiac arrest is one of the leading causes of death worldwide. In Europe alone it is estimated that approximately 350 000 people die from cardiac arrest each year [1]. Traditional interventions have not sufficiently decreased mortality rates and increased the rate of cardiopulmonary resuscitation (CPR) especially by first responders. This rate of first-responder CPR is critical to increase survival rates since the professional medical emergency services need approximately 8 – 10 minutes to arrive at an incident. In the Euregio Meuse-Rhine (EMR) the rate of bystander resuscitation is approx. at 27% [2]. In other countries and regions there is a rate between 65% and 75% of bystander resuscitation before the professional services arrive. The project "EMuRgency - New approaches for Resuscitation Support and Training" is a socio-technical innovation project with the target to increase the rate of bystander resuscitation and on the long run increase survival chances and the quality of life in our region [3]. In this project we are developing a number of services and innovative educational interventions to increase awareness, knowledge and willingness to help for inhabitants of the region. For this purpose the consortium is currently testing a notification-system for first responders and has developed technology-enhanced learning solutions to provide flexible access to resuscitation training for different stakeholder groups. Besides classical E-Learning interventions for institutions, a mobile application for CPR training is currently in development. In addition, we are designing a game-based learning solution for schools and universities as a more authentic way of training CPR skills. In this paper we introduce the design and implementation of this game-based learning solution. Based on a discussion of current approaches to train first responders we analyse the training from the perspective of the situated learning theory and discuss related work. Then we introduce ARLearn as the technological basis of the game-based learning intervention. The game-setting and game-design is explained next and the study design for the evaluation is introduced. Last but not least we discuss limitations and provide a research outlook.

2 Background and related work

Traditional training approaches for pre-hospital resuscitation training are mostly based on lecture-centric phases in combination with training of motor-skills on a manikin in a group-training context. In many European countries this training is part of a mandatory first-aid-training before being allowed to get the driver license. While this is on the one hand a window of opportunity to train large parts of a population in basic resuscitation skills and knowledge from an educational perspective this training format delivers only short-term knowledge and competence building whose retention times is normally not longer than 3 to 6 months [4]. From the perspective of the situated learning theory [5] this result is not surprising. The situated learning theory is a general theory of knowledge acquisition or an epistemology that has a central assumption that learning should take place in the same context in which it is applied. Herrington and Oliver [6] deduct the following guidelines for the design of educational interventions from the situated learning theory:

- Provide authentic context
- Provide authentic activities
- Provide access to expert performances & narratives
- Provide multiple roles and perspectives
- Support collaborative construction of knowledge
- Provide coaching & scaffolding at critical times
- Promote reflections to enable abstractions to be formed
- Promote articulation to enable tacit knowledge to be made explicit
- Provide integrated assessment of learning within a task

These design guidelines point into the direction of using simulations and game-based approaches for resuscitation training to increase authenticity on the one and on the other hand allow the application of knowledge to the problem context in which it could occur.

Earlier research explored the use of simulations and game-based approaches to train resuscitation skills to diverse audiences. Perkins [7] has discussed the potential of simulation for resuscitation training. The possibility to test and re-test processes and activities without involvement of any risks for a patient is seen as one of the most important benefits to use simulations in resuscitation training. The author then presents results of a literature review about the use of simulations in resuscitation training. In this review, different types of simulation approaches are identified, namely integrated clinical (hardware) simulators and online (software) simulators. These simulations have delivered positive effects in terms of learning outcomes and learning experience, mostly for medical professionals (and not laymen) and focus on advanced life support (and not basic life-support). In general, simulations are costly and need efficient integration into a related curriculum. While such investments might pay off in a clinical context, for the training of laymen such an investment is unrealistic, also because the skills to be trained are not comparable to the ones needed in advanced life support (ALS) for nurses or emergency doctors working in a hospital.

As an alternative to the full simulation environments authors have proposed game-based approaches for resuscitation training. Charlier [8] argues that game-based approaches to train basic life support (BLS) are a promising option for CPR motor skills training in schools. According to the author traditional approaches are mostly focusing on summative assessment due to scarce resources and material, while formative assessment might be much more beneficial for learners. She proposes a combination of peer-assessment and game-based assessment and presents a board-game designed as a proxy to assess first aid competences of learners. Creutzfeldt, Hedman, & Felländer-Tsai [9] propose alternatively the use of gaming in multiplayer virtual worlds as a pre-phase to traditional CPR training. In their study they could show that preparatory activities conducted in virtual worlds contributes positively to CPR performance and skills. Based on the design principles of the situated learning theory and the results of earlier research we have designed and implemented a game-based approach for pre-hospital resuscitation training. In the next part we introduce the ARLearn platform as technological basis to implement the intervention.

3 Technology

We are designing the intervention with the ARLearn-platform. ARLearn is a platform for location-based mobile learning. The platform consists of an authoring interface that enables game-designers to bind a number of content items and task structures to locations and to use game-logic and dependencies to initiate further tasks and activities [10]. The platform has been recently used for several similar pilot studies in the cultural heritage domain [11] and the training of volunteers for hostage-taking incidents in international organizations [12].

The cloud-based ARLearn service is hosted on Google App Engine as an open source project that permits others to reuse and contribute. ARLearn has been developed in an iterative design process, starting with a mock-up version, for which we gathered feedback on general approach, user interface and authoring/teaching aspects from two cultural science teachers and two technology-enhanced learning researchers.

Various kinds of clients connect to this game engine. The Android client allows for game play in the real world, while the StreetView-based client (called StreetLearn) offers a virtual environment [13]. Media items (including multiple-choice questions, video objects, and narrative items) are a central concept in ARLearn. They can be positioned on a map or made available depending on the game logic. A video can thus be bound to a coordinate, it can appear at a certain moment as a message in the player's inbox, or appear or disappear based on actions taken in the game.

An ARLearn game is a reusable game logic description that can be instantiated in numerous game-runs. Within a game, an author defines items, dependencies between items, game score rules and progress rules. A run defines users grouped in teams. While playing, users generate actions (e.g., "read message", "answered question") and responses. This output is also managed within the realm of a run. Basic elements of the object model are media items that hold information or add a function to the game. Media items can be positioned on a map or used for messages that users can receive at a specified point in time or in relation to a defined event. Specialisations of Media items allow to ask questions (MultipleChoice) or to include multi media (Audio- and VideoObjects). Dynamic items such as a transport task let users perform pickup and drop actions: A pickup item can be taken by users and can be dropped at a dropzone. Actions can lead (through dependencies) to new available items, increased scores or increased game progress. Items have a simple life-cycle with three states: Initially, an item can be visible or invisible (initial state). Invisible items can become visible (active state). When the item is no longer needed, it can become invisible again (used state). Items can define dependsOn and disappearsOn conditions for the state transitions. A simple dependency mechanism is put in place to support these conditions:

- Action-based dependencies are triggered by specified actions.
- Time based dependencies bind time offsets to other dependencies.
- Boolean dependencies allow to combine other dependencies to logically.

The following motivation guided the decision to use the ARLearn platform to realise the game-based learning intervention:

- The ARLearn platform is multi-user enabled
- The ARLearn platform is location-aware, which allows for realistic gameplay settings
- Commonly used smartphones can be used to play ARLearn games, which simplifies game distribution.
- The event-based game model of ARLearn allows to design realistic game processes, which simulate mission critical real-life situations and conditions
- The game-design should be re-usable so that the game can be easily adapted to other locations and contexts

The ARLearn toolkit is used for the design and implementation of the game-based resuscitation training. With the authoring environment all elements and roles are designed and dependencies are fixed. For the run of the game the players use mobile devices with the ARLearn client installed. In the next chapter we discuss the game-design that we have implemented with ARlearn.

4 Game-design & setting

4.1 Setting and game context

The game is envisioned as an extension of classical group-based resuscitation courses. These courses are mostly focused on transfer of factual knowledge and the training of skills on a CPR-puppet. The skills-training is focused on motoric skills and the right compression depth, frequency and rhythm. An underrepresented part in these trainings are learning activities related to procedural knowledge, the willingness to help and self-efficacy. Thus the game is designed to increase procedural knowledge, to train processes in an emergency situation and to influence the willingness to help and self-efficacy. The game-context is a first-aid course or a dedicated basic-life-support training. To play the game 3 – 4 mobile devices with the Android platform are needed and a computer for the debriefing session. It is expected that the players play three rounds of the game to allow improvement and reflection. A CPR manikin is placed in the vicinity of the training location and this location is used as the place for notifying the participants about the CPR case and leading them to the victim. The game is organized in messages that occur on the main screen of the ARLearn application. Each message triggers an activity of the players or provides input in form of video/audio messages.

The mobile devices with the ARLearn platform are used for several purposes.

- They enable the different users to play in a realistic environment, being guided to an actual AED device.
- They provide the possibility to send controlled notifications to users emulating communicative behaviour.
- They allow to monitor and record user behaviour and reuse this data a for later reflection and feedback session.
- ARLearn further allows augmenting the situation with location dependent information, process information and notifications, as well as instructive, situation-dependent educational materials.

4.2 Game-design

The game-design is oriented on the design recommendations for situated learning scenarios. The tasks involved in the game are aiming to produce a more authentic context for learners than the typical classroom lecture criticized earlier in the paper. The game-design is shown in figure 1. The game can be played with 2 or 3 players and there are 3 different roles foreseen: A CPR player, a player who documents the performance with video recording and an optional player who is responsible to find and get an Automated External Defibrillator (AED) to the victim.

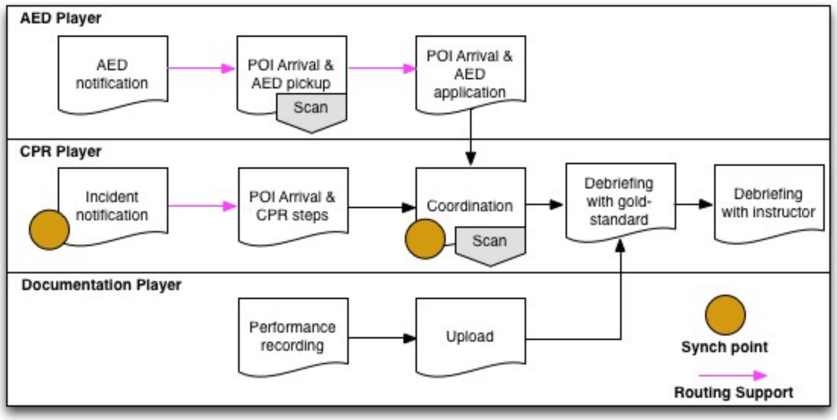

Fig. 1. Game-design resuscitation game

The game is organized in three phases: An introduction phase, a game-phase and a debriefing phase.

- Introduction Phase

The gamemaster gives a brief introduction about content and place of the game. The game is being explained, the rules and the aim. Groups are formed. Each group is provided with cellular phones.

- Game Phase

The game is initiated with a notification-message that informs the CPR player that a victim is in the direct surrounding of the team. The CPR player starts to identify the location of the victim accompanied by the documentation player. During the routing-phase the stress level of the player can optionally be increased with sounds or visuals that represent the decrease of oxygen in the body of the victim. After identifying the victim, the CPR player has to perform the steps required in case of a witnessed cardiac arrest, namely securing of the area, calling for help, controlling the breath and finally starting cardiopulmonary resuscitation (CPR) with a CPR doll. The documentation player records this process. As an option, the AED player receives the location of a nearby AED and he has to find the device and bring it to the location of the victim. Here the players have to scan a barcode to communicate to the system that the AED has arrived at the victim. Now the CPR player and the AED player have to coordinate their action in terms of continuing CPR and at the same time preparing the application of the AED. The documentation player is responsible for recording the performance in the best quality possible. The game is over after approximately 8 – 10 minutes after which the emergency medical services arrive.

- Debriefing Phase

When the game is over, the debriefing phase is started. The player meet at a location nearby and they enter the debriefing phase. The first part of the debriefing is based on a self-assessment. The team watches the performance and compares this to a gold-standard video that shows the ideal performance and situation. The results of the self-assessment are presented to a tutor who discusses the performance and provides tailored feedback to the self-assessment.

While we have presented here only one round of the game the players can change roles and play the game again. In this case the self-assessment will be done based on the three performances compared to the gold-standard. Since AED handling might not be part of all CPR trainings this part is optional.

4.3 Game components

The game-components are based on the concept of role-playing. Research has shown that 'repeated practices in realistic role-playing scenarios with situations and environments students are most likely to encounter' can increase confidence and the willingness to respond to an emergency [14]. The game enables students to experience the diverse roles involved in case of emergency.

The game content is related to the Chain of Survival, i.e. (a) to prevent cardiac arrest, (b) to buy time, (c) to restart the heart and (d) to restore quality of life. It comprises three phases, an introduction phase, a mobile gaming phase and a debriefing phase. In the Introduction Phase, players are presented a short introduction to the game, e.g. how to read QR codes with a telephone. They will then be provided with telephones and the game phase will start immediately. In the Game Phase, students play in teams of two. When opening the actual game, they already have the first message available, which relates to their role. The two initial roles are: role of bystander and role of AED support. The learners are randomly assigned to one of these roles.

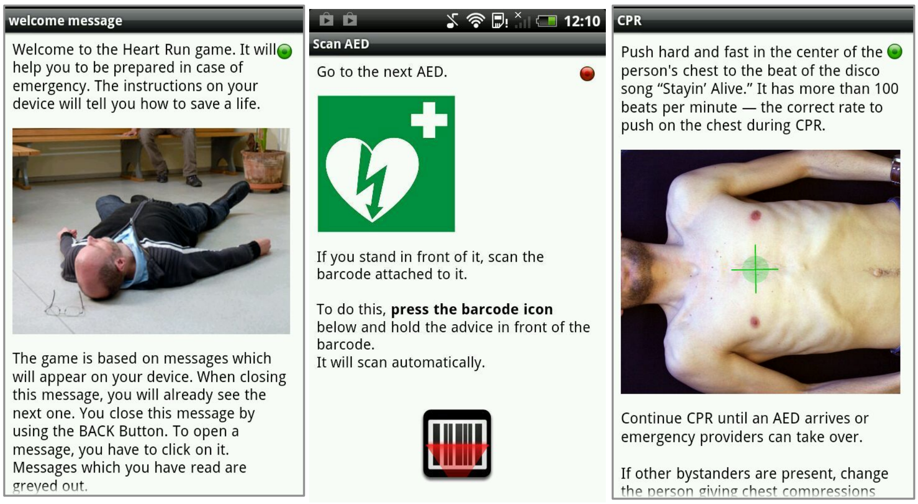

Fig. 2. Screenshots game-based resuscitation training

Also, in the course of the game phase, the player gets an unexpected alert message that requires immediate action. This time, no information is given on how to proceed. This part of the game has a third role integrated, the documenter. Immediately after the alert message has arrived, every player immediately needs to start action: find the next AED and get it (role of AED support), go somewhere and provide BLS (role of bystander), record the scene of action with the integrated camera of the smart phone and upload it to the system (role of documenter).

With the first message the game starts to count down 10 minutes. After this time, the game automatically ends with the message that the ambulance has now arrived and will take over the victim. Within the Debriefing Phase students revise and share the knowledge they acquired within the course of the gaming phase. To do so, their recording as well as an ideal type of action (gold-standard video) is presented. Learners are then required to compare both versions and reflect on things to improve. The game can be played several times, with participants switching roles. This way, the game allows students to perceive the emergency situation from different perspectives.

5 Evaluation planning

Our hypothesis is, that participants who follow the game-based learning intervention show equal knowledge and performance results compared to the control group but better retention of knowledge and self-efficacy compared to the control group. We are currently preparing a study to evaluate effects of the game-based learning intervention. The study design is shown in figure 3.

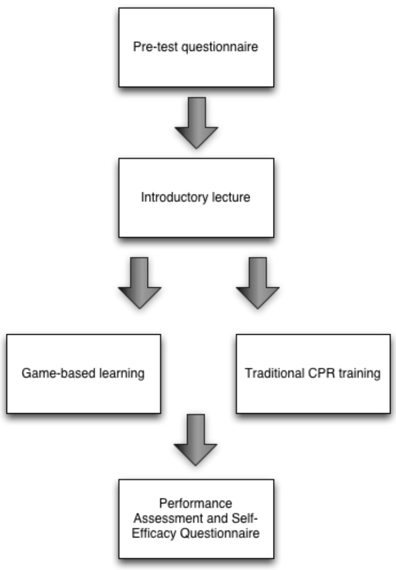

Fig. 3. Study-design game-based resuscitation training

All participants will first be provided with a baseline questionnaire to test their knowledge about CPR and their self-efficacy to act in case of an incident. According to Maibach, Schieber & Carroll [15] self-efficacy is a factor that is not directly linked to knowledge but can be the most important one in case of an incident. It can be best influenced through performance mastery and observational learning. After the pre-questionnaire all participants will be provided with an introductory lecture that will treat the basic knowledge about resuscitation. Participants will then be randomly assigned to the treatment group or the control group. The treatment group will follow the game-based learning intervention while the control group will receive a traditional CPR training with a doll and a control device that provides feedback about the depth and speed of compressions. In addition, a tutor will be present to give feedback to the learners.

The treatment group will follow the game-based learning intervention as discussed earlier. As a next step, all participants will be involved in a performance test on a CPR doll. Afterwards, all participants will fill out a post-questionnaire again related to their CPR knowledge and perception of their self-efficacy. The questionnaire will be again send out to the participants after 6 months after the intervention.

6 Discussion

This paper has introduced a game-design for a pre-hospital resuscitation training intervention for laymen. While the game-design is already worked out in detail, we have not yet decided with which means we can increase the stress of participants (e.g. emotional video footage, counters etc.). If the results of the first study confirm our hypotheses we will in the future implement a second study that will realize a factorial design in which a treatment group will receive 4 different implementations of the game-design that differ in terms of the stress-components involved. Another alternative for future research is the altering of the debriefing method used.

The game-design implemented will be published for others to be reused. We believe that the game-based training concept is a promising direction for pre-hospital resuscitation training for first responders. On the one hand, the method is easy to implement, on the other hand we expect more authenticity of the training without the costs of high-fidelity simulations often used in training scenarios for medical professionals. Furthermore, we aim to extend the game towards a longer-term involvement of players aligned with the EMuRgency project's goal to set up a community of trained volunteers for resuscitation.

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