A Virtual Reality Simulation for Children: Build and Create from the Perspective of a Toy Figure

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***Abstract*— Despite current (commercial) efforts to employ VR in educational and pedagogical contexts with children, the amount of topic-specific research leaves a lot to be desired. For example, no guidelines exist concerning the design or the application for this target group. Furthermore, there are no findings about health effects or potential benefits or issues. With this paper, we present an application, a toy brick construction simulation, which had the aim to adress some of these questions. The article describes the concept and first explorative evaluation, which was realized by conducting an expert interview with an experienced toy researcher. The presented findings should serve as hints concerning potential pedagogical benefits, effects and design aspects and be a basis for future studies with children. Furthermore, we hoped that they will incite discussion and promote research about the use of VR with young children.**

I. Introduction

Technological developments and a growing public interest have allowed immersive technologies like virtual, augmented and mixed reality to find entrance in numerous areas of social life. Besides applications for industrial, military or other professional purposes, there is also a growing market for gaming and leisure products. However, headlines like "Mattel and Google unveil virtual reality headset for kids“ [23] or projects like Google Expeditions clearly show that not only adults, but also (young) children are confronted with new technological possibilities. Yet, there is almost no research about the use of virtual reality (VR) by children [3], [16]. With our simulation, we wanted to have a closer look into questions related to the design and applicability of VR for this target group. A systematic research on this topic seemed necessary to us, as VR will sooner or later be accessible to many children [5]. We implemented a VR game that allows to create brick-based constructions from the perspective of a toy figure. As no clear guidelines for the design of VR applications specifically for children exist yet, we built upon related pedagogical research findings. The target group of the simulation is, above all, children in the elementary school age, whereby, concerning playing with blocks, there appears to be no age limit. The goal of the application was to promote creativity and movement and thereby offering not only entertainment, but also a pedagogical value for children.

The following section will briefly describe our reasons for using VR. Afterwards, the current stage of the research concerning children and VR will be presented. Section IV describes the concept and the implementation of the simulation, as well as the playing experience. Section V summarizes an expert's opinion of the simulation. Finally, the results are presented and discussed.

II. Why Virtual Reality

One reason for us to resort to VR was that it allows the user to discover realistic scenarios in a simulated environment. Thus, it offers new experiences that would not be possible otherwise. Especially the change of perspective is hard to achieve for young children in physical reality. Yet, it is an important developmental task. Furthermore, children now grow up multi-medially [5]. Their access to media has changed compared to previous generations and media play a central role in their life. Therefore, it is also sensible to make new concepts accessible to younger children to train their competences in handling technology and media. Clearly, specially designed environments can better direct this process than unsuitable or unsupervised random access. The third reason was that VR offers the possibilities to playfully train important skills [2]. Especially motoric abilities and processes have successfully been taught by using immersive VR. This was important to us, as we wanted to create something that bears some kind of pedagogical value. Overall, it therefore seemed a reasonable decision for us to work on a VR application for children.

III. Related Work

The use and effect of VR for children has not yet been sufficiently investigated [15]. Nevertheless, there exist some empiricial findings, which could at least be regarded as relevant or transferrable. A literature review by Bailey and colleagues concerning immersive VR and children presents several examples for the use of VR to teach preventive measures (i.e. concerning smoking or pedestrian safety) or to train certain skills [2]. It has also been shown that children can learn certain skills such as coordination or fine motor skills playing computer games [6]. So-called active video games (AVG), where the players are forced to physically interact with the game, using arms, legs, or their whole bodies, have even been shown to increase the energy expenditure of children (19 studies, children under 18 years) [22]. Additionally, the results suggested that AVGs can improve the activity level of kids in general. Although these were not specifically obtained for VR applications, it seems likely that similar effects could occur in VR as well. According to [18], studies show that by considering activities in VR, self-efficacy and behavioral change are catalysed by the user, such as the increase in physical activity. This supports the assumption that the results concerning AVGs could indeed be transferable to VR and children. Creativity is a core resource for problem solving [19], and both are directly linked [20]. According to [9], virtual reality environments (VRE), which incite imagination and offer immersion, are good tools to train problem-solving abilities and thereby creativity. When entering a VRE, non-existant objects and processes can only be fully understood due to the immersion, that challenges one's imagination. E-Teatrix, a software offering users the opportunity to tell and participate in stories, shows that supporting creativity by means of VR is possible [21]. It allows children to express their thoughts and feelings and thereby fosters their creativity and imagination. All of these examples show that VR can or could be used in a pedagogically valuable way by children. Beside all these positive aspects, there are also some concerns. As children, compared to adults, are experiencing VR as more realistic, the influence from the application is more intense to them [2] [15].This leads to the fact that applications for children must be carefully examined concerning what is presented and how it is presented. For example, there are ongoing discussions about the violence in video games and their impact on children and adolescents [14]. However, as the degree of influence is comparably high in immersive VR, especially negative experiences need to be prevented because of their potentially harmful effects [2]. At the same time, inherent values or role models need to be double-checked due to their potentially high impact.

Fig. 1: Inside the VR simulation, the user's perspective is scaled to the size of a toy figure and his or her forearms are rendered using a toy figure model.

(a) (b)

Fig. 2: (a) The user can use the touchpad to teleport through the room. The blue pointer indicates the target position. (b) A view of the virtual children's room, taken from atop a sideboard. Allowing the figure in the foreground to reach the floor is the exemplary pre-defined task.

IV. Methodology

In this section, the concept and implementation of simulation—the subject of the evaluation—will be described.

A. Concept

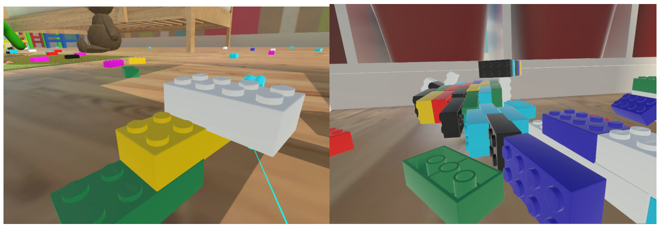
The simulation allows the user to collect toy bricks and use them to freely create constructions. Such constructions can further be used to solve tasks—both self-imposed or pre-defined—such as overcoming obstacles or reaching certain areas. As, according to [7], it is best for the cognitive abilities to gain experience through playful learning, the focus was to achieve a high fun factor. Furthermore, we want to enable the user to make experiences from a new perspective, in our case the perspective of a small toy figure.

B. Implementation

The simulation was implemented as a room-scale VR application in Unity3D using the HTC Vive VR equipment comprised of one spatially tracked, stereoscopic head-mounted display and two equally tracked 3D input controllers. It allows the user to freely move through the virtual space and to interact with basic hand gestures. To support immersion in the game world, we strived for a realistic environment. Great value was also placed on a realistic scaling of the user's avatar (Figure 1) and the bricks, modeled close to real life proportions of comparable commercial toys. A teleportation mechanism, where the user can point at a destination and reposition himself in the virtual world (Figure 2a), is used to work around the limitations of the actually available physical space. It is possible to teleport while holding (assembled) bricks. Toy bricks are available in different sizes and heights and can be connected according to the placement of the studs, at angles of 90° or 180° (see Figure 3). The user can pick up and carry bricks by first touching them with the controller and then pressing and holding the side buttons. When a grabbed brick touches another brick, the closest valid assembly configuration is previewed and both bricks are joined accordingly upon release of the side buttons (Figure 3). As we make use of Unity3D's physics simulation, basic physical relationships need to be taken into account to create stable constructions, see Figure 4.

C. Task Definition

The simulation was implemented in a generic way to allow the simple realization of pre-defined tasks through additive



(a) (b)

Fig. 3: (a) Different ways to assemble bricks. (b) Partially assembled and randomly spawned bricks of different color.

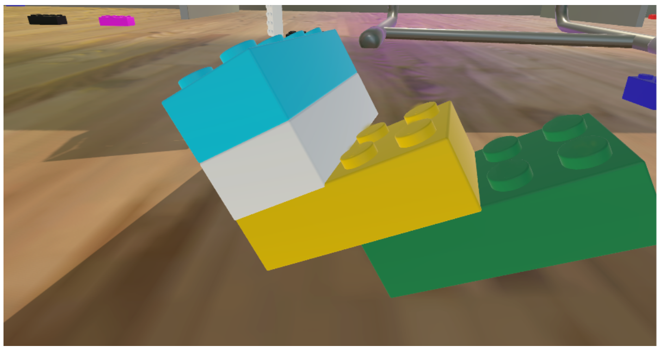


Fig. 4: Physical laws must be taken into account when building, so that structures do not tip over.

level loading and based on generic brick definitions. Bricks of variable shape and color and in different amounts can be spawned from configurable volumes, allowing varying starting configurations. For this paper, 240 bricks are spawned randomly in the room. The player may always pursue self-defined tasks and problems, such as building a stable house of a certain size. A single pre-defined task was added, where the user must rescue a non-playable toy figure (Figure 5).

V. Evaluation

The simulation was evaluated by an expert in the sector of toy research. In his field, he examines the potential benefit of toys for children, based on various criteria like functionality, stability and educational value. The latter can include the possibility to foster motor skills, balance, skills on social and emotional levels, cognitive abilities, awareness and problem solving. All of this is considered in relation to the suitablity for the developmental level of the child.
The decision to evaluate the simulation by conducting an expert interview was based on several reason. First of all, considering the preliminary state of research in this field, the inculculable effects on children made it questionable for us to employ other methods like oberservations or interviews right away (e.g. danger of high degree of motion sickness). Additionally, if we had decided to pursue empirical tests nevertheless, parents or children could not have easily been recruited as participants without the assurance of a qualified preliminary evaluation. Eventually, the lack of knowledge on this topic in general made it appear sensible to rely on expert knowledge in order to gain inital high quality results.

Fig. 5: Construction of a staircase to the toy figure. The player holds a blue brick in his right hand.

These could then lead to more focused investigations afterwards. We thus discussed our simulation in a semi-structured interview with the expert. The following subsections will summarize the results.

A. Evaluation of the Simulation as a Toy

The expert confirmed that the simulation fulfills many criteria that would be expected by a valuable toy. According to him it offers fun, excitement or even relaxation, self-control, the possibility to experiment and to sink into the play activity. He also emphasized that the game world is quite open, has no violent content, and with little feedback from the game, no correct or wrong behavior is declared. Concerning the character of the simulation, he did not rate the simulation as a pure construction game, since it also ”offers the possibility of a fantasy game”. This is supported by the demarcation from reality. Compared to conventional block toys, however, haptic feedback and the training of fine motor skills are missing according to his assessment. Furthermore, he rated intuitive functionality—to have as little unintended side effects as possible stand in the way of effortless creation and play—as a crucial point. He regarded the current state of the interaction as partially cumbersome and suggested it to become more intuitive.

B. Adequacy for Children

The assessment of whether the simulation is child-friendly depends on the age of the children. The expert considered the simulation to hold a great fascination, but at the same time to be extremely demanding. He believed that this high level of demand could displace other playing activities. In addition, he was not sure whether the simulation is playable for children on their own. As the real environment cannot be perceived by the player, there is a certain risk and the usability could be too complex.

C. Promotion of Movement and Creativity

The possibility to use the simulation to promote the motor activity of children was emphasized by the expert as a welcome side effect, especially the realistic movements, for example bending to pick up stones. In his opinion, this supports the immersion in VR and into the playing activity. However, he did not regard this aspect as a central point of this simulation, because the movements are neither excessive nor expansive. He saw greater potential for the simulation in the possibility to foster creativity and problem solving. This could be stimulated in the simulation by providing specific goals, like building a staircase for the figure. Furthermore, creativity could also be stimulated by the open world and the possibility to experiment. Due to the high-demand character, the user could have the desire to try out something, to test what works and what does not. In conclusion, for him, the simulation offered a great opportunity for creative behavior and flexible thinking. However, he wondered about the longevity of the motivation to use the simulation. This could dependend on the offered variety, for example introduced by new contents or changes in the functionality.

D. Personal Conclusion

The expert liked the idea and implementation of the interactive simulation. He also agreed with our opinion that children will have access to this technology sooner or later. Further, we expect that if there is a market, the industry will develop such software. To evaluate the effects on children and their development, he regarded an interdisciplinary approach – including experts from the computational, pedagogical and medical field – to be essential. The hereby presented results of the conducted expert interview support our claim to make a suitable and pedagogically valuable simulation for children. Nevertheless, to confirm these results, a study with children seems inevitable for us.

VI. Conclusion

Different potential benefits of a VR application for children, like fostering creativity or motor activity, were identified and potential risks and points for improvement were discussed. The results of our evaluation do not contradict our hypothesis that the simulation presented in this paper may be regarded as a pedagogically valuable and suitable toy for children, and thus, VR in general. However, two main limitations of our study need to be considered at this point. First, we did not evaluate our simulation with children. This is absolutely necessary to confirm or refute our results and to discover other aspects of the simulation. Second, the employed HTC Vive hardware is designed for adults. Thus, functional aspects, like the handling of the controller and the headset size, could not be considered as well. Further research has to be conducted, not only concerning our simulation, but concerning the topic of immersive VR and children as well. Questions need to address topics like possible health effects or risks, potential benefits, design guidelines or adequate research methods. In our opinion this has to be done by an interdisciplinary approach, including experts from a variety of different fields. We hope that our results were able to stimulate further debate about the topic of VR and children and that we could make a small contribution to this current research gap.

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