Scenario-based Serious Game to Teach about Healthcare

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***Abstract*—In this paper, we explore the concept of a scenario-based serious game for healthcare solutions. The complexity of the interactions and the multitude of actors is captured in a scenario, which is then played with the help of an additional game platform, here called "scenario system". The platform allows high school students to play through a healthcare scenario, possibly including eHealth technology, thereby teaching them about interactions and technology used in modern healthcare. The mobile serious game is based on context and role-triggered tasks for the players so that the game is guided, but includes a certain dynamic and flexibility. The project contributes a method and a tool to use scenarios for user testing of eHealth systems and services as well as an alternative method for teaching the complex domain of eHealth systems to unfamiliar users (e.g. highschool students).**

***Index Terms*—eHealth, Human-centred Design, Serious Game, Scenario-based Design**

I. Introduction

The Center for eHealth at University of Agder works with modern health and care solutions. These solutions are characterized by a multitude of persons that work together in any given situation. These persons stay at different locations using an underlying eHealth system for coordination. This can lead to unexpected situations which should be avoided because definite outcomes are mandatory in the health sector.

The introduction of new services is therefore always connected to a joint design of technology and service models. However, it can be problematic to design a service without stable technology at hand. In this situation, simulation of scenarios can be used to experiment with services and technology at the same time. The simulation of scenarios is like a multi-agent serious game including the users of health and care solutions and the technology and systems that they are using. Health and care technology can include all sorts of existing technology or systems on a prototyping stage, depending on what should be tested with a scenario play-through. A scenario including actors and health systems is shown in Fig.1 (1). Connected to Fig.1 (1), it has previously been studied how existing healthcare systems (here: telecare alarm services) in Norwegian municipalities are organized and operated to identify requirements (from infrastructure

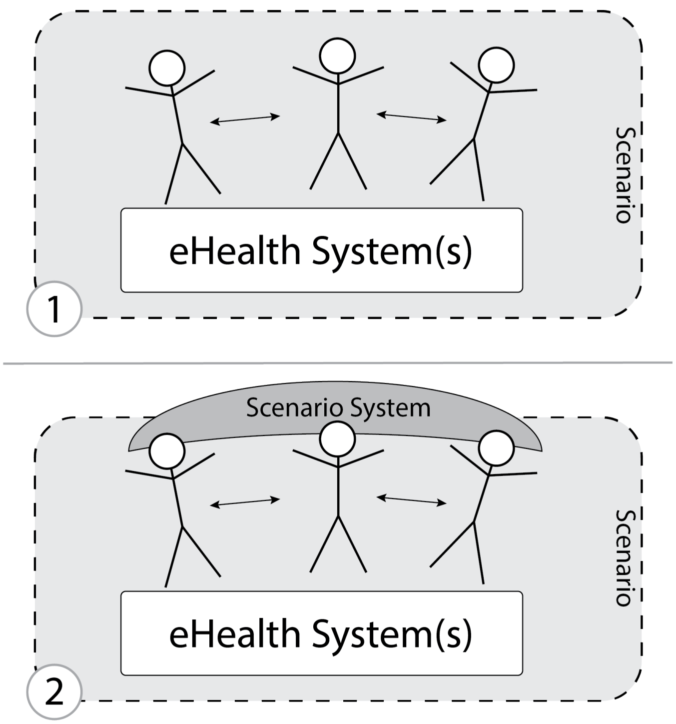

Fig. 1. (1) shows the scenario play-through without supportive technology; (2) shows the scenario play-through including a scenario system that acts as a game engine.

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to usability design) to improve existing systems and service models or conceptualize new ones [1]. In this paper, we want to include a system that helps to coordinate such scenario play-throughs. This system called "scenario system" helps to coordinate actors and health technology and is not considered health technology by itself, as shown in Fig.1 (2). The scenario system is the "game engine" that lets users take roles and issues tasks for them to perform. The primary goal of these play-throughs (serious game sessions) of the scenario is to help test the health technology and service models in place. Having a stable game engine to coordinate actors, the scenarios are easier to reproduce with multiple groups of people and therefore potentially lead to more stable testing outcomes.

In order to support the play-through of the scenarios by both professionals and students, we describe the scenario system, in this case a mobile system, that was developed to support the scenario game play in this paper. The focus is on the scenario play-through for the students, as this involves more detail and synchronization.

As shown in Fig.1, the gaming technology (scenario system) is introduced in addition to the eHealth technology that is used during scenario play, which means that scenarios can be played even without all health technology in place. Due to the parallel development of technology and design of service models, the scenarios are designed so that it is typically possible to run the particular scenarios without the underlying eHealth technology, or just by using parts of the technology.

In addition to supporting analysis and testing of healthcare solutions, the scenario play-throughs can be used as an active method to teach the complexity of healthcare scenarios to new users. Being located at a university, the Center for eHealth also attracts the attention of local schools that want to inform their students about modern health and care solutions. The traditional way to do this teaching - namely classroom teaching - has its limitations and is definitely not able to convey the complexity and concurrency of the technical solutions.

In this situation, the idea was to use the scenarios from the telecare setting to teach the details of modern health and care solutions, thus creating a serious eHealth game for students. Such an approach has many advantages. Firstly, it is easy to keep the teaching up to speed with the ever changing healthcare profession landscape. Health technology is a recent upcoming field and an important path for a career as many universities start to offer studies or courses in that particular direction. Secondly, the students are deeply immersed in the scenario and experience the health and care sector in a more realistic way than traditional classroom teaching can offer. This gives the extra benefit that young students are attracted to these scenarios even though the used technology and roles might be unfamiliar to them. Finally, as the scenarios are the same as the ones in our previous projects, we get additional input on the usability and feasibility of these scenarios. This way, the high school students become co-researchers within the topic of eHealth. Having the students simulate given healthcare scenarios and play through them, can uncover design flaws in the used technology or the organizational model of the services.

However, it has to be kept in mind that for healthcare professionals, the scenario description is quite high-level and indicates the sequence of events and activities to be done. The scenarios on this level do not include the low-level activities that are performed by the health professionals routinely. However, this might be problematic in the context of designing new service models, as new services might imply that existing high-level activities in the workflow have to be rearranged, redefined, and put together in a different order.

For high school students, the scenario situation is different. They need a much more detailed description of the specific scenario, since they are not trained in the subject. However, they can also find loopholes in the scenarios as they do not start with a preconceived sequence of activities. Another difference which has to be kept in mind while analysing the outcomes of played scenarios, is that highschool students are expected to run into problems that are not real problems for trained healthcare professionals.

This way, the scenario-based approach is a novel way of using technology in teaching, since technology in general is not used to its possible extent in teaching and learning contexts. We can make use of so much more when it comes to available technical functions. However, educational settings most of the time only use technology as e.g. file storage, file distribution and as a communication device between the students and teachers. The generally available sensors, cameras, virtual or augmented reality, the connection between mobile devices, possibilities for situational analysis and implementable logic for interactions is not used to its full potential in teaching.

This paper is structured as follows: Section II introduces the connections between games, gamification and education, especially related to task design. Section III describes the human-centred design methodology. Section IV presents how the telecare scenarios were constructed and Section V the game tasks and dynamic trigger design, followed by technical prototype specification in Section VI. Finally, Sections VII and VIII share the experiences, discuss the main results and summarize the contribution.

II. Games and Education

The introduction of games and gamification into education has come a long way these past years. Since many of the words like 'serious games' and 'gamification' have been used in different ways, it is important to outline our interpretation of these concepts. In this paper, we are describing a serious game which is a game that is developed for another purpose than pure entertainment. This is in contrast to the most mainstream definition of gamification (the use of game-design elements in a non-game context [2]). The serious game we describe is a full game, not only relying on (added) game-design elements to improve motivation, user experience or to change the user's behaviour. However, the line between those two can be blurry.

Serious games are widely used in medical education [3]. There are virtual adaptations [4], as well as real-life adaptations. Virtual serious games are played by the players virtually with an avatar. These games can be using virtual worlds, virtual reality, role-playing game (RPG) elements and more. In this research we would like to focus on a blended approach, bringing the game into the real world using mobile devices as player guidance and 'game engine' where the player is using the real world to navigate through, and where players play as themselves in designated roles given to them by the game engine. Currently, the most popular commercial games with such an approach are Ingress[1] and PokémonGo[2] by Niantic. In these games the player receives tasks and options to play the game within the real world, delivered through their mobile device. In contrast to those commercial games, the game we are describing in this research does not focus too much on the global positioning system (GPS), as the main task trigger and event catalyst. Our game is about acting in a specific healthcare-related scenario using the roles and instructions as given by the game.

Previous research has also shown that teachers enjoy integrating new technology into teaching when it is of use for them, and supports their teaching approach, or brings significant value into the learning environment [5]. One aspect that teachers see as important in their teaching is to create tasks for their students, including the option of creating those tasks by themselves, and to improve or adapt them in certain situations. Therefore, supportive teaching technology has to include the option for the teacher to shape tasks in the game and make the playable scenarios their own. Having an adaptable game with personalizable tasks for the teacher, makes it more likely for the technology to be integrated successfully in the long run.

Having established that tasks are very central in games for the teachers, we can also have a look at how important adequate learning task design is for the learners. There are several pedagogical principles that can be addressed with correct task design. The first pedagogical concept that is important to note is the zone of proximal development (ZPD). Defined by Vygotsky, the ZPD is "the distance between the actual developmental level as determined by independent problem solving, and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers" ([6], p.86). On the one hand this means that the learning tasks have to be designed within the ZPD of a student. On the other hand, it tells us that with adequate guidance, a learner is able to have an effective learning outcome with a higher range of achievement. Originally, this guidance was meant to be a teacher or peer, but guidance can also be provided through other means; e.g. technology. This can include scripted or artificial intelligence (AI) characters (non-player characters (NPC)) that help the student through a given task, or, it can mean that the roles are defined in a way that playing students are able to help each other through their provided materials.

[1]https://www.ingress.com/

[2]https://pokemongolive.com/

III. Methodology

This research project is based on a human-centred design (HCD) [7] approach. In an early phase, user scenarios were developed based on the outcomes from user workshops targeting telecare service models [1]. After that, paper prototyping of the mobile application was made. During the technical development, multiple iterations of prototypes were developed, and constantly tested directly with users. The base principles of HCD for the development of usable interactive systems can be found in DIN EN ISO 9241 - 210 [8]. Furthermore, a scenario-based design approach was not only chosen for analysis of the context of use, but is the basis of the shape of the game since the game itself is representing the play-through of eHealth-related scenarios. Therefore, it is important to analyze how healthcare situations take place in a real context.

IV. Scenario Description

The scenario that was applied for the serious game development was derived from the research project 'Model for Telecare Alarm Services' (2015-2017), that explored and evaluated organizational models for telecare alarm services in Norway [1] [9]. In that project, end-users from municipal healthcare and patient organizations participated in workshops and user-based simulations, in a laboratory environment to explore and test different service models for telecare. Telecare technology is used to support communication between citizens at home and health care services [10]. Telecare technology, that often has sensors at peoples home, is considered to be an important remedy for coping with the significant challenges of societal demographic changes [11]. The goal is to enable people with physical limitations to live independently at home as long as possible [12].

For the telecare alarm project, a specific telecare scenario was developed as a group simulation, where interaction between multiple test rooms is provided only by the use of technology. The scenario had a description of the telecare context and a particular alarm situation to be handled. One moderator from the research team was placed in each test room with a group of participants, and also one in the observation room. The scenario was repeated at least once, and for each repetition the participants also changed test rooms, so that each group played the different roles included in the simulation. The telecare scenario had assigned roles and there was a separate task list for each role. During the simulation of the scenarios, the moderators reminded the participants to think aloud and speak freely [13].

The main telecare scenario used in the development of the prototype was a fall scenario. It was performed as a role-play in a clinical laboratory. The roles with their associated tasks in the scenario were the following, as also shown in Fig. 2: a) a patient at home with a fall accident and triggering a telecare alarm with a Safemate GPS geolocation and communication device [14], b) a telecare alarm service operator receiving the alarm and communicating with the patient and the relevant services, c) a municipal home nurse on duty for home visits,

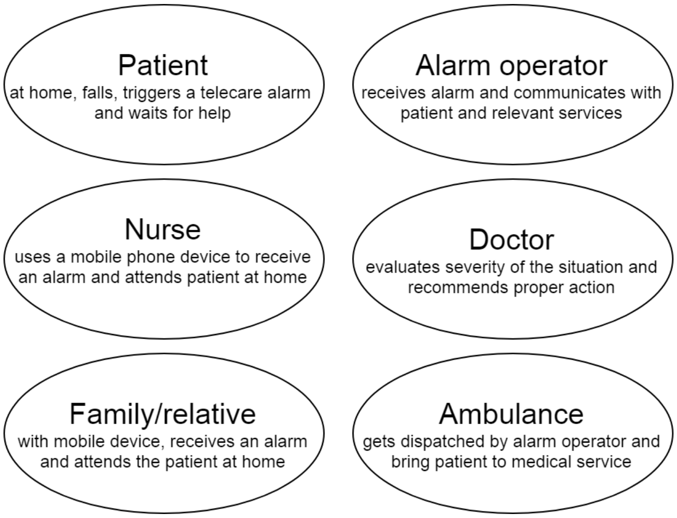

Fig. 2. The fall scenario and its roles.

using a mobile phone device to receive a message about the out-call, d) a family member with mobile device, receiving a message and attending the patient at home, e) a doctor with a mobile device to be called for advice on handling of the situation with the patient, and f) an ambulance service to attend the patient at home. In addition, the scenario was observed by a group of observers in the control room, following the interactions between the role actors and the technology. The situation is handled by the family member and home nurse as the first line of response. Their status report is used by the telecare alarm service operator to check with the doctor whether further action is advised. Finally, an ambulance to transport the patient to medical service is the last line of response in critical cases. The information flow between different roles consisted of electronic messages that represented the tasks to be executed and transmitted through mobile devices. After each performance of the telecare scenario, there was a group debrief where the participants reflected on the scenarios and the task flow.

To test the eHealth serious game, over 50 young people that participated in the research project 'High school students as Co-researchers in eHealth' [15], carried out several simulations in the clinical laboratory during 2018. The aim was to teach and experience eHealth, but also to test the different roles in the telecare scenario, and use the smartphone application that was developed to guide the task flow in the simulation [16].

V. Game Tasks and Dynamic Trigger Design

Tasks are very central game design elements. However, they are used in various varieties and shapes in games. This makes it necessary to have a closer look into the complexity of game tasks in order to be able to design tasks for a serious game. In addition, tasks are not only used in games, as learning tasks naturally occur in education settings as well [17]. A careful combination of both approaches can help to shape tasks in an educational serious game context.

Game tasks consist of their structure and surrounding processes [17], see also Fig. 3. The *task structure* includes the content (e.g. what to do, how, with whom, when) and tasks visualization (how it is shown in the graphical user interface (GUI). *Task processes* are processes surrounding the tasks such as the interaction with users or with the game world, the connection to the game world engine, and effects on the story-line and context of the user (gamer).

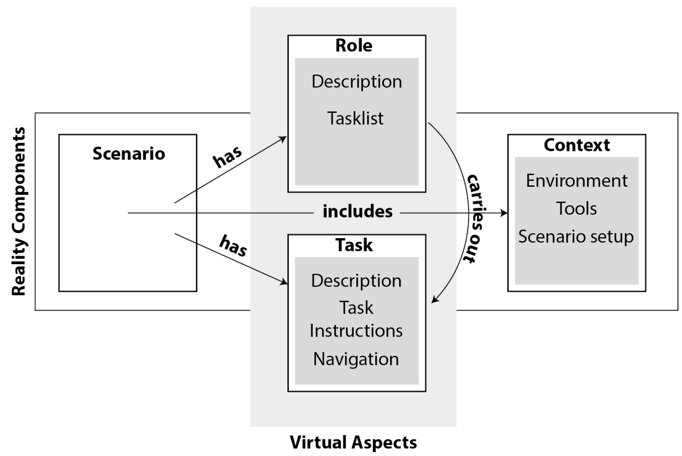

Fig. 3. The general setup behind the triggering concept in this project, including the virtual aspects of tasks and roles, as well as the reality components of the scenario and real-life context including the environment, setup and used tools.

Game tasks do not just exist; they are designed to appear or to be issued under specific circumstances. These circumstances can be simple or complex, but there have to be certain defined circumstances to when a task is given to the user (gamer). A simple example is when the user simply started the game, then the first task is made available. A more complex example is a task personalized based on the users level of experience, time, story progression, and personal decision making throughout the play-through. The circumstances that determine the availability of tasks are called *triggers*. A task can have one or multiple triggers that are necessary for the user to meet in order to get the task.

Tasks in role-playing games[3] are highly interconnected and usually not structured in a purely linear way. That means, the design for a scenario-based prototype needs to include different pathway options to give the players the (perceived) freedom of choice (including control, interaction, story [18], [19]), which is one of the most motivating aspects of game design elements [20], [21]. It is also necessary to create the possibility to have a personalized experience (to a certain degree). That means, triggers need to be defined carefully to make the right tasks appear to the players which make sense in the given playable scenario.

[3]Role-playing games are the kind of commercial games most similar to a scenario-based healthcare serious game that heavily relies on player-roles and task-based actions taken during the game-play.

In this version of the prototype, the set of available kinds of triggers is still limited. The following trigger types are currently available.

- User sending a trigger by pressing a button. The button is the primary method for a user to manually send a trigger to the server. A button can send a trigger signaling that the specific task has been completed, or on certain tasks a second button can be linked to a skip. A skip is when a user sends a trigger that a task has already been completed by another user. In the fall scenario, the nurse may be late to the patients house, and the ambulance has arrived before her. Then the ambulance will be able to signal that it has arrived, thus skipping any subsequent tasks for the nurse related to helping the patient before the arrival of the ambulance.
- Timer based trigger, running on the server. The timer is defined as a task in the scenario, but will not be sent to any users. Once the timer task starts it will count down, and when it completes it will automatically send a new trigger.
- External system events are triggers that come from other sources than the server or the client. Based on the scenario used in the prototype, the triggers could occur based on information sent from the eHealth-system used within the scenario. Currently, these triggers do not influence the game engine, but are given as information to the roles. An example would be to wait for a phone call, where the phone call is the trigger, but the game engine does not see whether it is activated or not.

Using these triggers and the task concept, the scenario as presented in Fig. 2 is turned into a game scenario as shown in Fig. 4.

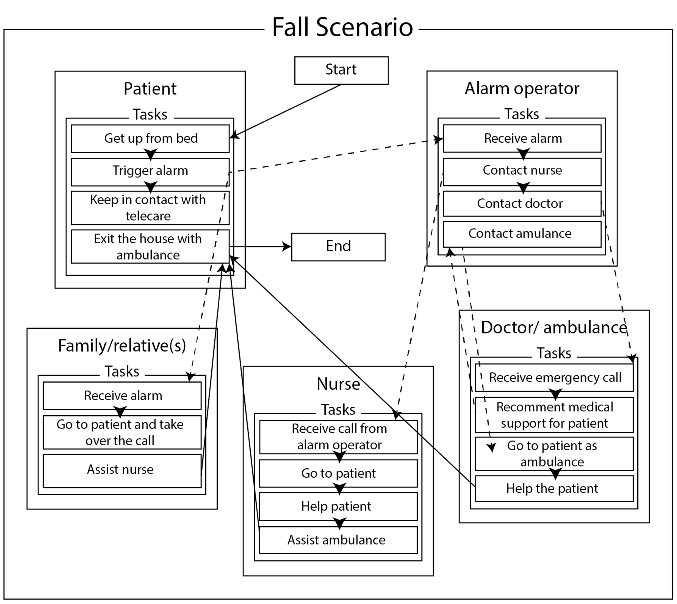

Fig. 4. Dynamics between roles and tasks in the playable fall scenario at the current stage of the prototype. Dotted lines indicate externally triggered events, such as phone calls, and the arrows indicate user triggered events.

VI. Technical Specifications of the Prototype

The prototype is designed to be used in a role-play setting, where the users are accessing it through a mobile device. The solution for the prototype is a web-based application, which utilizes the real-time engine Socket.IO[4] to ensure reliable bi-directional and event-based communication. Being a web application, it ensures cross-platform compatibility across multiple devices and operating systems. It also scales to the many different form-factors of mobile devices, to ensure that the user experience remains similar across all mobile devices. This is important when considering that the users are expected to use their own devices to access the application. The application consists of the following elements:

- *Scenario instance* - is the actual playing ground. It holds an instance of a scenario and keeps track of user progress. Each of the instances have a unique code which the users have to input in order to access it.
- *Scenario* - contains descriptions of all roles and their respective tasks.
- *A Role* - contains a description of the role the user is assuming, and a list of tasks within the scenario it is connected to. For the fall scenario, the following roles were created as shown in Fig. 5: patient, family/relative, telecare alarm service, home nurse, doctor and ambulance service. Please note that the two roles, doctor and ambulance service, have been put together into one combined role, because each of them is very small and would give a boring task for the student having such a role.

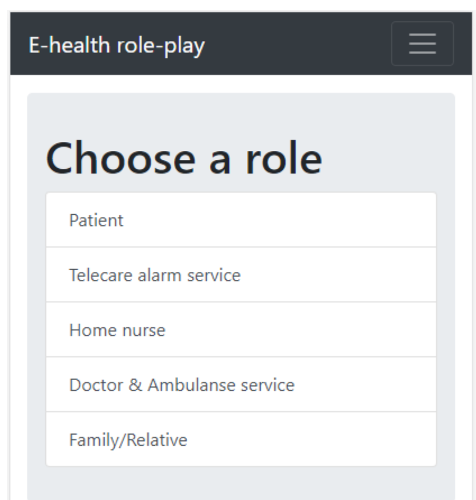

Fig. 5. Roles that can be taken within the playable scenario, in this case for the telecare scenario.

- *A Task* - is an activity to be executed, see Fig. 6 for an example. It is connected to its respective role. New tasks are presented when their trigger is activated. A trigger can be the completion of previous tasks or system events. Task activation is not restricted to the same user, a user can trigger a task for another user.

[4]https://socket.io/

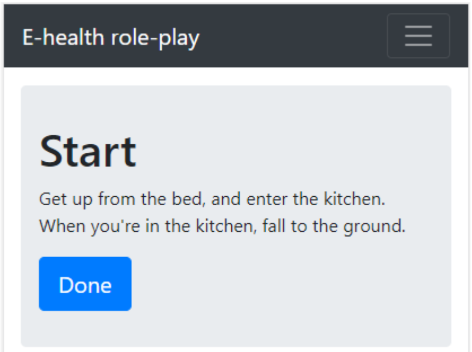

Fig. 6. Example task on how the patient starts the scenario. Upon pressing the "Done" button a trigger will be sent to the server, and a new task will be sent out to the appropriate users.

When the users enter the site, they will be presented with an input field where they have to enter a code. The code is needed to access the scenario instance, which holds the instance of a scenario. Multiple instances can be created and will not interfere with each other. Upon accessing an instance, the user will be presented with the available roles for the scenario. When all the roles have been chosen by at least one user each, the scenario will start. Upon start, the server will send the first available task to the user with the appropriate role. Upon completing the task, the user will send a trigger to the server, which will then distribute any new available tasks to the users as shown in Fig. 7.

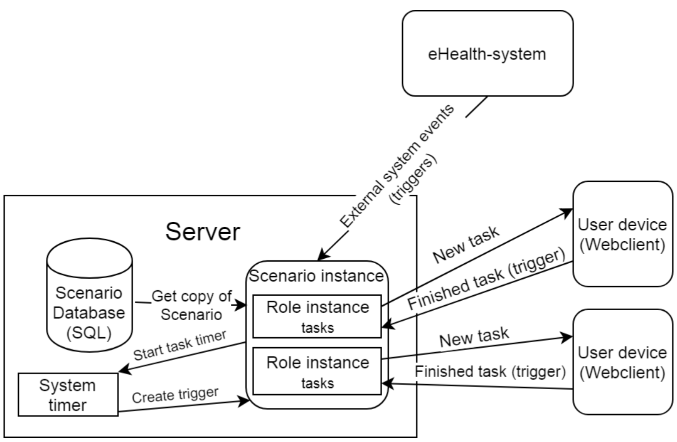

Fig. 7. The architecture of the server-client, displaying functionality within the server, and interactions between server, client and eHealth-systems.

For the moderators there is another separate page where they will be able to see all active instances, and create new instances. Creating a new instance opens a new page, where the moderators can add a name and choose one of the available scenarios for the instance they wish to create. When the instance is created it will be displayed on the previous page, and be granted a unique access code. If the moderators click on one of the instances, they will be able to monitor the progress of each task, send messages to each of the roles, or restart the instance. Restarting an instance will set all progress back to start, without the users having to select a new role.

VII. Experiences and Discussion

The original scenario description for the telecare scenario was used to define the different roles and tasks needed for the prototype. With the roles and tasks defined, some early sketches were made to define the requirements of the prototype. The first iteration was a paper prototype, where each of the roles had a set of cards with their corresponding tasks, see Fig. 8. Each of the task cards had a starting condition (trigger), which defined when the participant could start on that particular task. The cards were used to describe the flow of the scenario. Using paper for the first iteration proved useful, as it did not require any of the participants, in this case high school students, to have access to a mobile device. During testing of the paper prototype there were issues regarding the ordering of the tasks, as the participants were looking through all the cards they were given and accidentally rearranged the order. This resulted in a break of flow during the testing, with moderators having to assist the participants with getting back on track. After the testing was completed, the participants were asked several questions regarding the prototype, with the conclusion being that they would prefer it to be digital.

The second iteration of the prototype was a direct digital translation of the first iteration with some minor adjustments. This iteration allowed the participants to access the prototype from a mobile device, which included the opportunity of user feedback. Compared to the paper prototype of the previous iteration, this iteration reduced the error rate of participants accidentally going to the wrong task. With the reduced error rate we were able to get a better understanding regarding the individual tasks and their starting conditions. It became apparent that the starting conditions and the content of the tasks were confusing for some of the participants; the main issue was to understand when to start the particular task. Having all the tasks available at once and giving the participants the responsibility for starting the right task at the right time, caused inconsistencies regarding the flow of the scenario.

Other participants noted that some of the tasks were confusing and not sufficiently described. They also mentioned the use of hints as potentially useful in assisting the participants with the role play aspect, as many did not know how to correctly act or what to say when performing a task. In this context, an irritation appeared for the combined doctor/ambulance role, as it was not always clear which of the two roles was supposed to act on the next task. This problem was later solved by better explanation of the role, but still it appears that combining roles makes the role-play harder.

An issue regarding infrastructure became apparent during the testing phase of the second iteration. As some of the participants were expected to receive calls on their own devices, these users were unable to see the current task and its description. This also relates to the previous issue regarding how the tasks were described. The issue only affected the nurse and doctor/ambulance roles, as the other roles either called using a Safemate device or a land line. A few users solved

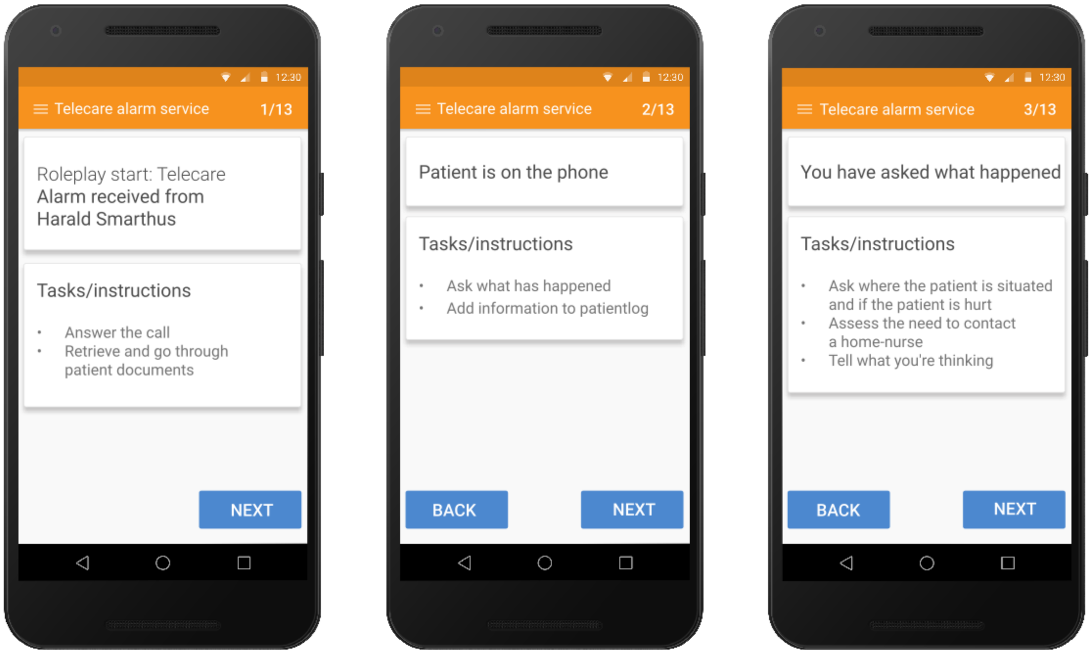

Fig. 8. Three screens from the paper prototype showing tasks tested during the first iteration: a) Start of the scenario "alarm went off" b) Follow-up task "contact with the patient" c) Follow-up task "gather information about the situation".

the issue by putting the call on speaker and minimizing it, in order to see the task again. The issue would be more prominent without the Safemate setup.

In the current iteration of the prototype most of the main issues have been resolved. Handling of triggers has been moved to an automated system, which distributes the tasks between the roles that the scenario is based on. The system currently handles user created triggers and event timers, eliminating the need for the participants to determine when they can start on the next task. The issue regarding infrastructure still remains, namely when the user receives a call. An improvement is that in the new infrastructure, users will jump straight back to where they were before taking the call. This is not a complete solution to the issue, but it ensures that the users still receive their tasks even if they are not active in the application. Even if the user closes the application, she is still able to jump back in by accessing the instance and going back to her role.

VIII. Summary and Conclusion/ Future Plans

In this paper, we have described the development of a serious game for scenarios that can be used in health and care applications. Learning tasks in education, tasks in healthcare scenarios and tasks designed for games share a lot of similarities. From this analysis, we have derived requirements to design adequate tasks for a healthcare scenario game, that includes the educational task aspects as well as game task aspects. That does not mean that the task design is flawless. Since the serious game designed in this research is played in a real-world setting, unexpected events and errors in the game flow can be resolved through a scenario supervisor.

Compared to attempts to play through the scenario without a supportive prototype to deliver the tasks, the prototype has proven to be helpful in the scenario-runs and has provided the students with the right information at the right time. The scenario descriptions were adapted during the development of the prototype, according to new insights coming from the involvement of students without a professional health background, and from general feedback about the game-flow, content, and usability. Interestingly, even without a professional background, students could understand the purpose of the roles and tasks and come to insightful conclusions about how important research and education in healthcare is.

Scenario-based games prove to be a good way to teach within complex domains and they provide a good understanding and feeling for the complexity of the problems and the routines. Using a game engine to run the games has been beneficial and has simplified the game execution considerably.

Improvement of the prototype based on further testing is planned. Moreover, the scenario methodology will be introduced in other courses related to health that also involve many actors and concurrent activities. This way, a similar learning effect for our health students as for the high school students should be feasible.

Acknowledgment

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