



# Using Mobile Devices as a Supportive Tool to Engage and Interest Young Students in e-Health

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*This master's thesis is carried out as part of the education at the University of Agder and is therefore approved as a part of this education. However, this does not imply that the University answers for the methods that are used or the conclusions that are drawn.*

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# Abstract

This thesis explores if mobile devices could be used as a supportive element to engage and interest young students in e-health by developing a prototype to handle simulations of e-health scenarios in a serious game setting. The prototype was to be used as a supportive tool for the research project *High School Students as Co-researchers in eHealth*. An iterative design process was deployed to develop the prototype, going through multiple steps per iteration, focusing on design and development, testing, and evaluation. The results from all of the testing were examined, and compared with the research questions regarding whether or not mobile devices are useful as supportive tools to engage and interest students. It is hoped that the study encourages future use of mobile devices in education and learning.

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# Summary

This thesis aimed to identify if mobile devices could be used as a supportive tool to interest and engage young students in eHealth.

This thesis first examines the problem statement and discusses the background related to the problem statement. Based on these, an approach to solve the problem is determined, and the thesis research questions are defined.

Next, literature related to the research question and development will be examined, such as human-centred design, mobile devices, scenario descriptions, and task trigger concept.

Further, we examine the processes needed to develop and test an application. The development used an iterative design cycle based on principles from human-centred design. The data gathering used several different methods to collect data, such as forms, observations, and group interviews.

Following the processes, it examines the actual development of the prototype using the method mentioned above, discussing all of the iterations, from the perspective of the front-end development of the application.

The next chapter analyzed the gathered data, and further elaborated on the results. As with the previous section, each of the iterations was evaluated, in addition to other findings and discoveries.

The results of the evaluation and discussion conclude that application may have the intended effect of being able to support creating interest and engagement in eHealth for young students. Additionally, further testing and development of the application are recommended, as other potential use cases were uncovered during the test phases.



# Chapter 1

## Introduction

### 1.1 Introduction

This project is an extension of the research project *High School Students as Co-researchers in eHealth* [1] and is based on the human-centred design approach [2], using user scenarios developed from user workshops targeting telecare service models [3]. These scenarios were used in an iterative design and development process to develop a prototype, with direct testing with users, using the base principles of human-centered design [2].

### 1.2 Background

Most young students have a close relationship with their smartphones. They use that smartphone in most of their daily activities, from sustaining relationships with friends and families to using the devices as a form of entertainment, often through videos and games. At the same time, health-care technology is evolving, and a lot of the solutions used within the field are becoming modernized. For a lot of these students, this new health-care technology could become a part of their lives when they grow up. Therefore it could be beneficial to raise awareness about the latest technology. At the same time, most countries, including Norway, are facing an ever-increasing amount of elders. This means that in the future, there will be a greater need for nurses and related jobs. By getting students interested in health, in particular, eHealth, at an early age, it might motivate some to pursue health when going for higher education after High School.

Role-play is a great way to immerse yourself into a new field, world, or environment. For students, role-play is often associated with role-playing games, where they assume the role as a fantasy character in a fantasy setting. But role-play is not strictly bound to fantasy or the digital world; it can also be done in non-fantasy settings in the real world.

### 1.3 Problem Statement

The scenarios used in the research project *High School Students as Co-researchers in eHealth* are derived from the M4ALMO project. In these scenarios, the instructions are set up in such a way that the participants either needs to know them beforehand, needs to have a general understanding of the processes within health-care or need assistance from a moderator with the instructions. In general, the instructions have a lot of information that is relevant to the scenario, but all of it is presented at the same time. This could potentially confuse the participants during a simulation and give them a poor experience.

### 1.4 Approach

We will investigate if we can interest and engage the students by using a prototype specifically developed to support scenario role-play. The scenarios and related eHealth systems used already exist and can be used to conduct simulations using a group of participants. The prototype will be an addition to the existing parameters. This prototype can be used to perform the simulations of the scenarios, using in this case students as the participants. This prototype would be able to support to role-play, by handling and distributing different tasks to the participants at the correct time, and only delivering information vital to the current progression of the scenario. This could ensure that the participants would be able to primarily focus on the role-play aspect, rather than the prototype itself. After completing the simulations, the results will then be evaluated to see whether or not this prototype has its intended effect.

## 1.5 Research Questions

Based on the problem statement and approach, the research questions for this thesis are as follows:

- Could mobile devices be used as a supportive tool to engage students in eHealth?
- What would be needed in order to create an application or serious game that could be used to support simulating scenarios?
- Would the proposed prototype improve the experience of the simulation?
- Would the prototype be able to improve the flow of the scenarios in the simulation?

## 1.6 Structure of the Thesis

In this thesis, we will discuss literature related to the problem statement and approach. Here we will take a look at the relations between games and education, what makes a system usable for humans, the use of mobile devices in education, the scenarios used in the project, and a design concept known as *Task Trigger Concept*. Continuing from here, we will take a look at the methodology that was used during the development and testing of the prototype, discussing the Iterative Design Process and data gathering methods. After discussing the methodology, we will take a look at the development and test cycles of the prototype. The discussion will be from mostly the perspective of the front-end design of the prototype, going through the design, and iterative development process. The iterative design process will describe how the scenario affects the prototype, both regarding design and functionality. Heading on, we will do a thorough evaluation of the previous chapters. Here we will discuss and evaluate the test results from the testing of the prototype, assess the potential for the future development of the prototype, and compare the results with the research questions.

# Chapter 2

## Literature Review

### 2.1 Using Games in Educational Contexts

Computer and video games are a maturing medium and industry and have caught the attention of scholars across a variety of disciplines. By and large, computer and video games have been ignored by educators. When educators have discussed games, they have focused on the social consequences of gameplay, ignoring significant educational potentials of gaming[4]. Mainly when talking about games and education, there are two different concepts to be aware of. The first being gamification, which is an umbrella term for the use of video game elements (rather than full-fledged games) to improve user experience and user engagement in non-game services and applications[5]. On the other hand, we have serious games, which are games specifically designed for education and learning, which do not rely on (added) game design-elements to improve motivation, user experience or change the users behaviour[6].

Serious games are designed with primary objectives other than entertainment and therefore clearly differ from conventional video games. Often serious games can be played on platforms such as personal computers, smartphones or video game consoles, and can apply multimodal interactive contact in any virtual environment[7]. They present an ideal playground to engage players in simulated complex decision-making processes like those required in medical training, as such serious games are widely used in medical education[8].

## 2.2 Usability and Human-Centred Design

Usability is now widely recognized as critical to the success of an interactive system or product [9]. Within the field of software development, it is the stress to meet technical and functional requirements that takes focus. But it is equally important to consider the user requirements to meet specific requirements. The requirements for a usable system can be summed up as follows:

- Increased productivity. A system designed following usability principles, and tailored to the user's preferred way of working, will allow them to operate effectively.
- Reduced errors. Avoiding inconsistencies, ambiguities or other interface design fault will reduce user error.
- Reduced training and support. A well-designed and usable system can reinforce learning, thus reducing training time and the need for human support.
- Improved acceptance. Improved user acceptance is often an indirect outcome from the design of a usable system.
- Enhanced reputation. A well-designed system will promote a positive user and customer response.

These usability requirements can be achieved via a human-centred approach. The human-centred design approach is a complement to software development methods rather than a replacement for them [9]. The key principles of human-centred design are as follows.

- The active involvement of users and clear understanding of user and task requirements.
- An appropriate allocation of function between user and system.
- Iteration of design solutions.
- Multi-disciplinary design teams.

Human-centred design is concerned with incorporating the user's perspective into the software development process in order to achieve a usable system. One of the most used methods of human-centred design is having direct involvement of users during the development and testing of the product, to ensure that the usability requirements of the interactive system or product are met.

Affordances are another vital factor when developing a usable system. The concept of affordances is not a new one for design, and in general, affordances are determined in part by the observers' culture, social setting, experience, and intentions [10]. According to Don Norman's 2013 book, *The Design of Everyday Things*, affordances define what actions are possible, and refers to the relationship between a physical object and a person (or for that matter, any interacting agent, whether animal or human or even machines and robots) [11]. An affordance is a relationship between the properties of an object and the capabilities of the agent that determine just how the object could possibly be used. An example of an everyday affordance is a chair, as it affords support, and therefore affords sitting. The same chair can also be carried by a single person (they afford lifting), but some can only be lifted by a strong person or by a team of people [11]. Buttons are the most common subject when discussing affordances for the digital interactive system. On-screen buttons often seem to protrude from the screen, which affords pushing [10]. In addition to the protrusion, buttons may include text or icons, or altogether be substituted by an icon. The most notable example is the save-icon, which resembles a floppy disk. The majority of users will see this icon and know that it is the symbol for save, but this is determined on whether or not of the user have any previous experience with it. This is something that has to be taking into consideration when developing a usable system to not confuse the users.

## 2.3 Mobile Devices in Education

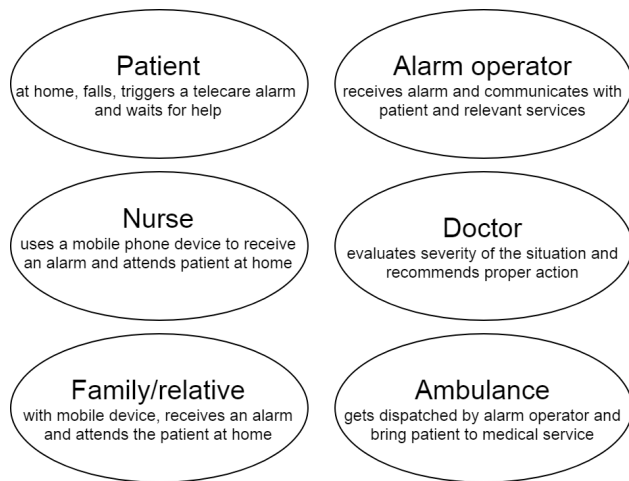
Modern phones have a variety of features that simply were not possible years ago, and are not just for voice communication anymore [12]. Earlier, mobile devices were generally exclusively used for voice and text communication, but now they are also used for work purposes, recreational use, and learning. According to the ECAR Study of Undergraduate Students and Information Technology, many students use mobile devices for academic purposes, es-

pecially when instructors encourage such use. However, both faculty and students were concerned about their potential distraction [13]. In 2014 according to the same study, 86% of the surveyed students owned a smartphone, and 59% of those stated that they used the device for class-related purposes. These students would use the devices various student-related activities, such as communicating with other students about class-related matters outside of class sessions, checking grades, looking up information while in class, or using the course or learning management system [13].

## 2.4 Scenario Description

The scenarios used in the development of the serious game were derived from the research project 'Model for Telecare Alarm Services' (2015-2017) that explored and evaluated organizational models for telecare alarm services in Norway[3],[6]. In the telecare 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 is a technology used to support communication between citizens at home and healthcare services[14].

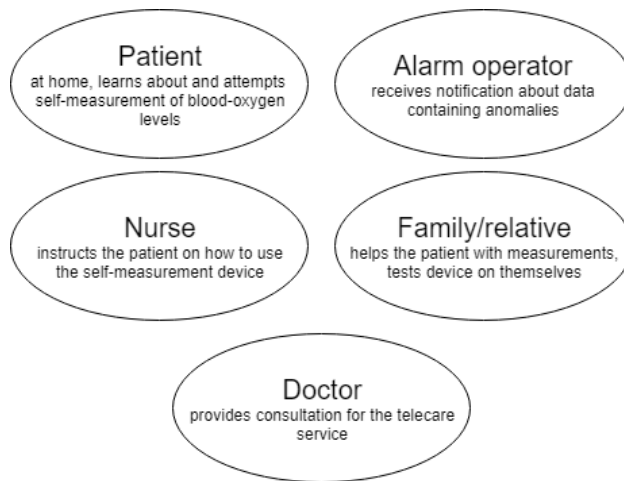
For the telecare alarm project, a specific scenario was developed as a group simulation, using multiple test rooms where the interaction was to happen by the use of technology. The scenario had a description of the telecare context and a particular alarm situation to be handled. One moderator from the research team was placed in each of the rooms 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 the test room. The telecare scenario had different roles, and each of the roles had their own separate task list. During the simulation of the scenarios, the moderators reminded the participants to think aloud and speak freely [6] [15]. One of the main group scenarios developed was a telecare scenario known as *Fall Scenario*. The particular was performed as a role-play in a clinical laboratory, with separate roles with associated tasks. As shown in the figure 2.1, the roles were as follow: a) a patient at home with a fall accident and triggering a telecare alarm with a Safemate GPS geolocation and communication device [16], b) a telecare alarm service operator receiving the alarm and communicating with the patient and the relevant service, c) a municipal home nurse on duty for home visits, using a mobile device to receive a mes-



**Figure 2.1:** The fall scenario and its roles. Adapted from [6].

sage about the out-call, d) a family member with a 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. Also, the scenario was observed by a group of observers in the observation room, following the interactions between the role actors and the technology. The handling of the situation was escalated from the family member and home nurse as the first line of response. Their status report was used by the telecare alarm service operator to check with the doctor whether further action was advised. Finally, an ambulance to transport the patient to medical service is the last line of response in critical cases[6]. Another scenario derived from the research project was a group scenario known as *Measurement Scenario*. As the fall scenario, the measurement scenario was performed under the same circumstances, with similar roles as shown in figure 2.2: a) a patient at home, learning about self-measurement of blood oxygen levels with a smart-device and attempting it by himself, b) a telecare alarm service operator receiving notification about an anomaly in a patients medical data and communicating with the patient and relevant service, c) a municipal home nurse instructing the patient on how to use the self-measurement device, d) a family member that by chance visits the patient and helps them with the measurements by doing it on themselves, and f) a doctor that evaluates the information from the telecare service. A moderator was also observing this scenario from the





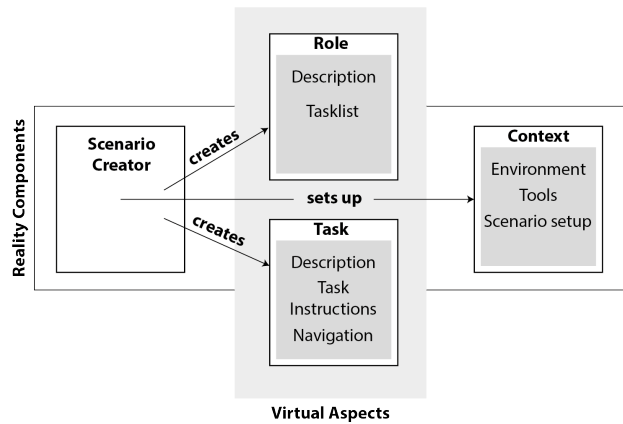
**Figure 2.2:** The measurement scenario and its roles.

observation room, following the interactions between role-actors and technology. This scenario is not considered critical but reflects a real potential interaction between a patient and telecare services. The situation displays that the elderly might struggle with new technology, which is apparent when the patient struggles to do the measurement by himself after the nurse has left. When the family member comes on a surprise visit, they help the patient by checking if the device works as it should, by trying it on themselves. This situation becomes the cause of a double measurement, with conflicting data. The telecare system picks up on the anomaly and alerts the operator, which in turn contacts the patient to check in on them. After having reached the patient, the telecare operator consults with a doctor about the measurements, where the doctor recommends a follow-up check on the patient for the following day.

The information flow between different roles was made of electronic messages that represented tasks to be executed and transmitted through mobile devices. After each performance of each of the scenarios, there was a group debrief where the participants reflected on the scenarios and the task flow[6].

## 2.5 Task Trigger Concept

Tasks are a fundamental part of the eHealth scenario, as they guide the participants through the scenario. At the same time, tasks are a very central



**Figure 2.3:** 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. Adapted from [6].

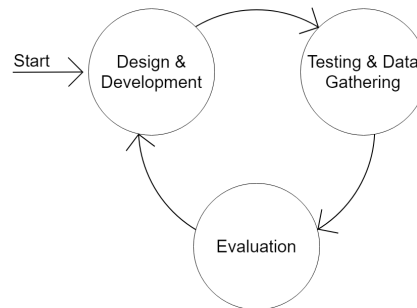
part when it comes to game design. Within games, tasks are used in a huge variety and come in many shapes. Therefore we should take a closer look into the complex design of game tasks to be able to design tasks for a serious game. Also, tasks are not only used in games but learning tasks also naturally occur in education settings[17]. Game tasks consist of their structure and surrounding processes[17]. The task structure includes the content, (e.g., what to do, how, with whom, when) and task visualization (how it is shown in the graphical user interface). The figure 2.3 displays the connections between the tasks, roles, and context within the scenario. Task 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)[6]. A simple task example is when the user simply start the game, then the first task is made available. A more complex example is a task based on story progression, time, and personal decisions made 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 required for the user to receive the task [17]. In general, the design of these triggers will determine how the tasks are distributed, so they will have to be defined carefully to ensure that the right tasks appear at the right time.

# Chapter 3

## Methodology

### 3.1 Iterative Design Process

When developing applications, an iterative design process can be beneficial as a way to identify any usability issues in the application. An iterative design process features cycles of invention and revision [18], which can save time during development. In this particular project, there were three distinctive phases in the process, as shown in figure 3.1 below. This process was cycled through a total of three times during this project.



**Figure 3.1:** Illustration of the iterative process used in this project. The first step is design and development, followed by testing and data gathering, and lastly evaluation of the previous processes.

#### 3.1.1 Design and Development

According to [Jakob Nielsen][19], a system is usable if it is:

- easy to learn, so users can go quickly from not knowing the system to doing some work;
- efficient, letting the expert user attain a high level of productivity;
- easy to remember, so infrequent users can return after a period of inactivity without having to learn everything all over;
- relatively error-free or error-forgiving, so users do not make many errors, and so those errors are not catastrophic (and are easily recovered from); and
- pleasant to use, satisfying users subjectively, so they like to use the system.

Taking these points into consideration, we will be able to define some terms before we start the iterative process. The terms we define do not have to have equal weight, as some might be more important than the others and should be the focus of the development efforts throughout the iterative design[19].

Before we can start with the design and development of a prototype, we will have to define some requirements. In general, you should determine the requirements for the completed prototype, and then scale those down for each of the different iterations, working towards the final requirements as you iterate. Often, we can start the process with a low-fidelity prototype, which allows us to create a mock-up design of the proposed solutions and features for the final prototype, we define some requirements that resemble those of the finished prototype. These requirements would be the main functionalities, such as navigation, content, and design choices. When doing low-fidelity prototyping paper-models are often used, but digital tools can be used as well. Paper-prototypes are generally a quick way to get fast feedback on preliminary architecture, design, and content, and therefore can be vital in a design process.

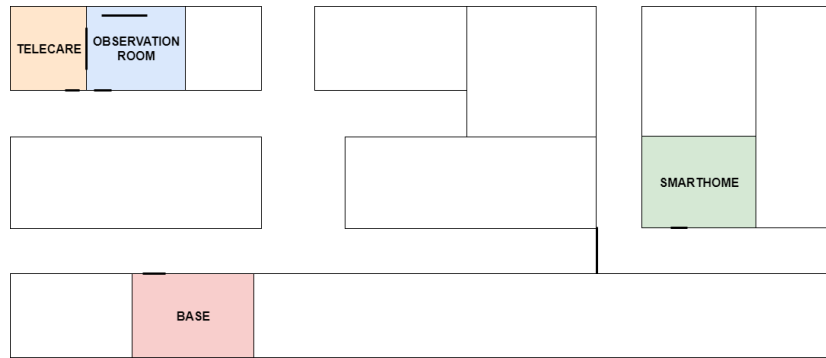
The next step is high-fidelity prototyping, which consists of using much of the same methods as the final product, and hence has the same interaction techniques and appearances as the final product.[20] By having similarities to the final product, these high-fidelity prototypes will offer more accurate interactions that are to be expected by the final product.

Both fidelity's are equally important in the design process as there are few differences between low- and high-fidelity prototypes, both in paper and

computer media, when it comes to uncovering usability issues. Often it is recommended to choose the fidelity based on practical considerations of prototyping and usability testing[20]. In the end, it was decided to use both low-fidelity and high fidelity prototyping in the iterative process, as they both would provide benefits that would ensure a more quality-based process.

### 3.1.2 Testing

When done with designing and developing an iteration, the next step would be testing. For this project, hands-on testing with the target demographic, young students would give the appropriate feedback to progress through the iterative process. Each of the tests was carried out with students in a con-



**Figure 3.2:** Map of the testing environment. Each of the rooms used during the testing has been assigned a color.

trolled environment, with moderators at hand to aid the students if there were any issues. The environment selected and participants were selected to be close to them, or the actual target users, to get as accurate test results as possible, which in turn would benefit the human-centred design aspect of the development[2]. The testing was carried out at the Center for eHealth at the University of Agder, using multiple test rooms. Each of the rooms had a moderator available. During each of the tests, there were, depending on the scenario, at least four or five students actively carrying out the testing of a scenario. At the same time, there were another group of students observing from the observation room. From the observation room, the students were able to observe the test group in real-time through several video feeds. Other than the observation room, there was the telecare room, the home of

the patient, and a base for the other roles. The telecare room had a land line, which would call when the Safemate device was activated. A mobile phone was also connected to the Safemate, and would also receive a call when the Safemate device was activated. During the testing, the participants were split into the two groups, one to participate in the simulation, and one to observe. The participating student was given each their role, and then got set up with their tasks. Before starting the simulation, all of the participating students were given a briefing on how to progress through the scenario. At the same time, the participants who were to call other participants exchanged their phone numbers. After the briefing, the alarm operator and patient were moved to their respective rooms, and a moderator accompanied both of them. When everyone was in place, the patient got the signal to begin their first task, starting the simulation. During the simulation of multiple different scenarios, the participants would after each simulation return to the base for a group interview. During the group interview, the participants and observers discussed what they had just done or observed. While talking the participants also filled out their respective forms. The methods of gathering data will be discussed in section 3.2. After wrapping up the group interview regarding the simulation, the two groups switched roles, meaning that the participants were to observe, and the observers were to participate. The new group of participants was prepared in the same manner as the previous group, using the same scenario or a new one. After the new round of simulation was completed, all the students once again returned to the base for debriefing, and the process would repeat for each planned simulation.

### **3.1.3 Evaluation**

At the end of the simulations, there would be forms for participants to fill out with feedback regarding the scenario and the prototype that they were using during the testing. In addition to the forms, the participants and observers would be brought together to reflect upon the experience they had just had. Here the participants would be asked how they felt the simulation went, provide feedback both regarding the scenario itself and the prototype, and comment on other experiences, observations, or issues that occurred during the testing. The post-simulation discussions between the participants is a great way to collect results, as the simulation is fresh in the participants' memories, which will give more accurate feedback. Before we can evaluate the results, we will have to look back at the requirements for the specific

iteration, and check whether or not if we were able to meet the requirements. We will have to take the requirements into consideration when evaluating the results from the testing. The evaluation stage of the iterative process is essential, as the feedback collected from this phase would lay the groundwork for the next cycle of the process. Taking that into consideration, every time you go through the process, you will have to evaluate the results you got from the testing properly. If the test results were not meaningful or did not give appropriate answers, you might have to revisit the test-phase.

## **3.2 Gathering Data**

There are two methods to gather data, the first being qualitative collection of data, and the other being a quantitative collection of data. Qualitative research typically involves purposeful sampling to enhance understanding of the information-case, while quantitative research ideally involves probability sampling to permit statistical inferences to be made[21]. For this project, qualitative collection of data was used, considering that the test phases had an emphasize on human-centred design, having direct testing with the users. For this project, there were two main methods of gathering data.

### **3.2.1 Forms**

Forms are a great way to both collect qualitative and quantitative data, as forms can be filled out by the participants by themselves. Also, the forms can both be physical and digital, meaning that you are able to distribute them both locally and over great distances. For this project, the forms were digital, with the exception of the first test. The forms were available for the participants at the end of each of the simulations, and the participants were sent the forms afterward if some of the participants had forgotten to finish them.

### **3.2.2 Observations and Interviews**

The simulations held were observed personally during each of the test session. During these observations, the following things were weighted:

- Is the scenario progressing properly?

- How are the participants progressing through the tasks?
- Do any of the participants have any issues?
- Is the application stable and behaving as expected?

All observations would be written down, if there were any occurrences during any of the simulations.

After each simulation, there was an open session where the participants were asked how they felt the scenario went, and if they had any feedback regarding the scenario or the prototype. Further, into the thesis, this will be referred to as "group interviews." All feedback was noted, especially any issues or questions raised by the participants.

### **3.2.3 Test Environment**

To test the eHealth serious game, over 50 young people that participated in the research project High School students as Co-researchers in eHealth [1] carried out several simulations in the clinical laboratory in 2018. The aim was to teach and experience eHealth, but also to test the different roles in the telecare and measurement scenario, and use the smartphone application that was developed to guide the task flow in the simulation[22]. Also during early 2019 there were carried new simulations, with over 50 young people participating in the project, in addition to a group of elderly with a health care background.



# Chapter 4

## Development and Testing

### 4.1 The Prototype

It was decided that a digital application should be developed. As most students have their own or access to a smartphone, they would be able to access the application through that or similar devices. By using a digital app, it could potentially allow for cross-platform compatibility, meaning that it would work across several different devices, using different operating systems. This would enable the application to reach more users and not limit it to a particular group with specific devices. A digital application would also allow updates to be readily available for all users, either through Google Play Store and iOS App Store for native applications or directly in a web application.

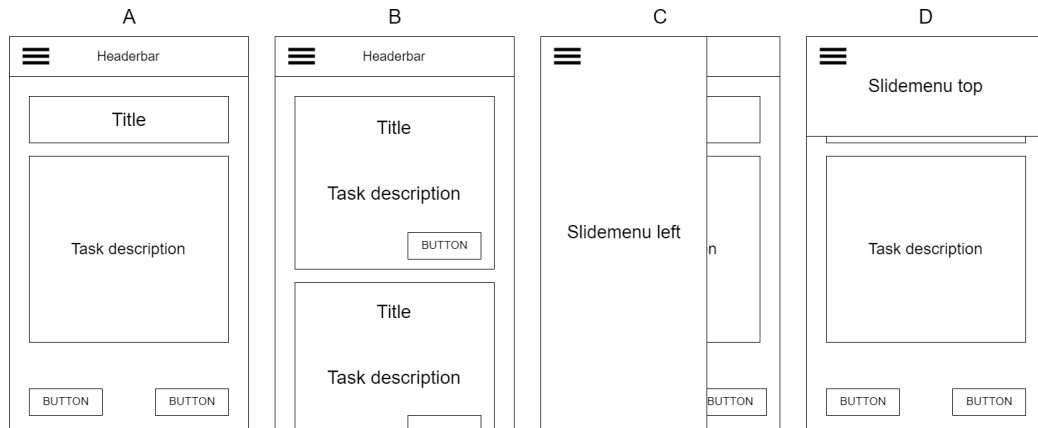
### 4.2 Design

The design should be easy for the user to become familiar with, and only present what is necessary. Several proposals were sketched, mostly taking inspiration from Material Design<sup>1</sup>. As shown in 4.1, the first element is the header bar, often known as the *Top app bar*. The bar contains information and actions related to the current screen in the application. In the sketches, a menu icon (known as a *Hamburger icon*) was added to the header bar. This icon is associated with opening menus, thus presenting itself as an affordance for the users. Next, we have the boxes that are to hold the title and task

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<sup>1</sup><https://material.io/>

information. For sketch A, the title and task description are split into two separate boxes. This proposal takes up a lot of space if you consider the buttons. In B the title, task description and button are all contained within the box, which allows for multiple boxes at the same time, though means that the user would have to scroll to see all of the tasks. The primary method for the user to interact with the application would be through the use of buttons. In A the buttons would be placed at the bottom of the interface, which allows the user to easily reach the buttons if they are using their device one-handed. In B, the buttons are placed within the boxes, which means that the button position would depend on the size of the box. Potentially for larger devices, this could mean that certain users would have to use both their hands to use the application.



**Figure 4.1:** Design sketches for the prototype. Each of the sketches present different proposals for the design of the application. In A, only one task may be displayed at once in the interface, whilst B supports multiple tasks at once, but expects the user to scroll to see all of them. C and D shows proposals for menu interface. C offers a larger menu, but covers over 60% of the interface, while D only covers roughly 25% of the interface, but offers less space in the menu.

### 4.3 Development

The prototype was built upon the foundation that is the scenario description. The completed application is used in a role-play setting, where users can access it through a mobile device. Throughout the development, the

prototype went through several iterations using the iterative design process. The first iteration was a low-fidelity paper-based version of the application. The second iteration was a high-fidelity digital prototype. And the third and final iteration was a functional prototype of the close to the completed application.

During the development, there were two roles involved. The first role was the front-end developer, which focused mainly on the development of the interface and user interactions in the application. The second role was the back-end developer, which developed all the system interactions. Going forward, we will go through the iterations focusing mostly on the front-end development.

Before designing any proposals for the design of the prototype, all the expected functionalities and requirements, for both front-end and back-end, of the final prototype had to be mapped. The requirements should include the specifications that are to be expected, such as what platform to use, how the application should be designed, and what specific functions are required for the app to reach the end-user goals. For the final prototype, the following requirements were mapped:

- The application should have cross-platform compatibility (smart phones, tablets, computers...)
- The application should have a design that is easy to use.
- The design should be appealing and easy to use
- The application itself, should be able to support multiple different instances of the same scenario.
- Each of the scenarios should have multiple different roles, with corresponding tasks
- The roles within a scenario should be interconnected, meaning:
  - if a role completes a task, the task should be able to trigger other tasks in the scenario, both for the users current role and other users roles.
  - A user should receive a new task at the right time according to the scenario progression.
  - A user should be able to know if the scenario is still progressing when they do not have a task available.

### 4.3.1 The First Iteration

#### Design and Development

To start the iterative design process, it was decided to develop a low-fidelity prototype for the first iteration. For the particular iteration, the following requirements were established:

- Each scenario should be split into roles and tasks.
- The users should be able to choose a role, with role specific tasks.
- Users should be able to know when to start their next task.
- User should be able to know when to go to the next task.
- The different roles should have tasks that ensure cooperation between the roles.

Starting with a scenario derived from the research project “Model for Telecare Alarm Services,” each of the roles and their respective tasks was transcribed and readjusted into several smaller tasks. The new tasks were also given a start statement, defining when the user can start the task, and an end statement, explaining what the user must be doing before going to the next task.

As seen in figure 4.2, the first draft was printed paper notes containing only information. It was decided that to create a design resembling that of A in figure 4.1 before any testing could occur. The reasoning behind that was to get more accurate test results from the tests, as the users would be handling a prototype with similarities to the potential final product. In the paper-prototype design, as seen in figure 4.3, we can see some of the functionalities that were specified in the requirements. The top card on the dummy screen is the start statement for the task, which defines when the user can start on the task. Below it is the main task description for the task they are about to complete. In the final application, the user would assume that once they have achieved what is presented in the task description, they would be able to progress to the next task when they press a button. With this in mind, there was added a dummy button for “next,” and also since the users would be able to cycle back and forth between the tasks with the paper-prototype, a dummy button for “back.”

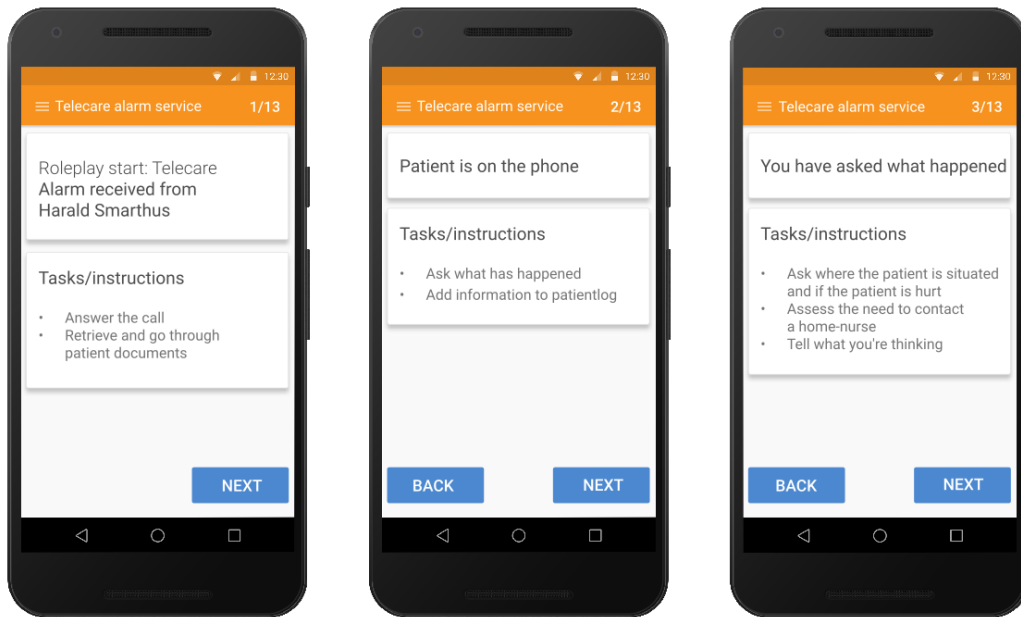
1	2
Rollespill start	Alarm mottatt fra Harald Smarthus
Oppgaver/instruksjoner: <ul style="list-style-type: none"> <li>- Reis deg opp av seng og beveg deg inn mot kjøkken.</li> <li>- Fall ned på gulv</li> <li>- Utløs alarm</li> </ul>	Oppgaver/instruksjoner: <ul style="list-style-type: none"> <li>- Besvar oppringing</li> <li>- Hent frem pasient dokument</li> </ul>
Du har utløst alarm	Dokument anskaffet

**Figure 4.2:** The very first draft of the tasks. The upper colored cell contain the start statement for the task, the middle cell holds the task description, and the bottom cell is for the end statement.

### Testing of the First Iteration

For this iteration, there was only one test session, using young students from Kvadraturen High School. In preparation for the first testing, there were created one version of the prototype using the telecare scenario, and one using the measurement scenario. The session took place at the Center for eHealth at the University of Agder, using the environment, as seen in figure 3.2. This particular prototype had feedback forms at the end of each of the roles task card sets. This meant that there were three extra cards per task set for each of the roles. These cards had questions regarding the prototype, where the participants were given question statements, where they could tell if they agreed with it or not. In addition, they had an open question where they could write down any additional feedback regarding the simulation. In addition to the written feedback, there was a verbal debriefing. During this debrief, the participants got asked whether or not they would have preferred if the prototype was digital instead of paper.

A more thorough analysis and representation of the results from this iteration will be conducted in chapter 5.



**Figure 4.3:** 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 patient" c) Follow-up task "gather information about the situation".

## Evaluation

During this cycle of the process, it became apparent that the task concept had potential. Using paper was a viable tool to test the prototype, but time-consuming to set up. If this version were to be further tested, it would both require time-consuming design and production work. Therefore, with these preliminary factors, it was concluded that the next iteration of the prototype should progress into a digitalized version. For the new iteration, some new requirements were specified:

- The application should allow for cross-platform compatibility
- The design should reflect the planned design of the prototype.
- The user should be able to select a scenario.
- The user should be able to select a role.
- Instructions should be present before starting the tasks.

- A user should only be presented one task at a time.
- The user should be able to go back and forth between their own tasks.
- The user should be able to know where they are in their own task progression.

These requirements would specify the general functionalities for the next iteration, on the basis that the automatic task-handling is not to be developed in the next iteration.

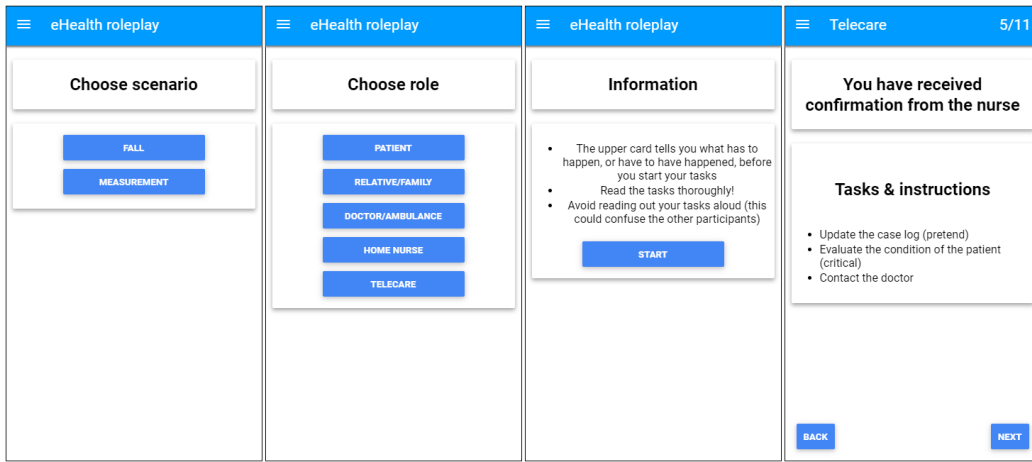
### 4.3.2 The Second Iteration

#### Design and Development

The first decision to make when developing the digital version of the prototype, was which platform to use. As the application was planned to be accessed from mobile devices, the obvious question was whether or not it should be a native application or a web application. After weighing the options, it was ultimately decided to create a web application for this iteration, as a web application would allow for cross-compatibility between multiple devices.

The first task that had to be completed was getting all the scenario data digitalized. This meant that all the information inside of each of the task sets had to be converted to a data list from the previous iteration. This data would have to be accessible by the digital prototype in some form that allowed it to display it on the user interface.

The interface for this iteration was designed based on the expected interactions. This meant that no unnecessary functionalities or interactions were to be present, at the same time, major sacrifices in the visual design had to be avoided. The digital prototype had its visual design inspired by the previous iteration, which had all the elements needed to meet the iteration requirements related to interactions. In figure 4.4 we can see all the different elements within the prototype. The interface received a static design based on sketch A from figure 4.1 with an aspect ratio of 16:9, which would ensure it to be able to fit within the screen of most smartphones generally and at the same time emulate the finished aspect ratio. The header of the interface contains an icon(non-functional), role title, and task progression. In the container, there is a title box, content box(scenario picker, role picker, and task information) and buttons.



**Figure 4.4:** The interface of the second iteration of the prototype. The first screenshot from the left shows the scenario selection screen, followed by the screenshot for role selection. The second screenshot from the right displays the instructions for using the prototype, followed by a screenshot showing an example of a task for the telecare role.

## Testing of the Second Iteration

For this iteration, there were three test sessions, with over 50 students participating across all of the sessions. During these sessions, there were students from Kvadraturen High School and another High school. As with the previous iteration, there were two available scenarios for testing. The test sessions also were simulated once again at the Center for eHealth at the University of Agder using the environment from figure 3.2. Previously, the preparations of the prototype had been prepared for each role with paper cards, but this time with the new prototype, the students had been informed beforehand to be prepared to use their own devices for the testing. Additionally, there was some setup required to get all the students connected to the internet, so that they could access the prototype. Despite this iteration being digital, the simulation itself was near identical to one of the previous iterations, except for the tasks being digital instead of analog. At the end of each simulation, the participants would find a link within the last task, directing them to a digital feedback form. Like with the previous iteration, there was a verbal debriefing after each of the simulations.

A more thorough analysis and representation of the results from this



iteration will be conducted in chapter 5.

## **Evaluation**

The digital version of the prototype seemed to amount to some success according to the response from the participants during the simulations. However, some of the issues from the previous iteration were still apparent. Issues such as knowing when to progress to the next task, and when to start the new task, were still prevalent and caused problems during the simulations. To address the issues, both issues that persist from the previous iteration and newer issues, we would have to build the application towards the final requirements. From this iteration, the following requirements would also carry over to the next iteration:

- The application should allow for cross-platform compatibility
- The design should reflect the planned design of the prototype
- Instructions should be present before starting the tasks

An addition to the above requirements, the following requirements were specified in order to get the prototype in line with the specification found in the beginning of the chapter.

- The user should be able to join a room tied to a specific scenario.
- The user should be able to choose a role.
- Each of the roles should have their own set of tasks, which should be able to trigger others tasks within the scenario, both for the specific role or other roles.
- Tasks should be presented to the users according to the scenario progression.
- A user should be able to know if the scenario is still progressing.

### 4.3.3 The Third Iteration

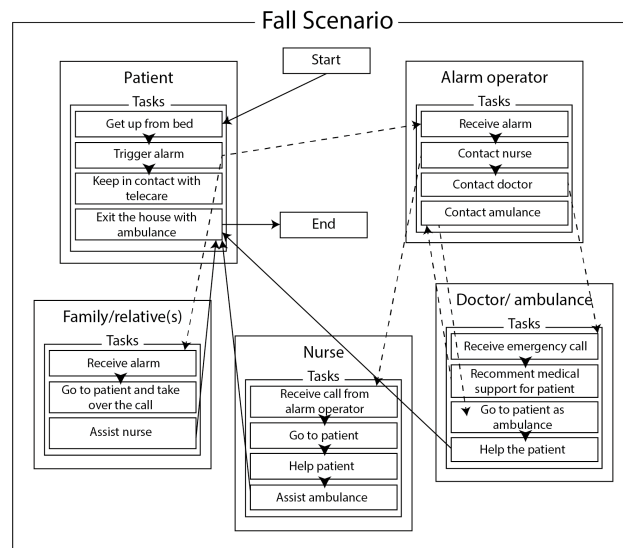
#### Design and Development

The third iteration of the prototype addresses the current state of the prototype. In this iteration, we are going to first discuss how the task handling system used in the prototype. By examining the task trigger-concept, we can determine the possible means of triggering a task in the prototype. Using the trigger and task concept, we are able to establish three means of triggering a task within the given scenarios. For the prototype, the focus of the triggers would depend on the characters or roles in the scenario completing their tasks. The first type of triggers would be user triggers. The primary method for a user to send a trigger to the server would be through button presses. This would be the general method for the users to manually send a trigger to the server, and be the only way for them to directly control when a trigger is sent. The basic functionality of these triggers would be to send data to the server, to signal that a specific task or subtask has been completed. This trigger could also be used as a mean to skip and automatically complete other tasks. If we use the telecare scenario, fall, as an example. In the fall scenario, the nurse should arrive before the ambulance if the progression of the tasks is done correctly. But if the nurse is late to the patient's house, and the ambulance has arrived before them, the ambulance would be able to signal that they have already arrived, thus skipping any subsequent tasks for the nurse, that is related to helping the patient leading up to the arrival of the ambulance.

The second type of triggers would be triggers activated within the server. For this prototype, the server would handle timed triggers. The timers would be defined as their own tasks, as this allows other triggers to activate them, and at the same time let them send their own trigger on completion. The timer task would not be sent to any users and is primarily a back end operation.

Lastly, we would have triggers that have been defined as *external system triggers*. These triggers would come from sources that are not directly connected to the server or the client. For the particular scenarios used in this project, external triggers could occur based on information sent from an eHealth-system used within the scenario. These triggers could be given as information to the roles within the scenario. In a scenario this could be for a role to wait for a phone call, and when the phone calls continue on their

tasks. This external factor would not be directly connected to the game engine, which means that it would not be able to know whether or not the external trigger has been activated or not.

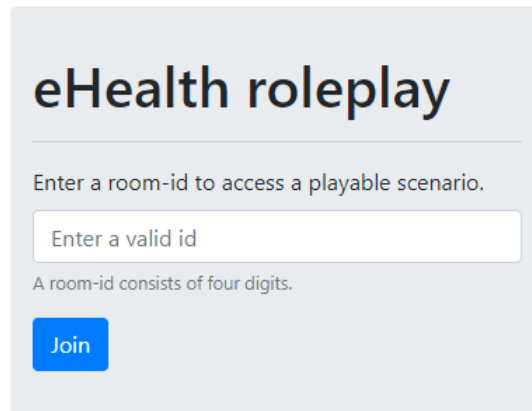


**Figure 4.5:** Dynamics between the roles and tasks in the playable fall scenario. Dotted lines indicates externally triggered events, such as phone calls, and the arrows indicates user triggered events.

Based on the three trigger types, we would be able to determine how the task connections within the scenario would look. Figure 4.5 indicate how the different tasks and roles could be interconnected with each other in this prototype.

Before doing any changes to the functionality of the interface, the whole front-end of the application got adapted to the front-end library Bootstrap<sup>2</sup>. By using Bootstrap, we could ensure that the interface would be dynamic and scale appropriately to all the different devices that could be used to access the application. The first apparent change in the application was the introduction of a new front page, as seen in figure 4.6, where the users can access the different scenarios using specific room codes. When the users enter the scenario, they will be able to select a role as with the previous iteration.

<sup>2</sup><https://getbootstrap.com>

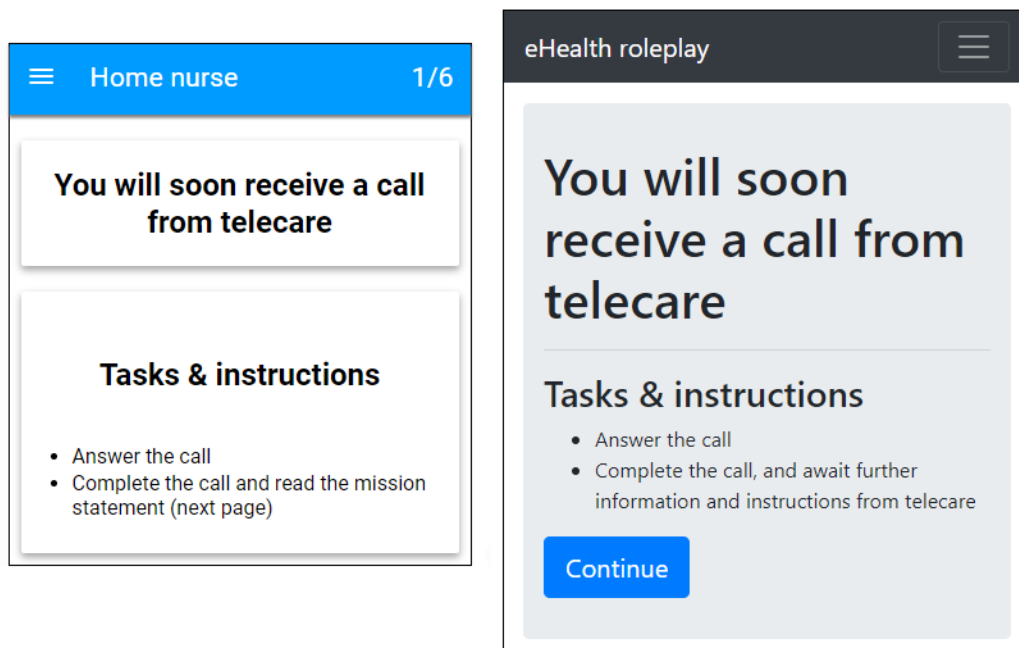


**Figure 4.6:** Front page of the application.

How the tasks were displayed underwent a change in order to support the new system for delivering data to the clients. Instead of a separate card for the start statement and task information, now both the start statement and task information were merged into one single card. This change was necessary both as a measurement to simplify the interface and to support multiple task-cards being displayed to a user at the same time. A comparison between the two iterations can be seen in figure 4.7. Compared to the previous iteration, the users would no longer be able to go back to earlier tasks. And when a user would press the button connected to the task, the current task would be marked as completed and removed. If a new task were available for the role, the user would receive the task. If not, the user would have to wait until the scenario would grant them a new task. In order to make sure that the users knew that the scenario was still in progress, a progress-bar was added to the interface. This bar would update for all users as soon as a user completed a task.

### **Testing of the Third Iteration**

There were a total of three test sessions during this iteration, and each had a different version of the prototype using the new task handling system. This time, there were two sets of students from Kvadraturen High School, where one of the sets of students were students who took part in testing of the first iteration, and seniors with different professional backgrounds, some health-care and other municipal.



**Figure 4.7:** On the left, how tasks were displayed in the previous iteration. On the right, how tasks are displayed in this iteration.

During the first test session, only the measurement scenario was available, as the other scenario had not been adopted into the system yet. In this session, the students from the test group in the first iteration returned. The responses from the participants were great, as they felt that the task handling worked a lot better than the first iteration they initially tested. There was only one issue that they mentioned, that there should be an indicator of whether or not the simulation was still ongoing when there were not any tasks available for a role. The second test session was the first time that the prototype had been tested on users that were not students. For this session, both of the scenarios were available for the participants. During this session, there were a lot of connection issues for the participants, which resulted in most of the participants losing connection to the application. The connection issues derived from the setup phase, where most of the participants were unable to get a proper internet connection, either through 4G or Wi-Fi. This seemed to be an ICT related issue, as it appeared that most of them were not too familiar with their smart devices. The third and final session was done with the current version of the prototype, using both the available

scenarios. In this test phase, there were several problems with the prototype, due to the complexity of the system. This resulted in mixed responses from the participants. One of the main issues was tasks that would not display without the user refreshing the application and going back into the scenario instance.

A more thorough analysis and representation of the results from this iteration will be conducted in chapter 5.

## **Evaluation**

The responses to the prototype during this iteration were mixed. In contrast to the previous iteration, where the prototype did not change during the test phases, this time, there were several changes in the prototype before each of the test sessions. This was one of the leading causes of the mixed results. Another factor was the infrastructure of the test environment, such as a Wi-Fi connection and external devices that did not function as intended. Most of the issues related to the prototype itself should be able to be corrected if more time is allocated to further development.

# Chapter 5

## Data Analysis

### 5.1 Evaluation and Discussion

In chapter 4, we discussed the development and testing of the prototype, in addition to the overall evaluation in each iteration, required to progress into the next iteration. Below we will examine and analyze the data gathered during the test phases and do a more in-depth analysis of the findings, observations, and discoveries made during the testing.

#### 5.1.1 Iteration 1

There were adjustments made to the scenarios during the development of the first iteration of the prototype. These adjustments were necessary to ensure a better experience for the participants. For the fall scenario, there were initially only three roles, as seen below.

- Alarm operator
- Home nurse
- Patient

But as the tasks were adjusted and adapted, it became apparent that more roles were needed. At this stage of development, some of the roles were not considered as a playable role in the scenario. In the scenario description, some of the tasks required that these non-playable roles were to assist another role, but if the scenario description were to be simulated, that part of the

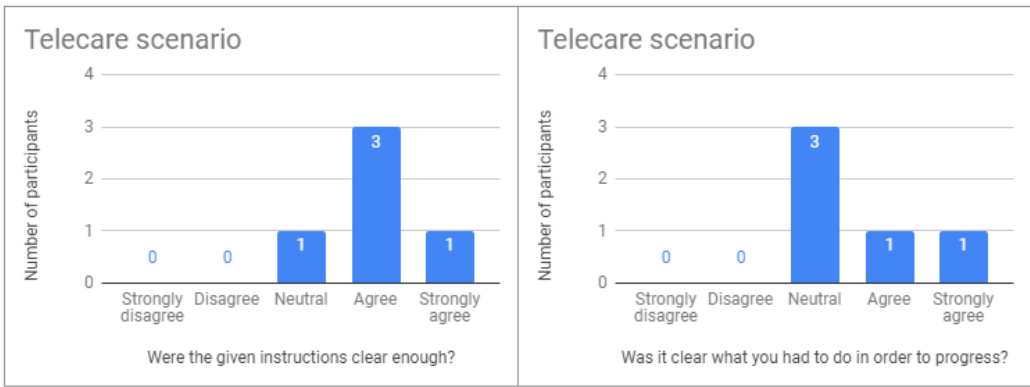
scenario would not be able to complete. If we look back at figure 2.1, we see the total amount of roles required within the scenario were raised to a total of six. But when further examining what could be done to the fall scenario regarding the roles, it became apparent that the two roles, doctor and ambulance service, used in the scenario had a significantly lower amount of tasks compared to any of the other roles. This could result in significant wait times before the roles would have anything to do during the simulations. Upon investigating the possible solutions to the issue, it was discovered that the doctor and ambulance service roles did not have any tasks that would collide with each other. In the scenario progression of fall, the alarm operator will first contact the doctor, and then ambulance services afterward. After having been contacted by the alarm operator, the doctor would have no more tasks left. Therefore, it would be possible for the doctor to assume the ambulance service role after completing the tasks related to the doctor role. Consequently, the following roles were proposed and implemented:

- Alarm operator
- Doctor/Ambulance service
- Family/relatives
- Home nurse
- Patient

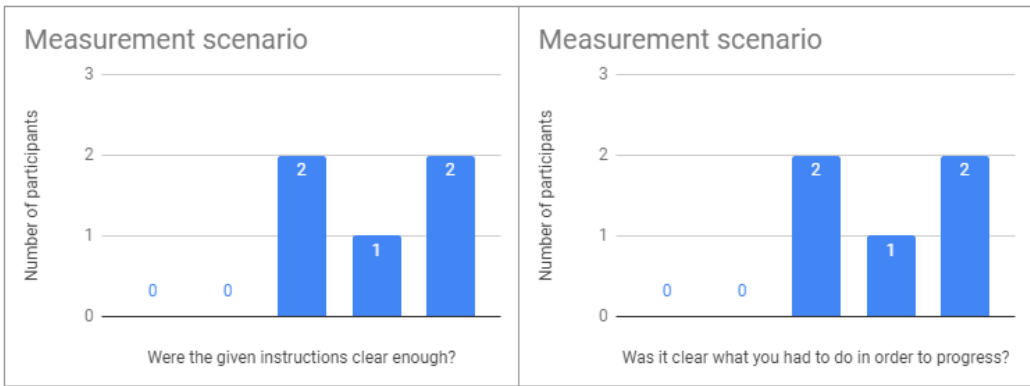
With this proposal, it ensured that all participants would have a decent amount of tasks for their chosen role. This change persisted through all the iterations and is active in the current state of the prototype.

It was the first time the prototype was tested, and the focus of the data gathering focused on whether or not the concept would work, rather than the prototype as a whole. The testing for this iteration only consisted of one session, with only a small group of students. In figure 5.1, we can see the responses submitted in the form handed out after testing of the telecare scenario. In figure 5.2, we can see the responses submitted in the form handed out after testing of the measurement scenario. Looking at the test results, we can see that the participants felt that the concept for the scenario, roles, and tasks worked. As seen in figure 5.1, it is apparent that the instructions were good, but could have been better. This would be something that could be changed in the next iteration, based on some of the comments made by the





**Figure 5.1:** Results from the first testing of the telecare scenario using the first prototype.



**Figure 5.2:** Results from the first testing of the measurement scenario using the first prototype.

participants. But, if we look at the second graph in figure 5.1 it is clear that some of the participants knew when to progress, while most were neutral on this aspect. This means that for the next iteration, we would have to investigate if there is something that could be done about the progression. In addition to the form questions, the participants raised several issues during the group interview regarding the scenario, simulation, and the prototype itself. Below are some of the comments made by the participants during the group interview.

- Some of the participants felt that the tasks should be more clear

- Hints and tips for the different roles. E.g. what the home nurse should do when they arrive at the patients house.
- Provide explanation on how the Safemate works, as some participants had no idea how to use it.
- The doctor should recommend a check-up of the patient for the following day
- Having all the tasks available at once led to some confusion. Some of the participants looked through task cards at the upcoming tasks and then rearranged them out of order on accident.

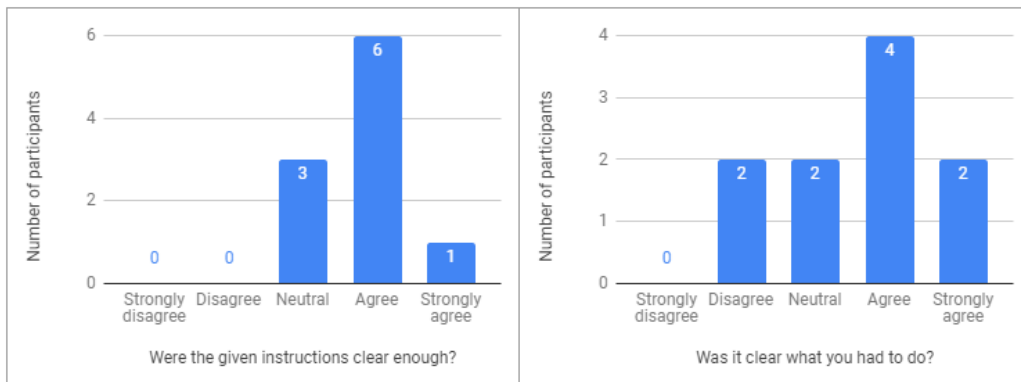
### 5.1.2 Iteration 2

During this iteration, there were a total of three test sessions. There were a varying amount of participants for each of the sessions, but during the sessions, except the third session, both of the available scenarios were simulated at least once. For this iteration, the questions in the form used to gather data had been slightly altered, in addition to new follow-up questions based on the answers given by the participants. Additionally, the participants were asked whether or not they would have preferred if the tasks were on paper instead. For these test sessions, the results of both the different scenarios are merged, as some participants forgot to specify the correct scenario when submitting the forms.

During the different test sessions, there were made several observations regarding the scenarios and the participants. Below are the main issues observed during the first test session of the second iteration:

- There were two instances during the first test session, during the simulation of the fall scenario, that the participant with the doctor/ambulance service role went too early to the patients house.
- Some participants seemed to accidentally skip tasks during the simulations.
- Several participants seemed to be confused regarding what to do on some of the tasks.
- Some participants seemed a little unsure when to start a task.

In addition to the observation, there were a total of 12 form submissions received from the participants. One of the responses had to be withdrawn from the results, as it did not contain serious answers. The responses to the main questions were as shown in figure 5.3. Of all the responses, there



**Figure 5.3:** Results from the first test session of the second iteration of the prototype, using both scenarios.

was only one that stated that they would have preferred to have the tasks available on paper. This was due to internet issues causing the participant to be unable to access the prototype properly. The rest of the responses stated that they would still choose the digital version if they had the choice, saying that they felt it would be a lot easier to use than the paper version. One of the responses also felt that digital would be better because *a smartphone is something that everyone has*.

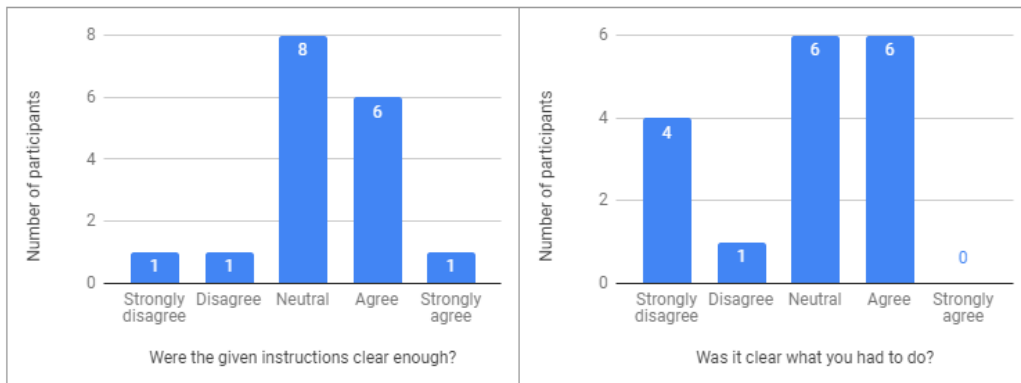
In the group interview conducted after the simulation, the participants requested instruction to be added after choosing a role in the application, in addition to getting a better introduction before starting the simulations. They also mentioned issues similar to the ones that were observed during the simulation, such as not knowing what to do on different tasks, and when to start a new task.

For the second test session, some of the issues from the previous session had been resolved, such as a better introduction before starting the simulation, and instructions within the application. But even though these had been resolved, some of the previous issues were still being observed during simulations:

- Some participants seemed to skip tasks during the simulation.

- Several participants seemed to be confused regarding what to do on some of the tasks.
- Some participants seemed a little unsure when to start a task.

During this session, there were a total of 17 form submissions received after the simulations. This time there were no responses that had to be withdrawn, as the participants had been explicitly told that the data collected in the form was for a real research project and that any non-serious submission would be rejected. The responses to the main questions can be seen in figure 5.4. This time the results were a lot more mixed, as the participating group



**Figure 5.4:** Results from the second test session of the second iteration of the prototype, using both scenarios.

of students was a lot larger than last time, with a total of six simulations in one session. The test session was greatly affected by time restrictions, which meant that only 30 minutes were allocated per simulation. These 30 minutes included setup, simulation, and group interview. This proved to be an issue, as the fall scenario required at least 15 minutes to complete, which left not a lot of time for setup and post-simulation group interviews. This caused the general experience to fall for the users, as they did not get enough time to be introduced to the application and how it worked. This was reflected in the form submissions, where seven of the responses stated that the tasks were not detailed enough, and did not provide enough information for the user. Though, this did not affect the participants' perception of the application. Examining the responses to the paper versus digital questions, still, a majority of the responses felt that the digital version would be a lot

easier and effective than a paper version. As with the previous test session, there was a response stating that *"You always have your smartphone with you"*.

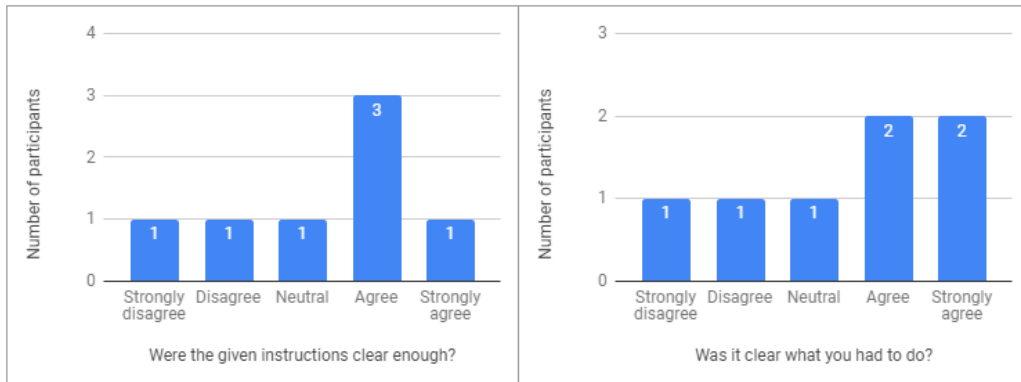
As with the previous session, the post-simulation group interviews raised a lot of the same issues as those that had been observed during the simulations, particularly the issue about what to do in the different tasks. Additionally, several participants did raise a new question, whether if it was possible for the tasks to be handed out only when they needed them.

In the last test session for this iteration, due to the small time frame between the test sessions and there not being any particular issues that could be resolved without redesigning the application, the participants would be the same version of the prototype as the last group. This was a much smaller group and had only allocated time for two simulations. During the simulations, similar issues as earlier were observed:

- Several participants seemed to be confused regarding what to do on some of the tasks.
- Some participants seemed a little unsure when to start a task
- Compared to the previous sessions, the participants did not seem to skip tasks, as there was no indication that any of the participant did so during the simulation.

In the last session, there were a total of 7 form submissions received after the simulation. The responses to the main questions were as shown in figure 5.5. Again there were mixed responses from the participants, particularly with issues regarding the instructions. Two of the responses felt that the interactions with the application were complicated when they had to handle phone calls at the same time, as they would be unable to see their current task.

The post-simulation group interviews were again similar to the previous sessions, raising the same issues regarding task handling. In addition, how to handle the phone calls were discussed among the participants. The only way they could think of circumventing this issue would be if they put the call on speaker phone and went back into the browser to access the application.



**Figure 5.5:** Results from the third and final test session of the second iteration of the prototype, using both scenarios.

### 5.1.3 Iteration 3

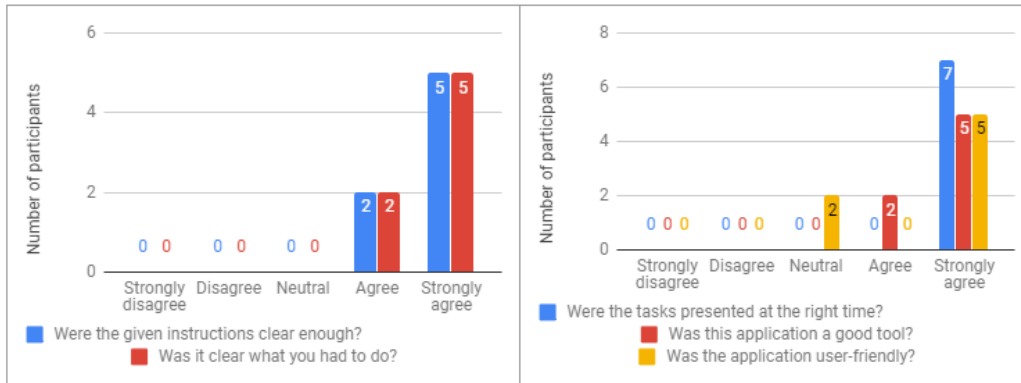
In the third and current iteration, there were three different test sessions. Each of the sessions had a different stage of the prototype, which meant that the results varied a lot. Additionally, the form used to gather feedback from the participants had been altered again, to accommodate gathering feedback for the new prototype. The paper versus digital version questions had now been removed from the form and replaced with questions regarding specific feedback for the prototype and research questions. In the first test session of the third iteration, the same group of students that tested the very first iteration returned. For this group, only the measurement scenario was available due to the early stage of development for the new prototype. During observations of the two simulations held with the group, there were only one issue observed:

- The patient role during the first simulation forgot to press the button to complete the tasks they had on several occasions.

This caused issues since the application would not send specific tasks to other roles, as the patient had not marked some of their tasks as completed, which would have sent new tasks to other roles. The participants who observed during the first simulation caught on to this and did not replicate that issue when it was their turn to do the simulation.

After the simulations, the participants submitted their responses to the new form. The responses from the seven submissions can be seen in figure

5.6. The two questions seen in the chart on the left in figure 5.6 show the



**Figure 5.6:** Results from the first test session of the third iteration of the prototype, using only the measurement scenario.

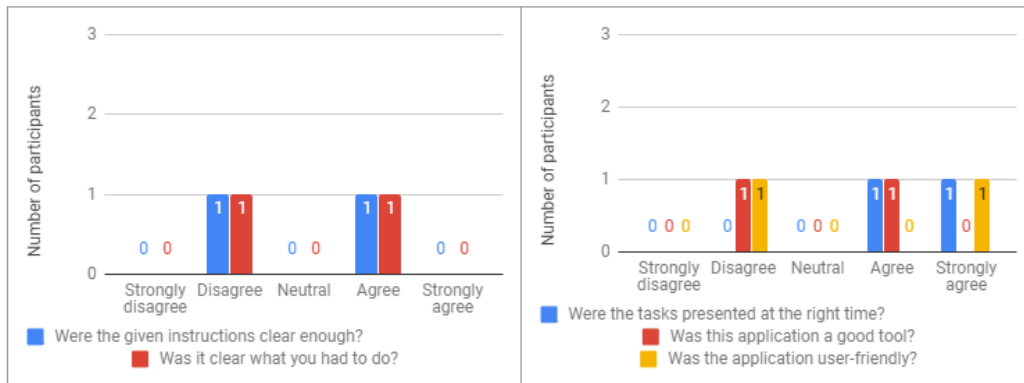
questions that had persisted through all the iterations. These questions are necessary to be able to know whether or not we need to adjust the tasks. Here we can see that the participants felt that the tasks generally did provide enough information and that it was clear what they had to do. In the graph on the right in figure 5.6, we see the responses to the questions regarding the prototype itself. According to the responses, everyone felt that the tasks were presented at the right time. Most of the responses also thought that the application was a useful tool for the simulation, while there mostly positive responses whether or not the application was user-friendly, with some being neutral to this aspect. In the post-simulation interviews, the group stated that they liked this iteration a lot better than the previous iteration they tested. This time they felt it was a lot easier to know when to do a task, and that it generally was a lot easier to complete the scenario. The only thing they mentioned that they would have wanted for the application, was something to indicate that the scenario was still ongoing when they did not have a task available, such a dummy task with information.

The second test session had a new group, consisting of seniors with several different work backgrounds, such as health care, the Armed Forces, and politics. This group presented a whole new challenge to the simulations, as this group had a much more limit ICT experience than the students that had been participating earlier. This resulted in the setup taking a lot longer than usual, due to connectivity issues, some of the participants not hav-

ing a smartphone and the limited ICT experience. Upon starting the first simulation, a lot of different observations were made:

- The patient were unable to get in contact with telecare.
- The nurse contacted the relative/family role.
- Several roles did not complete their tasks by pressing the button on the tasks.
- Connectivity issues persisted, due to some of the participants being unable to connect to the University’s guest network.
- The telecare operator took complete control of the whole situation in the scenario, without using the provided tasks.

As observed, the telecare operator was able to take control and complete the whole scenario without using the provided tasks. This was due to the participant who had the telecare role had a health-care background and knew which roles were available in the scenario. Based on this knowledge, they managed to delegate tasks to the other roles, and in the end, complete the scenario. After the simulations, only two of the participants submitted responses to the form. This is not a good sample size, but the results are displayed in figure 5.7 nevertheless, as they are both relevant when discussing the post-simulation interviews and due to the comments made in the responses. As



**Figure 5.7:** Results from the second test session of the third iteration of the prototype, using both scenarios.

shown in the left graph in figure 5.7, there was some disagreement about



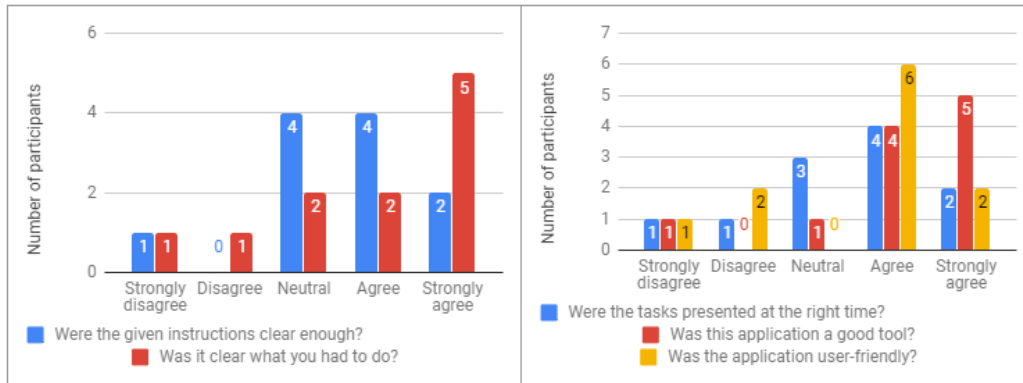
whether or not the instructions were good enough. This was based on the fact that several of the participants were struggling with the network, which meant that they did not receive new tasks. Though, when the network did work as intended, the participants felt that they did receive the tasks at the right moments, as seen in the right graph in figure 5.7. Again, we can also see that the responses disagreed whether or not the application was a good tool to support the scenario, and if it was user-friendly. During the post-simulation interviews, the participants discussed the user-friendliness, stating that how the interface was, could be easier for younger more ICT experienced users to understand. Also, the scenario itself got a lot of feedback from the participants, notably that the situation in the scenario was not realistic. As an example, they stated that in the real world, the doctor would not be contacted regarding the patient's situation, but rather the ambulance service.

The last test session held for this project was once again with students. This time the prototype had been updated once more, with several bug fixes, and a progress bar showing the progression of the current scenario had been added to the interface. During the simulations done by this group, there were several different observations made:

- The relative/family role answered the alarm call, which meant that the alarm operator did not get through to the patient.
- The application seemed to struggle after the first simulation.
- The alarm operator took the initiative to contact the nurse, doctor and ambulance service when the application failed.
- Some of the participants seemed a little bit unsure if the application had stopped or not.

The application did in fact struggle during the simulations, and this was the first time that it ever had done so, which meant that the moderators had to interfere with the simulation, and assist the participants for them to progress. What seemed to be the primary issue was that the application did not display new tasks without the user refreshing the application, and going back into the scenario. This issue seemed to originate from the server migration that had been carried out before the last test session, as the new server could not handle all the connections correctly. After the simulations were completed,

11 of the participants submitted responses to the form. The results can be seen in figure 5.8. The results from the simulations were generally positive,



**Figure 5.8:** Results from the last test session of the third iteration of the prototype, using both scenarios.

but at the same time quite mixed, as can be seen in both the graphs in figure 5.8. This was imparted to the issues regarding the application itself, as for each simulation, there were several instances of the application suffering from the problems. Though it should be mentioned, that the issues mainly affected only one role. Nevertheless, as seen in the graph on the left in figure 5.8, the tasks still need to be further adjusted. When it came to whether or not the tasks were presented at the right time, the results were decidedly mixed. Again, this could be due to the issues with the prototype. The responses generally felt that the application was a useful tool in this setting, excluding one of the responses from a participant who could not get the application to work properly at all. Regarding user-friendliness and, the responses leaned more towards positive, rather than negative. Although, those who felt that it was not user-friendly did state that better instructions before starting the simulation could have made their experience better, and probably have made the application appear user-friendly by knowing how to use it properly. In the post-simulation interviews, several of the issues mentioned above were brought up, such as the application not working correctly. Regardless, the participants seemed favorable to the application being used in this context as long as one could be assured that it would work properly. In addition, a proper introduction and hands-on demo of how the application works could have helped a lot. Lastly, some participants stated that thought that using

the application was an exciting way to do this kind of simulation, and could be expanded to be used in other areas of research and learning.

#### **5.1.4 Other Findings and Discoveries**

During the last test session, the possibilities of using the prototype as a learning method in the classroom were brought up. The prototype could potentially create a more engaging learning experience, compared to the standard learning environments. The learning curve using the prototype could be an interesting factor in the learning, as it would be difficult the first time through, but it became easier for each subsequent simulation using it. Also, the prototype could be adjusted to provide scenarios that would become progressively developed and adjusted for each time they were simulated. To elaborate further on the potential of the prototype, Alice Coward, a teacher for Health and Youth Development at Kvadraturen High School, had the following to say:

The prototype presents itself as a possible useful method to explore good and bad service, where you would be able to show each other what you could do better. This could result in a better learning environment, with more interaction between the students. In addition to the video recording could be a great method to evaluate when the students are active in their learning.

# Chapter 6

## Conclusion

### 6.1 Discussion and Conclusion

In this chapter we will examine and discuss whether we have found the answer to the research questions introduced in chapter 1. Also, we will discuss any potential future development for the prototype, before concluding the thesis.

#### 6.1.1 Discussion

Let us take a examine and compare the findings with each of the research questions:

##### **Could mobile devices be used as a supportive tool to engage students in eHealth?**

What did the mobile devices bring to the table? Using the application, we were able to gain a new perspective on how simulations could be done. By using the devices as a measure to handle task distribution, the participants always had the tasks at hand while immersing themselves in the scenario. The versatility of the devices, also meant that some of the participants could use the devices actively in the simulations, as a part of the scenario, e.g., to answer calls from other roles. Regardless, we must ask ourselves the following question; could it have been better without mobile devices? One could argue that with mobile devices, you introduce a lot of potential issues that could take up a lot of time. On the other hand, if everything is set up correctly with a refined application, mobile devices could provide an engaging and interesting experience for everyone participating. With this, we could argue

that there is a high potential for mobile devices to be used as a supportive tool, due to the available features of the devices.

### **What would be needed in order to create an application or serious game that could be used to support simulating scenarios?**

During the testing and development of the prototype, the features needed to create an application to support simulating scenarios were mapped. There are generally a lot of different features that could be added, but the application must be able to include the following at least:

- A platform that is easily accessible by the users.
- A framework to support multiple different scenarios, with different roles, and interconnected tasks.
- The ability to send and receive tasks between the users.
- The ability to present the tasks to the users in a meaningful way.
- Users should be able to indicate when they have completed a task.
- The ability to monitor scenario progression, for any moderators attending.

With these features, you would be able to generally create an application that could be used to support simulating scenarios. Based on the results from chapter 5, we can see that the prototype used in this project, which has most of the features mentioned above, was successful in supporting the simulations held during the project.

### **Would the proposed prototype improve the experience of the simulations?**

During testing, a lot of issues with the progression were in part due to problems directly connected to the application. Either it was an issue with the application itself, or with confusion regarding the application. Though, when participants knew how to use the application, it massively improved the experience. This was particularly true for the group that tested both the paper version and the near-completed digital version of the prototype. This group already knew how the scenario worked, and therefore, the application became a great supportive tool, that let them focus on the scenario itself. The results

of this group can be seen in figure 5.6. The fact that the group already knew how the scenario worked could have skewed the results in favor of a positive outcome. Therefore we would have to ask whether or not it was right to ask this specific question in this context. We could argue that the results are correct, as the question only asked whether or not the prototype improved the experience of the simulation. For the other groups, the responses were mixed, and it seemed that the prototype affected their experience of the simulations. This can be seen in figure 5.7 and 5.8. The learning curve that Alice Coward mentioned in her feedback regarding the prototype seemed to be present and might have been a little too steep at first. The curve should get easier for each subsequent simulation, but this was something that we were unable to test during the sessions. Several groups consisting of the same participants should have been able to test the prototype multiple times to get a more accurate result on whether or not the prototype did impact the experience during the simulation.

### **Would the prototype be able to improve the flow of the scenarios in the simulation?**

The purpose of this question was to see if the prototype could improve the flow of the simulations. Are the participants more autonomous with the application, or are they more dependent on the moderators? During the first iteration, the participants were dependent on the moderators to help out with the scenario itself, but during the third iteration, the participants depended on the moderators to help with the application. Regardless, the task handling system in the application did seem to help with the flow of the scenario, as can be seen in the right graphs, in figure 5.6, 5.7 and 5.8. Additionally, the instructions within the application received mixed responses, as some understood what they were supposed to do, while others struggled. Had the application had better instructions, perhaps a built-in tutorial, the responses would have been a lot better. By implementing this, the flow could have been increased, as more users would have understood how to progress. Some users also forgot to complete their tasks by pressing the button in the application, which impacted the flow of the scenario. At the current state of the application, the buttons are static, and the users easily forget to press them when they have completed the task. A method to remind the users to press the button would have been to make the button emit a glow after a certain amount of time.

## 6.1.2 Future Development

In the current state as a web application, the prototype does not have access to certain features available in smartphones. As a web application, it might not be able to push notifications to the device, unless the user has accepted that the web application may do so. Some browsers might also not support push notifications, especially if the device is locked. This limits the use of a feature that could be beneficial for the application. By using a native application, it is a lot easier to push notification to the device, regardless of the device is locked or not. Also, there are several other possible features that could be used to support the application. Here are potential features that could be added if a native application were to be adopted:

- Movement triggers - most smartphones are able to detect when you are moving. When the device detects that you are moving it would send a trigger to the server. As an example, it would send a trigger when it detects that the nurse is on the way to the patients home.
- Wake screen - native applications are able to prevent the screen from turning off. This would mitigate the sleep timer for a lot of devices, as many choose a short timer before the screen turns off.
- Advanced notifications - For Android and iOS devices, you are able to customize the notifications with custom actions. As an example, you could design the notification to be able to trigger a task directly from the notification tray.
- Improved stability - a native application might be more stable than a web application.

Another feature that could potentially be added to the prototype is support for external systems. During simulations of the measurement scenario, there was used a pulse oximeter to measure oxygen saturation in the patient's blood. This device was connected to a tablet that had installed an application for the oximeter. If the prototype had supported data from external systems, the prototype could have potentially received information from the tablet application when there had been an accidental double measurement, as described in the scenario, and triggered a related task based on that data. Other uses could be with external sensors, such as a fall sensor, which was initially planned to be used in the fall scenario.

### **6.1.3 Conclusion**

In conclusion, mobile devices could be used to engage and interest students if paired with the right kind of application. The prototype created for this project amounted to some success but would need further development and testing to reach its full potential. The application itself could have performed better if time had been better spent on the development of the prototype. Nonetheless, taking full advantage of the features of mobile devices and applications could be beneficial for supporting learning and education, if used in the proper context and setting.

The author recommends further development and testing of the prototype. Additionally, further examination of the uses for mobile devices in education is also advised to explore other uses than the one described in this thesis.



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# Attachment 1

## Simulation of eHealth Scenarios with Role-play Supported by an Interactive Smartphone Application

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**Abstract.** The transformation and digitalization of health services foresees a need for recruiting individuals with the combined knowledge of technical and health sciences. Education of young people in the domain of eHealth is an important contribution in the on-going digital transformation process. In this context, the research project *High School Students as Co-researchers in eHealth* aims to introduce technology-supported health care scenarios and research methods to young students in the Southern region of Norway. As a part of the project, simulation of eHealth scenarios was made in a clinical research laboratory together with high school students and experienced researchers. In the simulation, role-play was used to carry out the scenarios. To inform the roles, the tasks and their associated actions, an interactive smartphone application was used. This paper presents the simulation procedure and how the interactive smartphone was developed and used to guide the scenarios.

**Keywords.** Simulation, Health care modeling, Education and Training

### 1. Introduction

Health and social services are changing rapidly due to digitalization, and there is a need for individuals with a combined competence of computer and health sciences [1][2]. Combining health, organizational and technical issues is relevant for improving the technology-supported work processes. There is also a need for recruiting young people to contribute in the workforces of the future. At the University of Agder in Southern Norway, there has been a Centre of eHealth with a clinical research laboratory since year 2010 [3], where eHealth technology can be tested both in an early conceptual phase and during development regarding technical functionality, but also regarding impacts on organizational and clinical working procedures by use of multi test-room simulations where the interactions are observed and evaluated.

To introduce young people to eHealth, the research project *High School Students as Co-researchers in eHealth* was run as a collaboration between the University of Agder and high schools in Southern Norway, to allow high school students enrolled in a project

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course to learn about eHealth and research methods [4]. One of the learning objectives was to actively experience eHealth and as a learning method, a practical simulation was carried out in the eHealth research laboratory together with experienced researchers, where different eHealth-related scenarios were tested and carried out as a role-play. This paper presents the simulation procedure and how an interactive smartphone application was developed to inform the roles, tasks and their associated actions for the role-play used in the simulation of the eHealth scenarios

The research questions stated were: *How can simulation introduce high school students to eHealth in an educational and learning perspective? How can a smartphone application be used to guide the task flow in simulation of eHealth services?*

## 2. Methodology

As a part of the research project *High School Students as Co-researchers in eHealth*, 40 high school students taking a specialization in general studies, participated in an eHealth laboratory simulation during one day in September 2018. The high school students were 16 years old. The students carried out eHealth scenarios as a role-play together with researchers.

The project was led by the University of Agder and seven researchers within the domain of eHealth, having inter-disciplinary background from health informatics, computer science and health science were involved. In addition, one master student in Information and Communication Technology (ICT) was responsible for the conceptual and technical development of the interactive smartphone application used in the simulation. The role-play scenarios for the eHealth simulation were developed based on the experiences, results and technology from the research projects *Model for Telecare Alarm Services* [5][6] and *United4Health* [7][8], both performing several complex multi test-room simulations using the eHealth research laboratory infrastructure [9].

The high school student project was funded by the Research Council of Norway [10] with grant number 283737 and run during the year of 2018.

## 3. Results

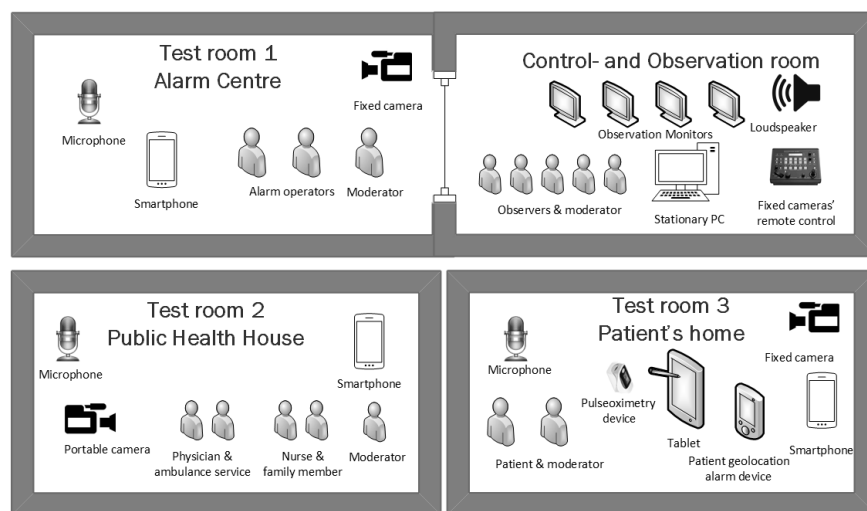
### 3.1. The Simulation Procedure and Scenarios

The learning outcome of the simulation procedure was how technology can help patients and support health service providers, by experiencing the different roles in a typical telecare or telemedicine scenario, by testing and interacting with devices. The simulation started with a short introduction about two scenarios to be carried out. Based on two pre-defined scenarios, the students in groups of 6-8 participants were assigned roles. The first scenario targeted a telecare situation which was: a) patient at home with a fall accident and triggering a telecare alarm with a GPS geolocation and communication device, b) telecare alarm service operator receiving alarm and communicating with patient and relevant services, c) municipal home nurse on duty for home visits, using a mobile phone device, d) family member with mobile device, e) physician and ambulance service with a mobile device and f) a group of 6-8 students observing in the observation room and following the interactions. The second scenario was a telemedicine situation which was: a) a patient performing measurements (pulse oximetry) regarding chronic obstructive

pulmonary disease (COPD) using a tablet device, b) family member to be notified, c) municipal home nurse for home visit, d) general practitioner for medical advises and e) a group of 6-8 students observing in the observation room. After each scenario a group debrief was made, where the students reflected on the scenarios and discussed how to improve them. The group switched the roles internally between the scenarios, to experience the situation through different roles.

### 3.2. The Laboratory Infrastructure

An eHealth laboratory was used that had three separate test rooms and one control- and observation room. The laboratory infrastructure is described in Figure 1. Test room 1 represented the alarm centre, Test room 2 a public health house and Test room 3 the patient's home. In the control- and observation room, the simulation was followed simultaneously on 4 large monitors, one for each camera source and one for merging the sources. Interactions between the test rooms were made only through technology and were guided by an interactive smartphone application. In each room, there was a moderator from the research team guiding through the simulation.



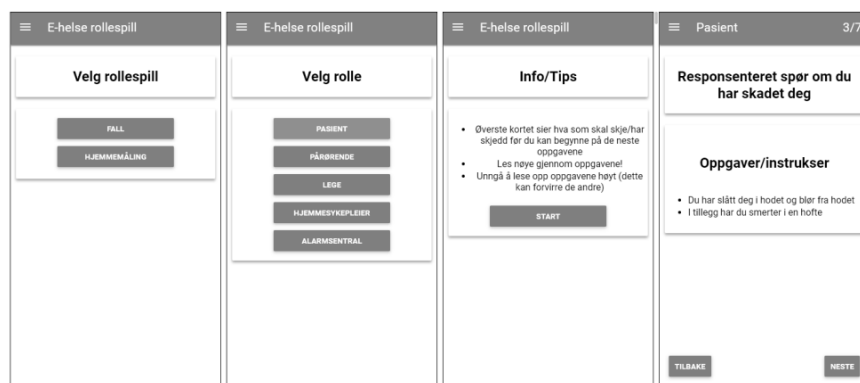
**Figure 1.** The eHealth laboratory with a multi test room set-up.

### 3.3. The Interactive Smartphone Application

To describe the roles and the associated tasks, the interactive smartphone application *eHealth role-play* was used. The application was developed as a basic web application using JavaScript, HTML and CSS. By basing the application on the web platform, it ensured cross platform compatibility, allowing the application to be accessed on any device having a web browser.

Upon opening the application, the user could select a scenario and then an associated role for the chosen scenario. Before presentation of the first task, a screen would display information about the tasks, explaining to the user the task triggers and guidelines to ensure a good experience for all the participants in the role-play. When a user chose to

start by pressing the start button on the screen, he/she was presented with the first stage of their role. Each of the roles had several stages that guided the user through the role-play. In each stage, there was a task trigger in the top card, which described the task trigger and task description. In this instance, the task trigger described what would have to occur before the user could start on the tasks in the bottom card. Once the user completed the tasks in the bottom card, he/she was able to go forward to the next task by pressing the next button. The progress between the stages was dependent on the different participants in the role-play, which could negatively affect the flow in the scenario and the experience of the role-play for the participants if the tasks were not followed precisely.



**Figure 2.** Screenshots from the smartphone application “eHealth role-play”. From the right: 1) Start screen with choice of scenario, 2) Choice of role, 3) Information about the task flow and a start button, 4) A task with instruction and a next button to continue in the scenario.

Regarding the user experience with the smartphone application, the students used their own device to access the application on the web before the start of the simulation. There were initially some technical issues that were solved with a mobile hot spot solution. As the students had limited experience from health services they needed introduction to the different roles and having one moderator in each test room for guiding both in the role-play and regarding the use of the smartphone application was required.

#### 4. Discussion

This paper has presented how high school students were taught the concepts of eHealth technology by applying theory into practice through laboratory simulation. Regarding the first research question on how to introduce students to eHealth in a learning perspective, the method of practical simulation in laboratory provided a student-centered approach endeavoring an early understanding of eHealth concepts. The simulation and role-play in the eHealth laboratory allowed the students to understand and experience realistic situations where technology would support the actors (health care providers, patient and family members) in handling the situation. About the second research question on how to guide the task flow in simulation, the interactive smartphone application *E-health role-play* was used instead of a traditional paper-based role description and task list. The idea was to use a device that all participants brought with

them and knew well. The application replaced the use of paper instructions and informed each participant about their role and the next task to perform. The moderators during the simulation were active and experienced researchers in eHealth, and the scenarios aimed to provide the students with insights and hands-on real problems to solve, but also reflecting on-going and recent research projects. As there is a need for recruiting new people into the eHealth domain, hopefully, some of the high school students will choose a related education and join the inter-disciplinary work force in the future.

This paper has some limitations, such as describing simulations made with students from one single high school. However, the paper has shared experiences and lessons learned regarding simulation as a teaching method for young students with the learning objective basic understanding of eHealth concepts. To conclude, the approach with simulation of eHealth service in clinical laboratory together with high school students and researchers provided the students with hands-on experience on real situations and how technology can be used. The interactive smartphone application replaced traditional printed papers and guided the task flow, even though there were issues that could be improved. Future work would include extension of the project period and recruit a larger number of high schools for enrollment. In addition, the smartphone application could be further refined by developing a new task handling solution based on the basic trigger concept described by Schulz in *Listening to Teachers' Needs: Human-centred Design for Mobile Technology in Higher Education* [11].

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## Attachment 2

# 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 based on a game platform. The platform allows game play for high school students, thereby teaching interactions and technology 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 in teaching for complex domains.

**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 actors that act simultaneously on the same case. 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. It has previously been studied how existing telecare alarm services in Norwegian municipalities are organized and operated to identify requirements (from infrastructure to usability design) to improve existing systems and service models or conceptualize new ones [1].

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

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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. 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 run into problems that are not real problems for trained healthcare professionals.

In order to support the play-through of the telecare scenarios by both professionals and students, we describe the (mobile) technology 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.

The gaming technology is introduced in addition to the eHealth technology that is used while the scenarios are played. However, as the eHealth technology is not always available when the new service models are designed, 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.

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 main stream definition of gamification (the use of game-design elements in a non-game context [2]). The serious game we describe is a full game and is not only relying on (added) game-design elements to improve motivation, user experience or 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<sup>1</sup> and PokémonGo<sup>2</sup> by Niantic. The player receives tasks and options to play delivered through their mobile device and play the game within the real world. 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 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 and to have the option of creating those tasks by themselves, improve or adapt 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 as well as 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, 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.

## III. METHODOLOGY

This research project is based on a human-centred design (HCD) [7] approach. In an early phase, user scenarios were

<sup>1</sup><https://www.ingress.com/>

<sup>2</sup><https://pokemongolive.com/>

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 directly tested 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] and 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 with interaction between multiple test rooms 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 room, such that each group played the different roles that were used 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. 1: 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, 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

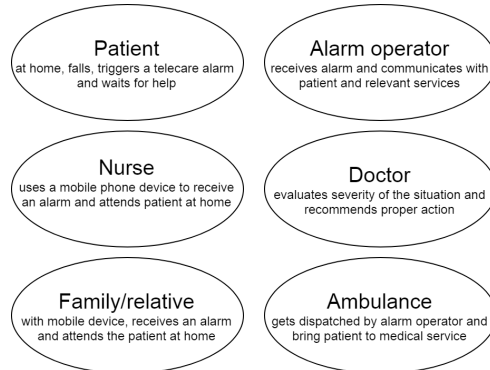


Fig. 1. The fall scenario and its roles.

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 handling of the situation was escalated from the family member and home nurse as first line of response. Their status report was used by the telecare alarm service operator to check with the doctor whether further action was 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 was made 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 a huge variety and shapes in games, which makes it necessary to have a closer look into the complex design of game tasks to be able to design tasks for a serious game. In addition, tasks are not only used in games, 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. 2. 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).

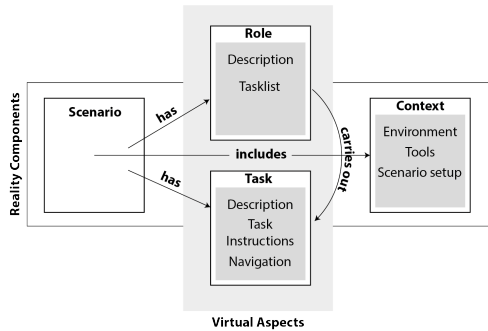


Fig. 2. The general setup behind the triggering concept in this project including the virtual aspects of tasks and roles as well as the reality components of the scenario and real-life context including the environment, setup and used tools.

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<sup>3</sup> 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.

In this version of the prototype, the set of available kinds of triggers is still limited. The focus was on triggers depending on characters (roles) in the scenario finishing their tasks to set the scenario in motion and keep the story going. The following trigger types are currently available.

<sup>3</sup>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.

- 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, if the nurse is late to the patients house, and the ambulance has arrived before them, they will be able to signal that the ambulance already has arrived, thus skipping any subsequent tasks related to helping the patient leading up to 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 an 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. 1 is turned into a game scenario as shown in Fig. 3.

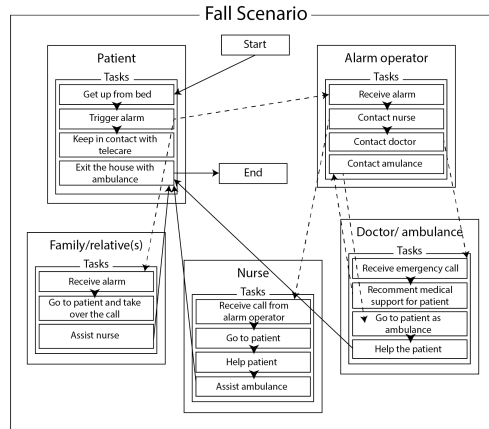


Fig. 3. Dynamics between roles and tasks in the playable fall scenario at the current stage of the prototype. Dotted lines indicates externally triggered events, such as phone calls, and the arrows indicates user triggered events.

## 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<sup>4</sup> to ensure reliable bidirectional 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. 4: 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.

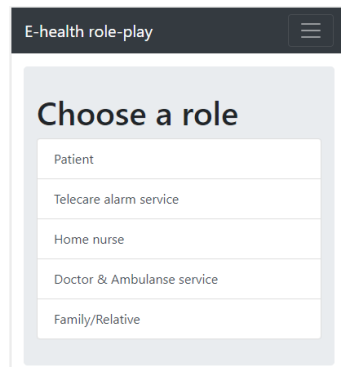


Fig. 4. Roles that can be taken within the playable scenario, in this case for the telecare scenario.

- *A Task* - is an activity to be executed, see Fig. 5 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.

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

<sup>4</sup><https://socket.io/>

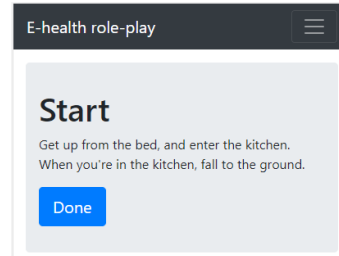


Fig. 5. Example task on how the patient starts the scenario. Upon pressing the "Done" button a trigger will be sent to the server, and a new task will be sent out to the appropriate users.

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. 6.

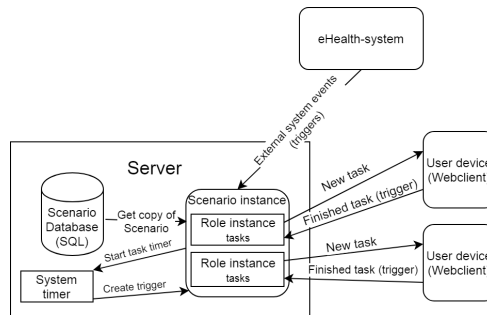


Fig. 6. The architecture of the server-client, displaying functionality within the server, and interactions between server, client and eHealth-systems.

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.

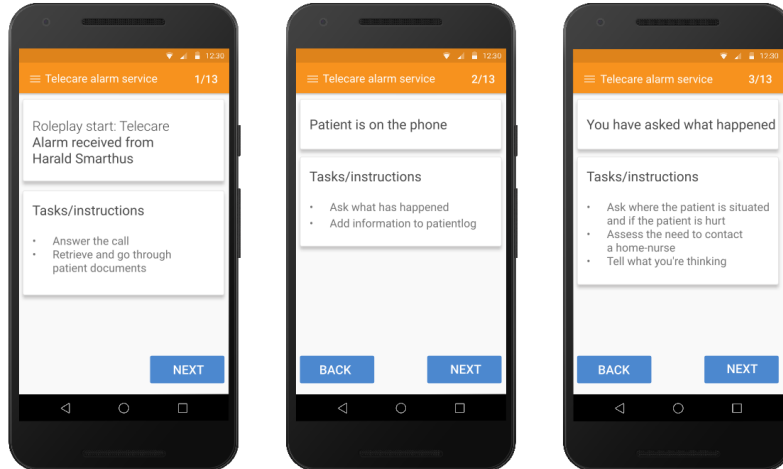


Fig. 7. Three screens from the paper prototype showing tasks tested during the first iteration: a) Start of the scenario "alarm went off" b) Follow-up task "contact with the patient" c) Follow-up task "gather information about the situation".

## 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. 7. 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 ap-

parent 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 device, 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 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 left, if they are not to minimize 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, (s)he 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 can derive requirements to design adequate tasks for a healthcare scenario game that includes the educational tasks aspects as well as task game design 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, relating to the involvement of students that did not have a professional health background or relating to 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.

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