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Research paper

IDO: modelling a serious educational game based on hands on approach for training dementia carers

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Abstract

Dementia is one of the burdensome diseases in older age for which there is no cure known. The demand for carers of dementia patients is growing as the population ages. We analyse serious games as an approach to provide dementia carers with training on care related problem solving and modelling real-world cases. We present the behaviour model of improved care process by applying serious games, describe the design of the interactive serious game, its game mechanics, game environment, game actors and the motivation reinforcement mechanisms. The results of the initial evaluation performed by surveying the people caring for their elderly parents and elderly persons themselves, both healthy and showing early signs of dementia, and using the System Usability Score (SUS) questionnaire provided favourable response to the game. The use of an ICT-based gamification approach as part the training package for dementia care will be beneficial for direct care workers leading to long-term improvement of dementia care quality.

Keywords: *Aging; Assisted Living; Dementia; Gerontology; Education of Carers; Serious game.*

1. Introduction

1.1. Context of Research

Dementia is one of the most prevalent and burdensome diseases in older age. By the year 2030, estimates suggest that there will be 74.7 million people with different forms of dementias worldwide. There is no cure for dementia: drugs address only the symptoms but not the causes of the disease, being in many cases ineffective or even harmful. Non-pharmaceutical interventions are continuously tested and updated to improve patients' quality of life: these include interventions to increase communication skills, reduce agitation and stress, and use of new technology. Serious games are one of the many proven, interactive and acceptable ways to examine the effects of a motor-cognitive performance, the transfer of training effects on untrained tasks, and the sustainability of training gains [1] in people with dementia and also in people caring for dementia patients.

This research based game targets direct care workers working with dementia patients. The value of disseminating evidence on these interventions is immeasurable, but surprisingly this knowledge is often not available to care staff. Direct care workers (e.g. associate professional nurses, medical assistants, care aids, or nursing assistants) are systematically excluded by accessing up-to-date evidence. Paradoxically, these workers face the most demanding work situations, being at the same time the most burdened group and the least trained one. Vocational training for most of them is unfortunately still in inadequate stage, since their working environment usually does not stimulate them to engage in lifelong training activities. Nonetheless, evidence suggests that if adequately trained, they can contribute both to improve patients outcomes and their own working conditions.

To facilitate this aim, an interactive serious game for dementia carers was designed, as part of the IDO project's [2] training package that will enable direct care workers to manage virtually a series of case scenarios and to learn through problem-solving activities was set to be developed.

1.2. State of the Art

Serious games have been applied successfully in the health domain, having their own place in the video game industry (serious games for health). While there are many studies listing serious games related to dementia [3], it is interesting to note that almost none are targeted directly at people working with dementia, i.e. the carers themselves - which is the main novelty of our contribution. Such games are a promising solution to improve everyday management of NPS, and eventually improve the quality of life of both patients and caregivers [4].

Most existing game are indirectly useful as they while focused on training/improving the cognitive features of the patient, also indirectly can benefit the carer, as patient's cognitive status is a key component in performing daily activities such as walking and bathing [5]. Studies also show that these types of games can fit to apathetic users [6]. It is important to note, that such games could also be used to prevent (thus not only not to treat) dementia [7]. Research [8] demonstrated the feasibility of using serious games in a medical setting.

We can classify "standard" dementia games based on the assistive function they perform, e.g., cognitive, physical and social-emotional games. Each of these functions may serve a variety of useful health purposes, such as preventive, rehabilitative, assessing and educative games [9]. Developers can use such principles as part of existing Artificial Intelligence (AI) hands on approach applications to create an affordable and accessible tool for cognitive training while at the same time allowing for the in-game

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estimation of the patient's cognitive performance [10]. Games thus can be also used to perform a screening test based by applying Fitts' law and Hick's law to test cognitive function [11], showcasing that the use of Serious Games offers the possibility to re-create a virtual environment with daily living activities, and providing a tool for cognitive evaluation of patients with Alzheimer's disease [12]. Another implementation [13] showcases measuring both criteria (concurrent and predictive) and content validity, while assessing its relationship with the Montreal Cognitive Assessment (MoCA) test.

2. Design of a game

2.1. Career Behaviour Improvement Model Based On The Application Of A Serious Game

An innovative game will be designed to work around the standard ineffectiveness of traditional training methodologies for direct care workers. We have foreseen the required amount of usable data so the game runtime, complexity and intrusiveness will be modelled and designed from the ground-up around the requirements and needs indicated by direct care workers, people with dementia, family carers, dementia experts. The behavior model to be gained from was based on the work of Wiemeyer and Kliem [14]. This behavior model is based upon the presumption, that playing such special games leads to better subjective norms, improved attitudes, more perceived control, higher self-efficiency, all going up from previous behaviors and experiences. This in fact leads to better overall intentions and the overall improved care process. A similar model was applied for depression behavior in [15].

This behavior model allows us to design the game "levels" in a more adequate way, to provide more objective and comprehensive results in contrast to subjective questionnaires or training exercises. These elements of innovation can be distinguished:

1. Continuous tracking of the user's abilities;
2. Determining an appropriate number of steps required to correctly train the abilities of the target user (player);
3. Keeping up and staying "half-a-step" in front of player performance;
4. Natural interaction and little-to-no learning curve;
5. Engagement with a learning-by-doing exercise;
6. Offering different levels of difficulty;
7. taking into account social and cultural background and technical literacy, producing a most natural game model for target demographics.

Based on the studies execution of the interface [16], this part should be designed to also work with individuals with low digital skills. Game should be as not invasive as possible and not require any supervision thus allowing regular usage on its own to reach higher training goals and providing the level of motivation needed for this to occur by adjusting the gameplay and utilizing the features of gamification

2.2. Design of game mechanics

The game mechanics model idea was be based on a combination of a Tamagochi and the SIMS series of games, where the players have to guide and take care of their characters. The game progresses throughout the character's everyday life.

Our game model have the simplified needs system from inherited from the SIMS games. The needs are:

Hunger - represents the character's desire to eat. The value representing hunger is increased passively and reduced whenever the character eats. The value's increase rate is magnified if the character is doing any activities that increase the fun value and reduced when resting.

Rest - this value tells how tired the character is. This value is reduced passively and increased passively when the character is resting. The reduction rate is increased for a short time after eating and when the character is taking part in activities that increase the fun value.

Social interaction - the value representing the need for socialisation. This value is reduced passively and increases when the player takes part in conversations with the character.

Fun - the value representing overall happiness and engagement of the character. This value is decreased passively. The reduction rate is multiplied when resting. Fun activities increase the value.

Players are be able to guide their characters to solve their needs, for example, he'll tell a hungry character to make food or tell a tired character to go to sleep etc. To make the game more engaging our game model supports mini-games for solving the needs and thus mimicking real-life care situation. For example, if we tell the character that he should go eat, we'll display a healthy sandwich making mini-game. Game model envisions such styles of mini-games:

A match three game (e.g. in a style of Candy Crush Saga, Bejeweled) - a mini-game where the player is presented with a grid of game pieces with various colors. The player has to swap two neighboring pieces horizontally or vertically to make a horizontal or vertical sequence of three or more of the same colored pieces. The game pieces involved in the sequence are destroyed and the player is awarded points. After reaching a certain amount of points the task is considered complete.

A memory game - the player's goal is to uncover all presented symbol pairs. All symbols are covered and placed onto a grid. The player can have at most two symbols uncovered at a single time - uncovering a third symbol hides the two symbols from before. Thus the player has to memorize the positions of each symbol. If a pair of the same symbols is uncovered the symbols stay uncovered and the player can continue discovering other pairs.

Process training game (e.g. sandwich making) - the player is presented with a task that has a set of simple subtasks that need to be completed in a specific sequence. Once all subtasks are completed the main task is also considered to be complete.

For a social interaction simulation - the model of game mechanics includes a simple dialogue system, where the player talks with his character, asking about his day etc. Future vision is to actually include an option of a real-life communicator such as Skype or Facebook chat in here. The character's house will be decoratable, where the player will be able to change the appearance of predefined furniture according to his taste and also to fulfil the needs of patient (depending on the level of dementia). The available furniture options will be based around the games progression.

The progression of the game is defined by the time spent taking care of the player's character. There will be no penalties for not progressing through the game, as the game has to be relaxed. Progress will be visible by introducing additional gameplay scenarios and mini-games. The wider selection of furniture to decorate the house will be a slight encouragement to play the game more.

Game will have a feature of unlockable levels and add-ins (codes will received as learning rewards from progressing through the training course affiliated with IDO project). The add-ins will include purely cosmetic items, like furniture or wallpapers, and additional gameplay scenarios which will be described in the already mentioned training course.

Game art was developed over the course of discussion with specialists in the area and by showcasing the initial sketches to the affiliated parties. To not burden the player with complexity the patient characters and their environment in the game had to create a light and easy-going mood. To achieve the desired visual results the characters had to be more cartoony or stylized rather than real-

istic. The exaggeration of certain characteristics and color would help reach the wanted style. Having this in mind the first concept designs for the characters were made. Through feedback the conclusion was that the first designs turned out to be more like caricatures of the patients and would not set the desired look and mood of the game. With the second iteration of designs, the patient characters were looking cleaner, but their features still lacked character and lifelikeness. For the last concepts the patient character designs were reworked to look more human-like and emphatic.

The proportions of the characters were changed to look slightly more realistic also adding conspicuous facial features, and color. With the addition of animation, the patient characters will reveal their personalities, achieving desired look and feel of the game. Game art and character development timeline is shown in Fig. 1.

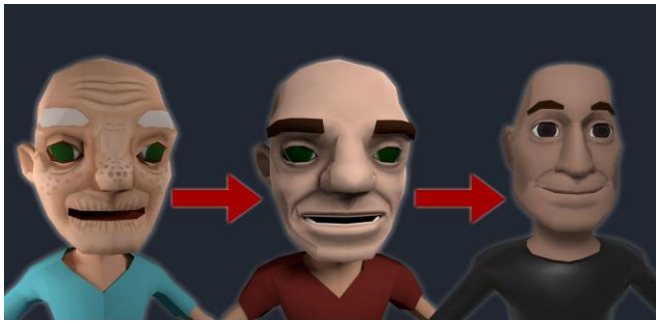


Fig. 1: Game art development timeline.

At first, the environment was designed following the same exaggeration of form and color as with the patient characters (Fig. 2). Having the diverse audience of the game in mind, the exaggerated style of the environment could cause certain problems. Stylized form objects could cause various interpretations for different people and might complicate the game. Using simple, realistic and clean object forms with bright colors helped achieve the desired mood without overcomplicating the environment (see a sample screenshot in Fig. 3).



Fig. 2: Initial style of the game environment.



Fig. 3: Final style of the game environment.

2.3. Implementation

The game's virtual interactive environment was designed for a universal, multi-platform game engine - Unreal Engine 4 [17], allowing maximum technical transferability and to run on mainstream and most affordable desktop and mobile platforms via a HTML5 compatible web browser, thus not requiring any expensive or specialist hardware. The game implementation uses the standard gameplay framework defined by Unreal Engine 4. The game implementation is based on game patterns [18]. All objects that exist in the game world are defined as actors the main one being the Game Mode actor which describes the rules of the game. Pawns are physical representations of Controller actors in the game world. Controllers can "possess" a single Pawn at a single time and passes on control commands. There are two types of Controllers - Player Controllers and AI Controllers. Player Controllers receives input from the player and processes this input to control its' pawn. The AI Controllers control the pawn with the game engine's artificial intelligence implementation.

Following Nagle [19], the serious game includes interactions of five components: Actors, Objects, Contexts, Behaviors and History. Actors (players) gain and develop their personal experience by playing and impersonating game characters. This is achieved by manipulating context (in our case, domain of dementia care), and objects within context. To successfully manipulate objects, the player must learn basic principles of care and apply them in a meaningful way to achieve success in game world. Actors can perform certain behaviors at any given moment of game play, however these behaviors are defined and constrained by objects, contexts and play history. History refers to a timeline of events and leads to enrichment of actor's personal experience through meaningful interactions in a game world.

The game is controlled and influenced by six main actors (Fig. 4):

1. Player Controller - it handles player input and controls player pawns. The controller is also used to interact with activity entities. Interacting with these entities guides the Patient Character to do the activities associated with them;
2. Character Creation Pawn - the player's representation during character creation. It presents the player with the character customization user interface and has a reference to the Patient Character to allow it's customization;
3. Game Pawn - the main pawn that is controlled by the Player Controller. This pawn is possessed after the player finishes customizing the Patient Character and also includes camera manipulation functions that the player could observe the game world from various points of view;
4. Patient Character - the pawn that represents the patient that the carer has to look after. This pawn's behavior is controlled by the AI Controller;
5. AI Controller controls the Patient Character's behavior, as mentioned before. It is driven by the game engine's artificial intelligence system based on behavior trees;
6. Activity Entities exist as actors that can be interacted with by the Player Controller and the Patient Character. An example of an Activity Entity is a couch. The player can interact with it during gameplay to tell the AI Controller to guide the Patient Character to the couch where the character can rest.

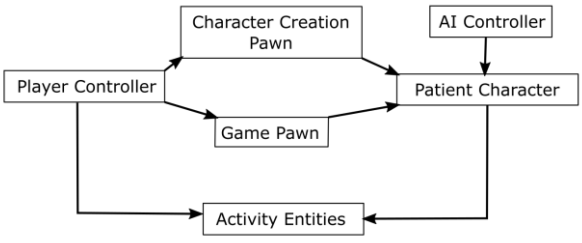


Fig. 4: Game's main actors and the relationships between them.

3. Evaluation

The initial evaluation was made in the Lithuania, Kaunas region, by surveying the people caring for their elderly parents (as it is quite common in Lithuania) as well as elderly persons themselves, both healthy and showing early signs of dementia. This evaluation involved the opinions of 10 carers (aged 40-65, age of parents 65-95), 10 healthy elderly people (age 65-82), and 4 elderly people with signs of dementia (age 75-95). Group of surveyed elderly were the same people carers supervised (their family members).

Quantitative System Usability Scores (SUS) [20] were collected. The questionnaire included evaluation of 10 items with one of five responses that ranged from Strongly Agree to Strongly disagree. The questions included evaluation of the perceived complexity, intended frequency of use, ease of use, the need for technical support, integration of functions, internal consistency, confidence of users and the need to learn before using the game. The SUS results (mean score and range) are presented in Table 1. The scores were good for carers and healthy elderly people, while for elderly with early signs of dementia mean SUS score was above average (larger than 68).

Table 1: Evaluation results

	Carers of elderly	Elderly people (healthy)	Elderly people (with early signs of dementia)
SUS mean	82	89	75
score (range)	(73–96)	(71–98)	(61–88)

4. Conclusion

We believe that the use of an ICT-based gamification approach as part the training package for dementia care will be beneficial for direct care workers involved in pilot testing under the following dimensions: a) improving their attitudes towards people with dementia and their family carers (most of all their level of empathy and understanding towards these users); b) improving their knowledge, skills and competences on dementia care; c) ability to reflect and change their daily work routines using inputs from best practices in dementia care.

The long term impact is envisioned as: a) improved satisfaction at work; b) actual application of best practices of dementia care in their daily work routine; c) improved quality of care provided; d) reduced caregiver burden.

The usability of the game was evaluated using System Usability Scores (SUS). The SUS scores were good for carers and healthy elderly people, while for elderly with early signs of dementia mean SUS score was above average (larger than 68).

The evaluation will be repeated once again, one the project progresses further-on, this time directly in the nursing houses of Portugal, Greece, Italy and Sweden. Medical personnel will be involved in the evaluation of the fine-tuned to confirm the findings.

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