Approaches of Participatory Design in the Design Process of a Serious Game to Assist in the Learning of Hospitalized Children

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Abstract. Although the literature shows initiatives of conception of serious game for the support learning of hospitalized children, generally, the design process stays on the draftsman responsibility, exclusively, being based on the initial requirements set-up. In this scenario, this article presents the design process of Three-Dimensional Virtual Environments (3D VEs), based on games, here considered as serious game, to assist in the learning of hospitalized children. The serious game is grounded in the Reference Model for conception of 3D Virtual Learning Environments (3D VLE) to assist hospitalized children [4] and counted on Participatory Design (PD) approaches. From the approaches of Contextual Inquiry (PD technique) with health professional, including the hospital class teacher, it was possible to identify the main needs and expectations related to the conception of a pedagogic, interactive and ludic tool that supports learning on children who stay long periods hospitalized. However, the serious game proposal can be extended to all the childish public interested in learning by means of serious games. In the next stage of PD process, we will apply the Mockups technique with the patient (children) using the prototype developed.

Keywords: Serious games · Participatory Design · Three-dimensional · Learning virtual environment · Hospitalized children

1 Introduction

Serious games are a category of interactive games, which allied to Virtual Reality (VR) and Human-Computer Interaction (HCI) have as purpose going beyond entertainment, because they offer a wide possibility of simulations of daily situations, for example, simulating critical situations that involve some kind of risks, as well as being

applied in human awareness about social problems. Serious games can be applied in many knowledge areas, as business, governmental, politics, engineering, health, among others [8].

However, one of the areas that had most benefit within the usage of serious games, mainly combining training and virtual education, is the health area [5, 6]. Several surgery procedure simulators based on games are being used by medicine students for virtual training, in order to reduce physical laboratory costs and accelerate the learning of students. In the context of hospitalized children, are found initiatives of Three-Dimensional Virtual Environments (3D VEs) conception, based on games, with educational purpose [1–3], once the long periods of internment interrupts the process of school learning and the social interaction between the children and their teachers and classmates.

Although the literature shows initiatives of conception of 3D VEs, based on games, for the support learning of hospitalized children, generally, the design process stays on the draftsman responsibility, exclusively, being based on the initial requirements set-up. In this scenario, this article presents the design process of a three-dimensional serious game to assist in the learning of hospitalized children. The 3D VE based on games, here considered as a serious game, due to its pedagogic proposal, is grounded in the Reference Model for conception of 3D Virtual Learning Environments (3D VLE) to assist hospitalized children [4] and counted on Participatory Design (PD) approaches.

Participatory Design (PD) offers techniques that favor the dialogue between designers and users, in order to build technology collaboratively [7]. PD is a method in which participants are invited to cooperate and interact with designers, researchers and developers during the design process. According to [12] "…they can participate during several stages of the creative process, e.g. they participate during the initial exploration, problem definition, and requirements elicitation, in order to help to define the problem and to focus ideas to get valid solutions. They also can contribute during development, aiding at the evaluation of proposed solutions".

In hospital context, the PD aids the designer to investigate and understanding the relation of the hospitalized children with the technology being proposed, starting with the collaboration of the own child and the health professional that live with the hospitalized children.

Following this introduction, the paper is structured in four sections, as follows. Section 2 presents the materials and methods used in the research; in Sect. 3 we show the interface design of serious game proposed and, finally, Sect. 4 focuses on the conclusions of this study.

2 Materials and Methods

Initially, we conducted a Systematic Review (SR) in the specialized literature, in order to answer the following research question:

- Which the main methodologies/techniques of Participatory Design are being applied in the process of 3D VE design with educational focus to the childish public?

The SR included three stages: planning, conduction and results extraction. In each stage the steps were aligned with the PRISMA [10] methodology. In the planning phase, the SR protocol was established, which includes the SR objectives, the research proposition, the keywords, the search strings combination employed on the research, the main database indication, the inclusion and exclusion of articles criteria and the procedures to be applied on the stages of preliminary selection and final selection.

To answer the research question, it was used combination of search strings, applying in the IEEE and ACM databases. Out of 220 works found during the SR conduction stage, 31 works were selected on the preliminary selection stage and 12 works were included on the final selection stage, the ones who seek to answer the referred research question. Figure 1 shows a distribution of the works included and excluded from Systematic Review.
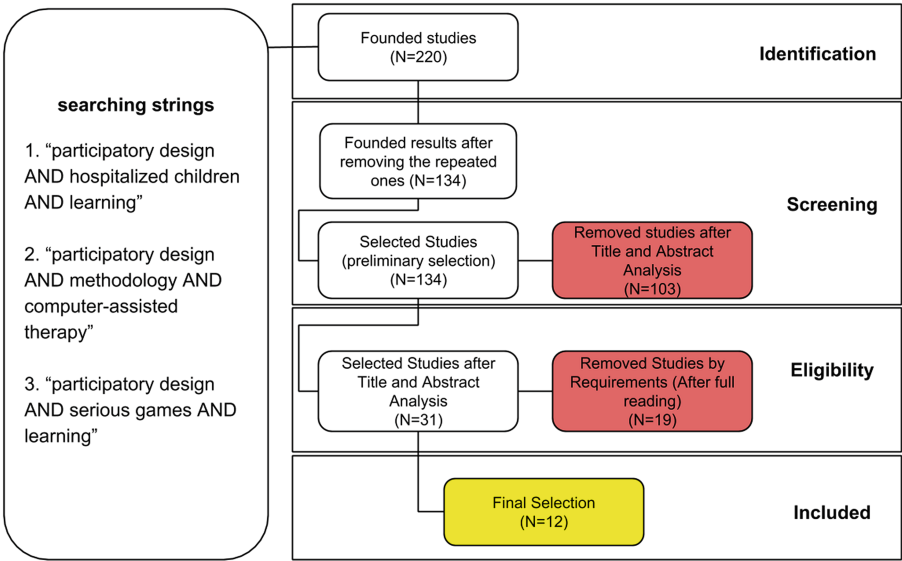

Fig. 1. Distribution of studies included and excluded from Systematic Review

From the results obtained with the SR, we could identify the main techniques that have been applied to conceive design project centered on the user, including the know-how of the interested parts and their needs. Table 1 presents the identified Participatory Design techniques and their main characteristics.

Considering the Participatory Design approaches presented in the Table 1, we select the Contextual Inquiry and Mockups techniques because they were the only techniques found in the SR that are applied in the beginning of the interface project development. The approach of successive meetings of Participatory Design follows the same principles of Contextual Inquiry technique. In sequence, the Sects. 2.1 and 2.2 present a brief description of the selected techniques.

Table 1. Classification of Participatory Design Techniques

Technique	Approach	Expected Results
Contextual Inquiry [7, 14, 15]	The interviewer observes and questions the user in his natural context of work (brainstorm reunions and interviews)	• Detailed understanding about the work process, contextualized in the users natural environment; • Needs assessments; • Suggestions from potential users
Mockups [7]	The interviewer observes what the users have to say through prototypes development in different levels of detail and fidelity.	• Production of prototypes in paper with the possible alternatives that meet the client requirements.
Cooperative Cognitive Course [7]	The interviewer applies a formulary with questions to be answered about the Cognitive Course of a determined activity that is implemented on the already prototyped interfaces.	• It is obtained an evaluation about the interfaces related to the learning facility and verifies possible design fails related to the requirements originally specified.
Creative Participatory Design [11]	The interviewer presents the prototype under testing and align with the ideation/brainstorming.	• Prototype' Refinement.
Successive meetings of participatory design [13]	Discussion, negotiation and exchange among stakeholders and real users.	• Creation of several products (documents, diagrams, prototypes, notes, etc.).
Creative Participatory Design [11]	Storyboarding, low-fidelity prototyping technique	• Users develop design concepts and ideas which are translated into design directions for the development of the game.

2.1 Contextual Inquiry

Contextual Inquiry technique consists on field interviews conducted with the final users in their real work context. In this study, the final users are health professionals and hospitalized children. The application of Contextual Inquiry involves the whole development team with the stakeholders through brainstorms reunions and interviews. The technique also foresees quiz applications with the users, in order to collect the maximum amount of possible data to be analyzed in the future. The Contextual Inquiry technique is based in four main principles[1]:

- Focus – inquiry planning phase, grounded on a clear comprehension of your intention;
- Context – observer the customer do their job inside his own workplace;

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[1] http://www.usabilitybok.org/contextual-inquiry.

- Partnership – dialogue to customers about their job and try to make they talk about any failures in the process;
- Interpretation – try to share with the customer an understanding about the aspects in the job that actually matter.

This way, applying the Contextual Inquiry technique includes a high reliability in the obtained information, considering that it focuses in the interfaces development totally geared to the needs and diversities of the final users.

2.2 Mockups

Mockup is a final prototype of the object to be developed, with the goal of testing, studying or sampling of its artifices. Usually, it presents all the components that will be part of the product final version in development by clear and objective ways, avoiding dual interpretation.

This technique counts on information collected by the developing team with stakeholders, seeking conception concepts, layout and/or content. Mockups are usually resulting processes of the Contextual Inquiry technique application, starting from the premise that the final product should to suit the users' needs, besides of foreseeing the users diversity and different everyday situations.

2.3 Application of Design Participatory in the Serious Game Proposed

From approaches of Participatory Design selected, the design process was divided in two steps:

- first step – we applied the **Contextual Inquiry** technique [9] that counted on brainstorm reunions and interviews with the project multidisciplinary team, involving computing and health areas professionals. The stakeholders contributed collaboratively with the game design process (defined topic, main characters and interaction strategies), considering the emotional/social state of hospitalized children and serious games native aspects. During this step, we identified the main characters role in the process of interaction with the child, seeking to improve their emotional/social state, beyond investigating how characters could motivate learning, even the children being in a situation of pain and fear.
- Second step – this step still will be applied to include the design practice centered on the child participation. The hospital team will select children that are hospitalized longer time (7 to 10 years), in order to have access to the serious game initial prototype. The register of interactions in the game will be realized through video recording, for posterior data analysis. In this step the game design process will count on another PD technique, **Mockups** [7], which notices what users have to say through prototyping in different detail and simulation levels. Participate on this technique the users of technology; in this case, we consider as users children/teacher. The interviewer (designer) observes the users during exploration on 3D VE. In sequence, the multidisciplinary team stimulate the children to express

their ideas and wishes drawing (paper prototyping) what they would want to change in the game, which scenarios they would like to discover in the next stages and which characters they would like to be part of the context.

3   Interface Design of Serious Game Proposed

Serious game proposed interfaces were designed considering the data collected on the Contextual Inquiry sections (first step). During the brainstorm reunions and interviews, we identified the necessity to develop a 3D VE to assist in the learning of hospitalized children who are kept away from the school routine for medical treatments.

Highlight the 3D VE here proposed, is grounded in the Reference Model 3E Virtual Learning Environments conception to assist hospitalized children [4], which predict the application requirements, the interaction strategies that can be applied in the VE and the human factors involved in the process.

We present below the main characteristics of the prototyped interfaces for the proposed serious game, which were designed with the participation of the health area team from the partner institution of this project (Hospital Universitário Julio Muller in Brazil). Therefore, the game is being developed only in Portuguese:

- in search of a 3D VE that combines learning, entertainment and socialization, it was proposed a 3D VE based on the following strategies of interaction: learning based on games and avatar;
- the serious game scenario starts in a hospital room, as observed in Fig. 2, which was modeled from interviews realized with the health professionals. Additionally, the development team personally met a room from the pediatric wing;

Fig. 2. Initial interface of the serious game (context hospital room)

- the child begins the navigation in the game selecting his/her own avatar to represent himself/herself in the VE. Through the avatar, the child explores the environment and interacts with virtual objects. Highlighting that by selecting the avatar, this one shows up dressed with a white coat, usually, used by health professional, in order to familiarize the children with the hospital team;
- given the diversity of users (children) that will play the serious game, the health team asked to be modeled avatars from different ethnicities (white, black and indigenous). This way, the game counts with six avatars, being a boy and a girl for each ethnicity (Fig. 3);

Fig. 3. Avatars for selection

- considering that hospitalization is not a trivial task for children, for carrying with themselves not only their sick body, but their costumes, routine and main characteristic: "playing" [16], the scenario for the curricular learning process happens in a square to bring joy, so named "Joy Square" (Fig. 4). The transition between the initial scenario (hospital room) and the square, occurs by an interface transition;
- in the first development stage of the serious game, the hospital class teacher suggested us to explore the following theme "Recycling and Environment", for treating an interdisciplinary subject, cover Mathematics and Science contents, propitiate the environmental awareness and include risky situations to alert the children about the presence "dangerous trash". The Math discipline was included in the interdisciplinarity because to progress in the game, the child needs, for example, in one of the game situations, to verify if the garbage bin still have space to throw the trash in. Each garbage bin has capacity for 10 units of trash and each kind of trash has its own units (Fig. 5).
- On request of the hospital class teacher, we had insert a non-playable character in the serious game (Lady Rose), who has the responsibility to collect the trash
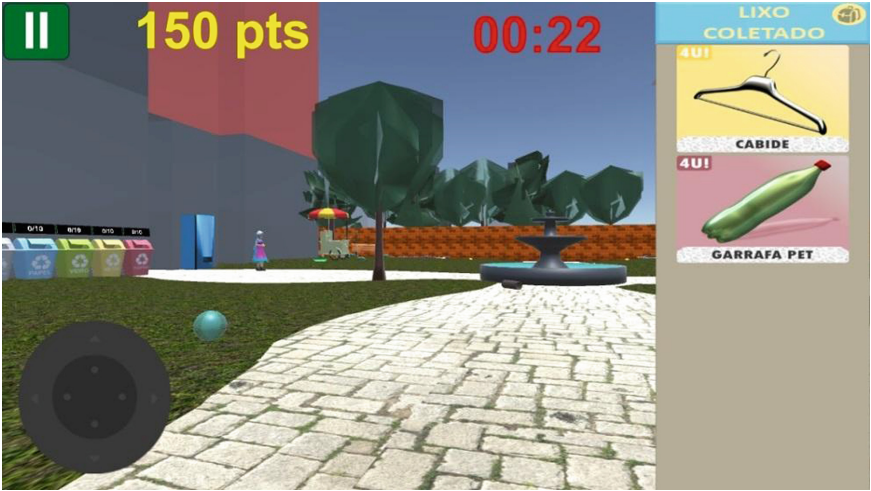
Fig. 4. Interface "Joy Square" (learning based on games)

Fig. 5. Interface with the garbage bin of the "Joy Square" to selective collect

considered dangerous for the child. Lady Rose executes the task to collect and put in the right garbage can named "dangerous trash", if she is called by the player (child). The player asks for the intervention of Lady Rose every time he/she encounters a dangerous trash and the alert siren is triggered in the VE. To ask Lady Rose's help, the player only needs to click on the character that is walking on the square (Figs. 6 and 7).

Fig. 6. Lady Rose (non-playable character)

Fig. 7. Lady Rose collecting "dangerous trash" (syringes, medicine, others)

- Other requirements were collected to the interface project during the PD technique application – Contextual Inquiry, such as the score system definition, type of environment sounding, format of the dialogues between player and non-playable characters, scenario composition and avatars appearance and caricatures that accompany the dialogues. The health professionals suggested for the dialogues to have an easy vocabulary for the expected age group, so it influences not only the reading but text interpretation as well, but also the understanding of the concepts related to the serious game "Recycling and Environment". Other two phases of the game, also related to the theme, were defined with the multidisciplinary team support.

4   Conclusions

From the approaches of Participatory Design with health professional, including the hospital class teacher, it was possible to identify the main needs and expectations related to the conception of a pedagogic, interactive and ludic tool that supports learning on children who stay long periods hospitalized. Therefore, techniques of PD enabled to develop a game designed closer to the hospitalized children reality and health professionals' needs.

However, the serious game proposal can be extended to all the childish public interested in learning by means of a 3D VE based on games.

The initial prototype was validated by the health professionals involved in the interfaces project. In the next stage of Participatory Design process (Mockups), we will include the patient participation (children) in prototype tests, as presented in Sect. 2.3, in order to seek the improvement of the serious game interfaces and its functionalities.

Considering the final users are children who are part of a generation that uses mobile and electronic devices since their early years, their participation during the serious game development is effective to produce consistent interfaces with the target audience interests, even before providing the game widely to the society.

We intend to apply the game in real situations of learning with hospitalized children, seeking to investigate the knowledge acquisition level acquired through the game, in order to validate the tool as a pedagogical instrument.

Finally, this study represents a relevant social contribution to the Health and Educational areas that use the 3D VE for different matters. For the Computer area, this study represents a reflection about the best practices of interfaces project of 3D VEs, as well as it identified the need of methodologies proposition grounded on PD approaches for the conception and evaluation of 3D VEs, specially, based on games.

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