Using Virtual Reality and Rapid Prototyping to co-create together with hospitalized children.

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Abstract. This study reports on a social project involving a collaborative process to co-create toys together with hospitalized children, using Virtual Reality, play practices and 3D Printing technologies. The project had two main phases: the co-creative process with the children and the production of prototypes based on the children's creative drawings. For the activities involving the children, static virtual reality environments were created to stimulate the children to draw. These drawings were used as reference for the design of 3D toys that then were printed in plastic. A positive effect of the experience on the children's behaviour was observed during the hospital routine procedures. Despite the technology required and considerably high cost for producing custom pieces with 3D printing, the project was executed successfully. This initiative shows the potential for practical interdisciplinary collaboration approaches between product design and health sciences.

Keywords: Plaything · Virtual Reality · Hospitalized Child · Cancer · Rapid Prototyping.

1 Introduction

Being hospitalized means to stay in an unfamiliar environment with unfamiliar people and to be subjected to routine therapeutic procedures that can be traumatic. Hospitalized children are particularly vulnerable. Fear and anxiety, feelings that are commonly associate with hospitalization, can result in emotional distress leading to negative consequences such as sleep disturbances and separation anxiety [1].

Play is essential for the neuro psychomotor and social development of children. According to Francischinell et al. [2], therapeutic play refers to practices indi-

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cated for children experiencing atypical life situations that can be life-threatening, among them hospitalization. Interventions based on play have shown to be beneficial for hospitalized children by reducing anxiety levels [3]. Koukourikos et al. [4] concluded that play is of high therapeutic value for hospitalized children from physical and emotional perspectives. Additionally, play-based occupational therapy has been shown to reduce pain, anxiety, and fatigue levels in children with cancer during hospitalization [5].

Technological developments have brought to light a resignification of the meaning of play. In the context of hospitalization, the use of computerized interactive virtual space has been shown to be effective in reducing depressive symptoms among children with cancer [6]. Additionally, Scapin et al. [7] found a effect of pain reduction in hospitalized children with burns.

3D printing technologies has brought new possibilities of prototyping customized objects. Silva et al. [8] reported the development of a customized upper limb prosthesis for a child using 3D scanning and printing through interdisciplinary collaboration between product design and rehabilitation, as part of a Brazil-Norway project on assistive technologies [9].

This paper describes a collaborative project named CODI (CO-creation and DesIgn) where toys were co-created together with hospitalized children, combining play, virtual reality and 3D printing.

2 Methods

This study reports experiences with introducing practices of playthings in the care of hospitalized children with cancer. This section describes each of the activities and the role of each task. The hospital activities lasted five days and the entire project took approximately three and a half months. The structure of the project and the activities are presented in Fig. 1.

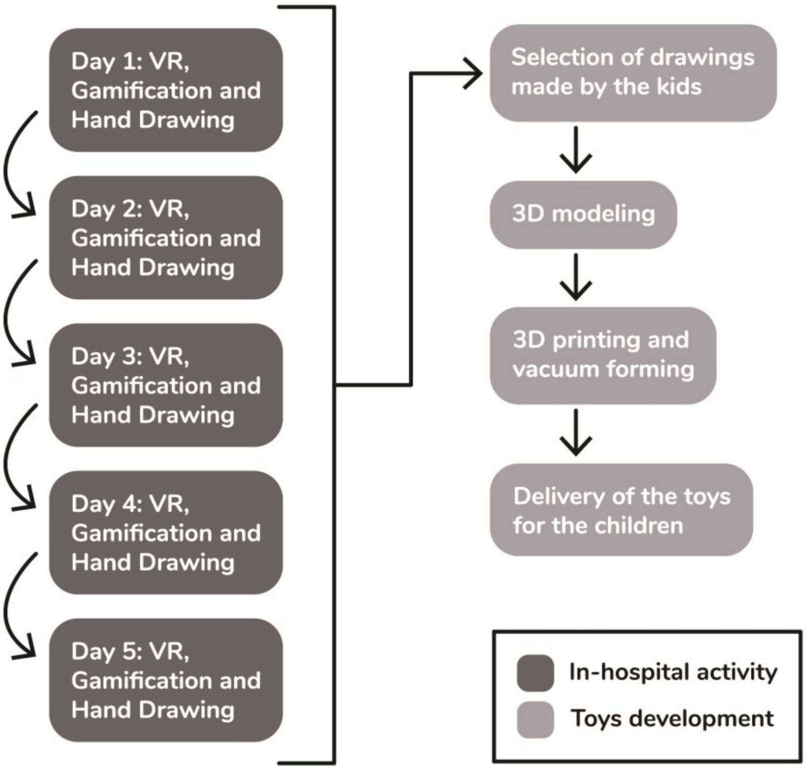

Fig. 1. Main project activities.

2.1 Participants

The project was carried out in the pediatric oncology ward in the childhood cancer hospital in Sorocaba. A total of twelve hospitalized kids participated with permission from parents or guardians, of which Due to the sort time to execute the project, only three were selected to have their drawings turned into toys. Their ages were eight, nine and fifteen years old. There were two boys and one girl. None of the children knew about the entire process, it was told for them that was a project with virtual reality and hand drawing, so no expectation or frustration would be created, the delivery of the toys was a surprise.

2.2 Procedures

2.2.1 Virtual Reality and Hand Drawing

VR technology was used during all the sessions as a distraction and relief from the hospital environment. However, the main purpose of this activity was to guide themes for hand drawings that the children were asked to produce after using the VR headsets.

The virtual reality experience was achieved using a low-cost smartphone VR solution (VR Box). The immersive virtual environments were selected using the following predetermined requirements:

1. No sudden movements to avoid nausea (VR sickness). These children may be particularly sensitive due to chemotherapy.
2. Each session was limited to ten minutes to reduce the risk of nausea (VR sickness). The time was reduced to two minutes to ensure that there would have no side effects.
3. No horror or frightening virtual environments were used as the purpose was to provide a positive and uplifting experience.
4. Different videos was used each day to achieve variation, to guide the theme for the drawings and to control the theme for the drawings.

Usually, the most popular 360º videos on the internet are related to roller coasters or horror movies, making it hard to find videos for kids that fits the requirements and also it was not guaranteed that the internet would work at the hospital. It was therefore decided to create static virtual reality environments using cubemaps (the environment represented by the 6 surrounding planes in a cube) that were converted to equirectangular images that are used with VR glasses. Three different environments were created using this technique: 1) a room in which the children was told belonged to friendlymonsters. The children were then asked to draw the monster who lives there and to put it in an empty picture frame on the wall; 2) a space scene where the children were asked to draw whoever they think lived on one of the planets; and 3) the bottom of the sea were the children was asked to draw something related to that theme (see Fig. 2). Children experiencing the immersion in virtual reality is presented in Fig. 3.

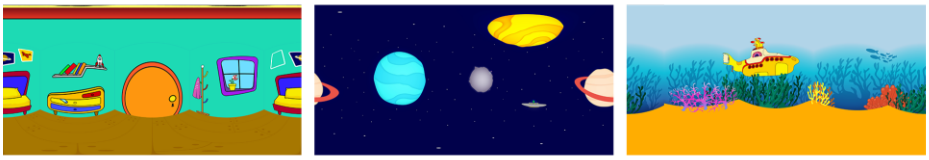

Fig. 2. Child-friendly Immersive 3D environments: room (left); (b) space (center); (c) sea (right). Source: authors.

Fig. 3. Hospitalized children experiencing immersion in VR. Source: authors.

2.2.2 Gamification

Gamification was used to motivate the children by keeping the children's interest in the activity. Due to health conditions, they may not feel well and thus lose their urge to participate in the activity.

The sequence of videos was used as levels, starting with static environment and then 360 degree animations. As a reward, the basis of a medal was created using MDF (Medium Density Fiberboard) and the design of the medal was divided in four pieces of stickers (Fig. 4). At the first day, the children received the basis of the medal, in the following days they received a piece of stickers and, at the end of the week, they would receive a final medal with the text "MINI DESIGNER" representing a gamification badge. The environment was also created using colorful clothes, to symbolize something good that was outside the hospital.

Fig. 4. Medals as gamification rewards.

2.2.3 Hand-drawing and Modeling

After the week at the hospital, three drawings were selected. Fig. 5. Shows the three drawings, namely a rocket (the eight years old child), a spaceship (the nine years old child) and a marine turtle (fifteen years old child).

Fig. 5. Children's hand drawings selected for prototyping.

The software ZBrush (Pixologic Inc., United States) was used for the 3D modelling of the drawings following the exact shape that the children made, to make them feel that the drawing had actually become a 3D object. The children were also asked to sign their drawings and their signature was modeled at the bottom of the toys, to show who were the creator of each toy.

The 3D objects were created with the same view of the drawings and the other parts were based in real objects and animals to give the complete shape for the toy (see Fig. 5).

Fig. 6. 3D models based on the children's drawings.

2.2.4 Toy Production

A 3D printer (Builder Mega 2, Mousta, Brazil) based on FFF (Fused Filament Fabrication) process was used for creating the final toys (Fig. 6), using ABS (Acrylonitrile Butadiene Styrene) filament. This is a thermoplastic which is not associated with any adverse health effects. This material is also used in the toy industry.

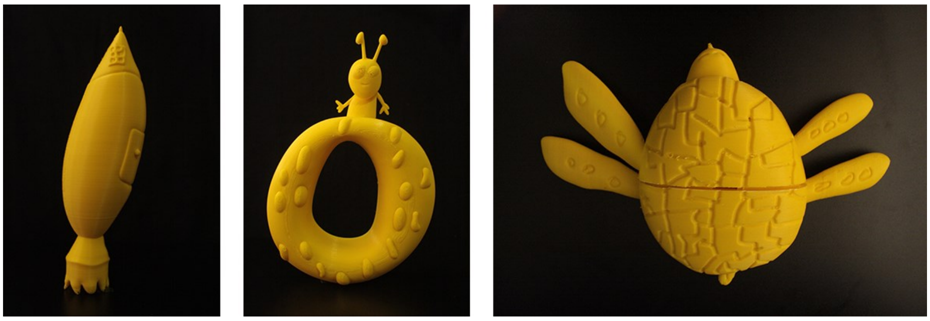

Fig. 7. 3D printed toys.

Previously it was determined that the largest dimension of each toy would measure 20 cm (7.88 inches). The rocket was 3D printed in one piece due to its simplicity. To ensure the best printing quality, the marine turtle was divided in six pieces, in that way the details of the face, paw, shell and the children's signature were all printed in different directions and positions that would guarantee the quality of the details.
The spaceship was the most laborious to print due to the fragility of the alien and also because of the transparent cabin, that it was not possible to print since ABS is not

opaque. The cabin therefore would covered the alien, not following exactly the drawing. To solve those problems, the alien was first separated from the spaceship so if any parts of it breaks it would not be necessary to print another large spaceship which require much 3D printer filament. The alien was printed in several pieces in case it would break. This is a fragile toy for a child which may encounter rough handling. The thinnest parts were the neck, arms and antennae, they were thickened in a way that would not be different from the painting and to ensure robustness. The final alien was printed with the back to the floor so the layers stand vertically when the alien is inside the spaceship. The direction of the layers were crucial for the strength of this part. Horizontally, the thinnest parts were breaking between layers, vertically, the parts were still thin but harder to break. Since it will be inside the protective cabin, it may not be break so easily. The direction of the layer were chosen to improve robustness.

To solve the problem with the spaceship cabin, it was decided to use a milling machine (Roland MDX540) to make a bipartite mold of the piece and then use vacuum forming to make the cabin with the polymer PETG (glycol-modified polyethylene terephthalate) that is transparent, resistant and easy to form. The mold was made of wood and MDF (Medium Density Fiberboard) which was covered with body filler to be used at the vacuum forming so the mold could be used more than once and the MDF would not mark the PETG. The mold was sanded with 80, 100 and 220 sandpapers, the sides of the molds were sanded together to ensure that the two parts would close. After the vacuum forming process, the two pieces of PETG were glued together and sanded. Fig. 6 illustrates the production of the spaceship cover.

Fig. 8. CNC machining and vacuum forming processes used to produce a transparent spaceship cover.

Final decorations were performed with water based ink only and varnish to protect the paint and guarantee that any of the materials would not be toxic or cause damage or pose any health risk to the children. All the processes and materials used during the project were selected specifically considering the potential risk to the children.

3 Results and Discussion

By observing the toys produced from the primary drawings made by the children and which resulted from the production processes, we can conclude that the goals of the project were successfully achieved (see Fig. 7). The final toys proved to be a precise and playful representation of the designs originally made by the children. But, most importantly, the ludic experience of VR, hand drawing and gamification was shown to be a unique and very positive experience for the hospitalized children undergoing chemotherapy as they got a brief escape from the hospital environment and its routines. Experiences of play have been reported to benefit hospitalized children from both physical and emotional perspectives [3-5]. The toys were handed over to the two boys. Unfortunately, the girl passed away during the development of the toys (see Fig. 8).

Fig. 9. Final version of the toys and their respective drawings made by the children (above); children's signature on the toys (below).

Fig. 10. Children receiving the toys based on their drawings.]

Virtual reality seemed to please the children and in some cases it was possible to note that the children seemed to react differently to needles when they were wearing the VR-headsets with lesser manifestations of suffering and pain compared to when they were not experiencing immersive VR environment. Benefits of this practice were also reported by the children's mothers. These observations agree with the findings by Li et al. [6] and Scapin et al. [7].

Gamification helped the children participate and engage in the activity. With hospitalized children, it is not only the motivation that determines their participation or not, but also how they are feeling in the very moment. During some days, there were children that could not participated because they were not feeling well because of the chemotherapy.

This project is part of a Brazil-Norway collaborative project on education, research and development of interdisciplinarity approaches to Product Design, Health, Rehabilitation and Rapid Prototyping technologies [9]. Other results from this initiative have been reported in contexts of universal control for smarthomes appliances [10], text entry adaptations and keyboard layout for improving typing efficiency [11-14], and strategies of empathy development for inclusive design [15].

4 Conclusion

This paper reported a social project based on collaborative design, play practices, virtual reality and prototyping of toys for hospitalized children undergoing chemotherapy. The most important conclusion from this project refers to the relevant benefits that play practices and the experience of immersion in virtual environment can bring for hospitalized children by simply experience something different and fun. Ultimately, engaging hospitalized patients in such experiences may represent an escape from the reality of a hospital routine. Reports from the nursing team and children families support this finding. Furthermore, the use of technologies of 3D modelling and printing allowed the production of precise representations of the children's drawings as real toys. Based on the potential benefits that can come from collaborations between the areas of Product Design and Heath, initiatives similar to the one reported here are therefore encouraged.

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