

Co-designing a Hybrid Game for Training Use of Proper Personal Protective Equipment in Different Clinical Scenarios

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Abstract—As highlighted by the current COVID-19 pandemic, all healthcare staff must use proper personal protective equipment in each clinical environment. This requires an understanding on the suitability of various types of equipment for different clinical scenarios, as well as knowledge on their appropriate application. Thus, learning how to use personal protective equipment in different healthcare environments is of great importance, and innovative ideas to support learning are needed. Recently, digital game-based learning has gained a lot of interest as a tool creating motivational learning for different learners. In this publication, we are presenting a hybrid game for training use of proper personal protective equipment. The player needs to select and put on suitable equipment for the clinical scenarios presented by the game. The initial game concept and the technical setup were created by following co-designing method in a multidisciplinary workshop. Subsequently, an early prototype version was introduced to nurses and nursing teachers for comments on further development ideas. According to the experts, the game concept is warmly welcomed for different user groups. The experts also provided several development ideas, which are introduced in this publication and implemented for the future versions of the game. The game is built around personal protective equipment tagged with passive UHF RFID tags and can thus be easily modified for different personal safety equipment and different clinical scenarios.

Keywords—*co-design, game-based learning, hybrid game, infection control, nursing education, occupational safety, patient safety, passive RFID, personal protective equipment*

I. INTRODUCTION

Staff members in hospitals, care homes and other care environments are at risk of infection themselves, and subsequently at risk of infecting their patients/clients. Especially during epidemics, infected staff members will further diminish the capacity of the healthcare system [1]. Infections cause significant harm to the patient and his/her relatives. Infections also lead to longer hospital stays, higher medical costs, and increased mortality [2]. Thus, the staff must use proper personal protective equipment in each healthcare environment. The goal of the protective equipment is to shield the staff from droplets from coughs, sneezes, vomit, or other body fluids from infected patients and contaminated surfaces [1]. The availability, safety, and effectiveness of such protective equipment are crucial to protect healthcare staff in different working environments and clinical scenarios [3][4].

Examples of personal protective equipment include gowns, coveralls, gloves, masks and respirators, face shields, goggles, and foot/leg covers [5]. The equipment must be put on correctly and in the right order [6][1]. It should be also noticed that overprotection can be a problem, as it may make work more difficult, and even lead to an increased risk of infection during removing the protective equipment [1]. The use of personal protective equipment thus requires an understanding of the suitability of various types of equipment for various clinical scenarios and knowledge on their appropriate application [6]. World Health Organization

(WHO) also guides workers to optimize personal protective equipment to decrease the global protective equipment shortage [4]. By minimizing the use, and by using only appropriate equipment, the staff can decrease the amount of waste. Thus, learning how to use personal protective equipment in different clinical scenarios is of great importance for healthcare staff, and innovative ideas to enhance and support learning are needed.

In this publication, we are presenting a hybrid game concept for training use of proper personal protective equipment. Hybrid game refers to a combination of physical/tactile game and digital game. The player needs to select and put on suitable equipment (physical game) for the clinical scenarios presented by the game (digital part). The initial game concept and the technical setup were created by following co-designing method in a multidisciplinary workshop. Subsequently, an early prototype version was introduced to nurses and nursing teachers for comments on further development ideas.

The game is built around personal protective equipment tagged with passive ultra-high frequency (UHF) radio frequency identification (RFID) tags, and can thus be easily modified for different personal safety equipment, for different players, and different clinical scenarios. The battery-free and wirelessly operated RFID tags draw energy wirelessly from an external RFID reader antenna and respond by sending their unique ID by backscattering. These extremely low-cost tags are functional from distances of several meters. Passive UHF RFID tags can be attached to human body or embedded to the surrounding environment and then “activated” or “deactivated” by touch [7]. These properties also make it an attractive solution to be implemented to human–technology interfaces [8][9] and games [7].

II. GAME-BASED LEARNING AND NURSING EDUCATION

The use of games to support teaching and learning has a long history, and recently game-based meaning creation and related new practices have become increasingly important [10][11]. Researchers and teachers are working to find new methods to learn and practice new things, while new learning styles have also been found to play a key role in reaching different learners, such as visual, auditory and kinesthetic learners [12]. Game-based learning is largely based on the idea that when students change, teaching must also change [13].

The digital natives, students speaking the native digital languages of computers, mobile devices and game consoles, have devoured information through mobile devices since childhood, and played a variety of digital games, where their data processing skills have developed significantly. Thus, game-based learning today refers mostly to digital game-based learning [14]. Digital game-based learning is a very good method to increase learner motivation, to develop attitudes towards what is being learned, and to improve performance [15]-[18].

One choice that then arises in game development, is the choice between the pursuit of procedural or conceptual knowledge. Traditionally, games aim for the same procedural knowledge that have been sought in classroom assignments to review what has been learned. Simply put, procedural knowledge means being able to perform tasks in the order designed for them. For example, to perform the tasks required to clean and bandage a patient’s wound. Conceptual

knowledge, on the other hand, means deeper understanding of the meaning and objectives of the tasks. For example, a wide variety of nursing tasks can be performed, when you know how to perform the tasks correctly and in the correct order. However, then when it comes the time to plan and reorganize tasks, you need to know their purpose in depth, so that you can re-plan how to do them [19]. Thus, when designing games, it is important to decide what kind of knowledge the game aims to achieve [20]. Is the game intended to be used to review and recall performance, or is the game seeking a deeper understanding to develop functions?

In nursing education, case-based learning is one of the most widely used learning principles. In case-based learning, students concentrate on real cases or event scenarios and work together to solve situations and problems that arise in them. Such situations and scenarios could often be translated into a digital game with situations to be encountered and problems to be solved [21]-[23]. In this way, case-based learning is transformed into game-based learning, wherein a virtual world, real clinical situations can be learned and practiced, and where the nurse should be very agile in making decisions about actions and progression. In a game, it is possible to guide the player to very detailed, correct choices [24]-[26].

III. GAME DEVELOPMENT BY CO-DESIGN APPROACH

The design process of the game in this study followed a co-design approach [27]. In this article, co-design refers to the collective creativity of a multidisciplinary group of people. In co-design, the users are given the position of ‘expert of his/her experience’, and play a large role in knowledge development, idea generation, and concept development. Usually, the process starts with a pre-design phase or so-called fuzzy front-end of the design process, in which understanding of users and contexts of use is increased, and technological opportunities are explored. After this phase, the process follows the traditional design process, where the resulting ideas for the product are developed first into concepts, and then into prototypes that are refined on the basis of the feedback of the future users.

In this study, the co-design process started with a series of design workshop, in which 10 persons attended. The group included “end users” (3), technology providers (3), service designers (2), pedagogy expert (1), and technology researcher (1). In the first two-hour workshop the focus was on empathizing and exploring problems and challenges in care environments during pandemic and defining one key problem to be solved. In the second workshop, technical possibilities were presented with help of technology demonstrations. The aim was to define a potential technology solution for solving the problem. The potential solution was defined as a motivational education tool for training the use of proper personal protective equipment in different clinical scenarios, with help of RFID technology, which links the physical world to the virtual world. The third workshop was already about concept creation, in which paper prototypes were co-developed. The group ended up with a hybrid game concept, which combines simulated game-like scenarios (on a computer) and real-life activities (putting on correct personal protective equipment). The real-life activities were considered important to enhance the learning, while game-like elements were considered important to engage the user. The process continued with further conceptualization and early prototyping. Finally, the first game concept and game setup

were introduced to nurses and nursing teachers for comments and further development ideas.

IV. PRACTICAL GAME IMPLEMENTATION

The main goal of the game is to teach the player to use correct protective clothing and equipment in different healthcare environments and situations. It is targeted especially for nursing students, but it is useful for any person who is operating in healthcare environments, allowing also new ways of orientating a new worker to the workplace. In crisis situations, nurses who move from their normal duties to other duties, required by the crisis, can quickly recall and practice how to properly use the personal protective equipment in different situations. The game can be utilized in classroom teaching, similarly to any simulation, in which co-students are observing others performing. It also allows distant teaching, as the teacher can be in a different place to the player. Further, the game can also be played without a teacher. The aim is to make learning fun, in order to increase the motivation to train, as well as multisensory, in order to enable different types of users to learn.

The game setup includes a laptop, an UHF RFID reader device, and a reader antenna, as presented in Fig. 1. The RFID reader system is connected to a laptop with a cable. Passive UHF RFID tags are attached to various protective equipment, as presented in Fig. 2. The reader system communicates wirelessly with the RFID tags. RFID reader sends electromagnetic UHF waves to power-up the tags, which respond by modulating their unique identification code to the carrier-wave and backscattering it to the reader equipment. Fig. 2 shows example situations from the game, where putting on the right personal protective equipment in the right order is practiced with RFID-tagged equipment. First, the player wears a face mask (a). Then, the player returns to the game to think about what other equipment is needed (b) and receives instructions from another player or teacher (c). One situation requires the use of protective gloves (d) and another the use of a protective cap (e). In some situations, an insulating jacket to be worn over the nurse's clothes is needed (f).

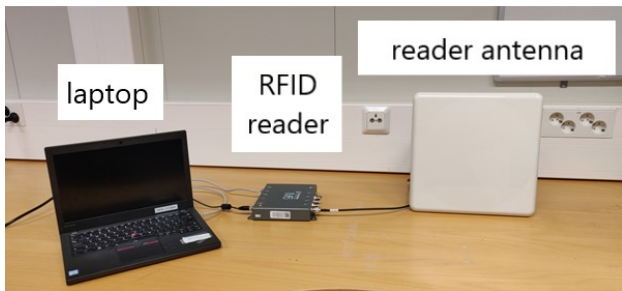


Fig. 1. The game setup includes a laptop, an RFID reader, and a reader antenna.

Examples of two different environments are presented in Fig. 3 and 4. Fig. 3 scenario is a home care visit during the COVID-19 pandemic, while Fig. 4 scenario is an “isolation room entrance” from a hospital ward and additional information from the patient record system. After the game has shown the player the scenario, the player should select the correct equipment, which can be placed in the physical gaming environment, such as on the classroom table in Fig. 2.

The game continues by the player selecting the tagged equipment one by one and putting it on, at the same time making it readable for the RFID reader, which is connected to the laptop.



Fig. 2. Different situations in the game, where the player practices putting on RFID-tagged proper personal protective equipment in the right order: a) a mask needs to be put on, b) player thinking about the next move, c) player discussing with another player or teacher about the game d) gloves need to be put on, e) a protective cap needs to be put on, f) an insulating jacket needs to be put on.

The game continues by 1) indicating wrong equipment, followed by a hint for the user to pay closer attention to specific details in the scenario, or 2) indicating the correct equipment and encouraging the player to continue. The game screen can also be projected to the classroom wall, which makes it easy for others to follow the game. These features are yet work in process.



Fig. 3. Scenario 1: home care visit during the COVID-19 pandemic.

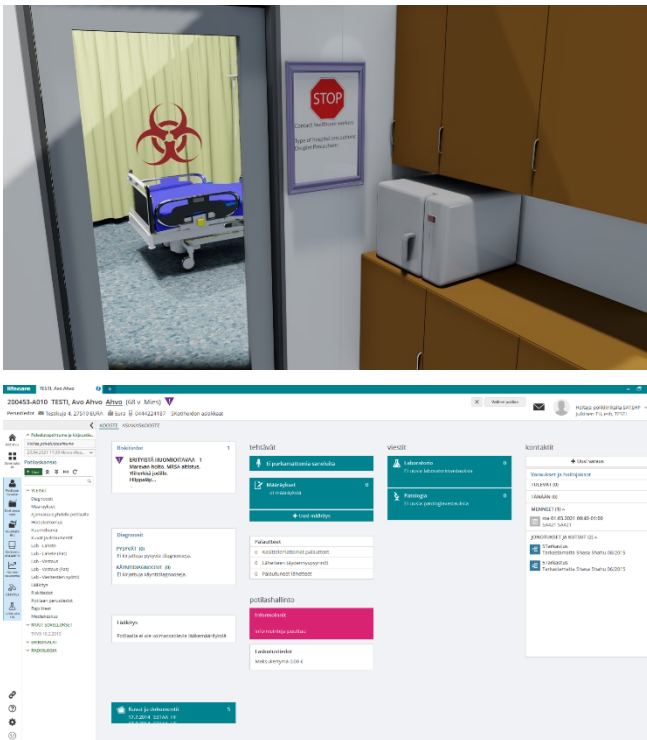


Fig. 4. Scenario 2: an isolation room entrance from a hospital ward (above) and an excerpt from the patient record system to be interpreted by the player (below).

V. FURTHER GAME DEVELOPMENT AND EXPERT COMMENTS

From the technology's viewpoint, the game will be further developed by adding more game elements, such as time, points, and progress indication. Additionally, the RFID reader's transmitted power must be made adjustable in the game, in order to enable calibration of the game to the physical gaming environment (classroom, home, workplace) to provide optimal read range at the same time preventing false readings of tagged equipment. It must also be considered that the backscattered signals of RFID tags can be noisy and unstable. However, as the focus of this study was on co-designing, these details will be considered later in the development process, when a more mature game concept is created based on the comments from the experts, i.e., nurses and nursing teachers.

From the game design's viewpoint, the game concept and early game setup were validated by introducing the early prototype version to nurses and nursing teachers, who were not previously involved in the design and creation of the game. Totally 4 participants (nursing teacher: 1, practical nurse teacher: 1, nurse: 2) were recruited for giving feedback. The following thematic areas were covered: 1. usefulness of the game (how, to whom), 2. potential gaming environments, 3. essential content (such as the most beneficial new scenarios), 4. improvement ideas, and 5. opinions about the educational aspect. The feedback collection was done by demoing the early game prototype (scenario, game set-up, and game logic illustrations) and interviewing the participants afterward.

In general, the game was seen as useful to many user groups. The benefits described were 1) engagement as the game makes learning more fun and entertaining, 2) the game contains different elements, which could boost learning and help in remembering important issues, 3) the game also allows

players to commit mistakes with no serious consequences (and learn from it).

The experts found potential users to include nursing students, practical nursing students, and care assistant students (simulations, group-assignments, assessment of learning), newly hired nurses or other employees (orientation), professional nurses, practical nurses, and care assistants (recap, changing from one kind of working environment to another), other professionals working in care environments, and relatives of patients.

The importance to teach others than nursing professionals was emphasized. Especially in home care and care homes, there are many other professionals working and visiting in addition to nurses. These include social workers, physiotherapists, caretakers, cleaners, etc. In these professions, there may be different skill gaps and thus need to learn about correct safety equipment, as their education may not be focused on these issues as much as nursing education. During crises, like pandemics, visitors are typically allowed in care facilities only in exceptional cases. The game could then be incorporated into the instruction. Additionally, the professionals ideated that the game could also have scenarios for a layman, and for all students, especially catering, tourism, and other industries, which require good hygiene.

The experts also identified different places, where the game could be played. In addition to different (nursing) schools, the game could be seen to be played at home (necessary tools provided as a gaming kit), in care environments (newly hired employees or to nurses during training and seminars, relatives) and generally in places where seminars and training are being conducted.

There were many ideas about the useful scenarios in the game. All experts suggested, there should be scenarios, which require different types of precautions (incl. standard precautions, contact isolation, droplet isolation, airborne isolation) as different isolation conditions require different protocols for personal protective equipment. Examples varied from hospital-related environments, such as isolation rooms, hospital wards with their different special features, surgery rooms, and emergency care, to home care and care homes. In these scenarios, there could be various patients/clients, which would affect the gameplay. There could also be scenarios for less critical environments, such as daycare, grocery store, etc.

There was also interest in further developing the game towards teaching how to behave or prepare different procedures. For example, performing different task inside an isolation room affect the required protective equipment (showering vs feeding). The game could also teach how to get laboratory samples, as also different lab tests require different equipment. Additionally, the game could be modified to teach about the tools you need instead of just the protective equipment. The game could show what equipment and tools to gather before going to the patient's room, and how to dispose of/clean/store them after the use according to hospital/care environment protocol. For example, in a wound care case, the players should select which tools and care products are needed. The procedures could also include changing bed linens, as hospital beds require different linens (what, how, in which order). The game could also show how to segregate medical waste.

Additions suggested were especially about instructional game elements, guiding the player in the consequences for

doing things wrong and explaining the reason why that happens. Each correct step should give the player a positive point, while each wrong step could give a negative point. Additionally, it was emphasized that disinfection needs to be done in each step, which also should be taken into account in the game. It was seen that as important as to know what to wear and in which order, is to know in which order to take the equipment off, and how to dispose of them. The game could also provide additional educational content (videos on how to wash hands, other details, open questions about how the scenario would change if something unexpected would happen...). It was also seen as extremely important that the game contain stories, humor, and other entertaining content to keep the player motivated.

It was seen important to be able to play also in groups and remotely. One idea was to make an orientation version of the game without the tactile component. The student would orientate and practice at home with the plain orientation game version, and the hybrid game would be at school. The student could participate in the hybrid game session after having sufficiently correct answers in the plain orientation game. The orientation game might have similar scenarios and only menus from which you would select the correct equipment in correct order, for example.

The experts also found game scenario development as a potential tool for teaching. The game development could be done in collaboration with game development students. Nursing students could also be a good pilot group for user testing. They could give feedback on how engaging and informative the game is. They could also suggest for details to add to the game after their work practices. The scenario and game development also offer interesting thesis topics.

VI. DISCUSSION

Instructional game-based learning, its ability to take into account different learners, and produce a variety of situations for the player to solve, inspired a multidisciplinary team to co-design a hybrid game for training the use of personal protective equipment. The game can be used in asepsis and hygiene education in classrooms, but it also provides a tool for self-training. The game can be utilized also in orienting a new worker or anyone who will be operating in healthcare environments. The game could also teach healthcare professionals about renewed or otherwise changed practices due to for example crises or new guidelines. As the game combines visual, auditive, and tactile components, it has the potential to support auditory, visual, as well as kinesthetic learners. Playing the game aims at increasing especially procedural learning. The game concept is scalable, as the scenarios can easily be developed for different purposes by changing the environment, patient/client, as well as tasks to be done in the scenario.

As serious games combine both the entertainment element as well as “the useful element” (educational element in this case), the development of such products requires various skills. In our case, expertise from game design, RFID technology, nursing, as well as education was combined in order to develop the early game concept. The co-design approach proved to be an effective way to include various stakeholders in the game development process, which may improve the match between the real user need and the provided solution, as suggested in other articles [28][29]. This may also reduce the number of iterations in the development

process, thus saving time and effort. Co-designing also has the potential of enhancing conceptual learning, as when designing for example the various game scenarios and the correct answers, students may learn even more compared to just playing the game. Thus, co-designing serious games will serve as an interesting teaching method for multidisciplinary student groups.

Our future work is to further develop the game prototype in a multidisciplinary group and later test the learning outcomes and user experiences related to the game. Game development platforms and tools will be selected based on the content and game versions.

VII. CONCLUSIONS

This article presented a hybrid game concept for training the use of proper personal protective equipment in different clinical situations. In the game, the player needs to select and put on suitable equipment for the healthcare scenarios presented by the game. The game concept provides a useful tool for various stakeholders. According to the interviewed nursing experts, the game concept is warmly welcomed by different user groups. Further, by making small modifications to the game, it was found to provide versatile future possibilities. These development ideas will be implemented for future versions of the game. As the game is built around personal protective equipment tagged with passive UHF RFID tags, it can be easily modified for different personal safety equipment, different players, and different clinical scenarios.

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