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Puzzle Playground – Teaching VR Interactions Through a Puzzle Game

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Abstract. In recent years, it has become clear that modern education is not currently equipped with the proper tools to fully support remote teaching. Virtual reality (VR) has the potential to make remote education viable in the future. Nevertheless, many teachers and students lack experience and familiarity with this technology, which poses a challenge to its adoption in education. In this paper, we introduce Puzzle Playground, a game that builds familiarity with VR by teaching object interactions through puzzles in an interactive experience tailored for educators. Players gradually learn VR interactions by completing various puzzle levels. A preliminary user study indicated that people who learned with Puzzle Playground grasped VR interactions faster than those who learned with printed or visual methods.

Keywords: Virtual reality · Interaction techniques · Educational technology

1 Introduction

Recent efforts to modernize educational tools in classrooms with novel technologies have brought a resurgence in interest in virtual reality (VR) for education. Although VR is a promising technology, educators have remained inexperienced with it, which is a major roadblock to its adoption in this context.

Many VR applications employ similar interaction and control schemes, making it easier to switch between them. Nevertheless, the initial hurdle remains: people with no VR experience struggle to understand these mechanisms during their first tries. By overcoming this difficulty, they can acquire a solid foundation that prepares them for using a wide variety of VR applications in the future.

The contribution of this paper is twofold: (i) we identify the common basic interactions and controls in most VR applications, and (ii) propose *Puzzle Playground*, a very accessible game designed to introduce inexperienced VR users to

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interaction mechanisms. Preliminary evaluation of the game suggests that the learning retention and performance of its players is higher than that of other participants, who learned with either a written explanation or a recorded video.

2 Related Work

VR continues to develop, extending its applicability in many domains. Medical applications, for one, can significantly benefit from VR [7,13]. Moreover, many other application domains show promising enhancements with such technologies, including simulating military battlefields [11], learning physics [3], assisting surgery [11], and conducting medical simulations [10].

Specific to VR in education, there are several surveys available analysing recent research [1,9,12]. Elston et al. [4] try to address this issue by giving general guidelines to teachers adopting VR for medical education. Holly et al. [5] discuss how to design VR experiences for teaching.

Apart from general guidelines, Carpenter et al. [2] discuss the readiness of such technologies in education. Furthermore, they point out, from their survey, that a limiting factor is teachers' familiarity with the technology and the lack of training material.

Specifically for interactions in VR, a few attempts have been made to facilitate the user experience and their learning curve. Yang Li et al. [8] provide an analysis of gesture interaction in VR, covering the classification of gestures and input devices to enhance the user experience in VR environments. Users may be helped in understanding these gesture interactions with smart visualizations. For example, Xin-Yu Huang et al. [6] used fingertip tracking and a first-person perspective to facilitate interaction between users and game objects. Still, no evaluation was performed to assess if fingertip tracking could assist users in becoming familiar with VR.

In conclusion, while the potential of using VR in education is enormous, user familiarity remains a problem and hinders the practical inclusion of VR in educational settings. This paper addresses this gap specifically for VR interaction.

3 Game Design

We designed and developed Puzzle Playground, a first-person puzzle game in a sandbox playground centered around common VR interactions. It consists of several levels, each with a single objective to complete. For each level, players learn one VR interaction type and must subsequently apply it to solve the task at hand. The levels' setup allows the players to make mistakes and easily recover from them, encouraging them to explore the interactions until they have fully mastered them.

As the game is aimed at beginners, the number of interaction mechanisms is kept small. Based on the most popular VR games and applications, we identified the following interaction categories as the most important to learn:

- *grabbing and displacing* objects
- *rotating* objects
- *scaling* objects
- *bringing distant objects into your hand* (informally known as 'tele-grab')

The introductory levels present one of the four basic interactions above, and are expected to be easy to complete. Since the players are introduced to the mechanics one by one, they can fully focus on each learning objective. The challenging levels test players' skills by requiring them to combine multiple interactions to complete the level. These levels reinforce and deepen players' skills through repetition and recall in different contexts.

Every level contains instructions in the form of floating UI elements, with helpful explanations on accomplishing the interaction(s) needed for the level. Therefore, players of Puzzle Playground also get familiar with how to interact with basic UI elements.

3.1 Game Environment

The game scenario is a stylized kindergarten environment. This environment is beneficial for the learning objectives due to two reasons. First, a kindergarten creates an analogy to the inherent learning experiences associated with early education. A kindergarten is typically the first educational institute. The goal of Puzzle Playground is to educate inexperienced players on interactions in VR. A concrete example is stacking blocks to practice grabbing and moving objects. Stacking blocks is a typical activity in a kindergarten, thus players who understand the analogy could intuitively start stacking blocks. Second, a kindergarten has the benefit of being a fairly simple environment. This reduces distractions for the player, as opposed to being indulged in a more thrilling environment, which might then drive attention away from the puzzles and the learning goals.

To focus on interactions, there are no navigation mechanisms, meaning that the player can not move around the environment.

3.2 Level Design

The game consists of six levels, with one elementary puzzle per level. This section will explore and justify each level's design in depth.

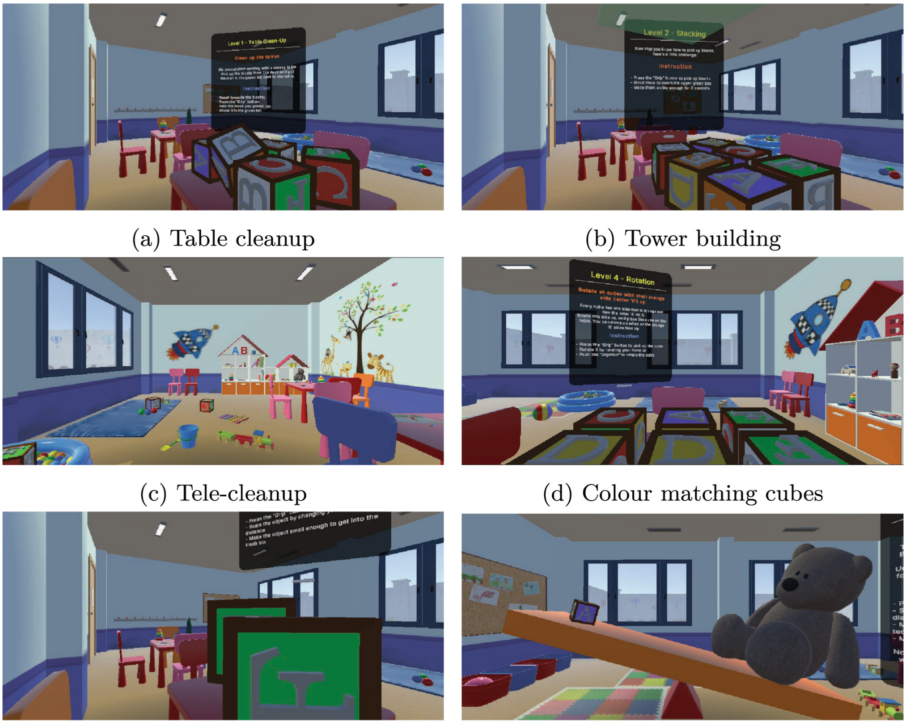
Out of the six levels, two are dedicated to picking up and placing objects: one to introduce the player to the interaction and another to complement with a more precise placement of objects. These two are followed by one level dedicated to grabbing distant objects ('tele-grabbing'), as it is similar to regularly grabbing objects.

Grabbing and tele-grabbing are the interactions that are most likely to be included in a VR game or application. Therefore, the first three levels at the start of the game are dedicated to teaching these mechanisms.

The following three levels focus on less popular interactions, that may occur less often in games and applications, but are nevertheless very helpful in a interactive classroom setting, e.g. to better visualize or appreciate an object or phenomenon. The fourth level introduces object rotation. Two options are available to the player. They can either use the orientation of their hand to rotate an object they are holding or use a stick on a VR controller to rotate it.

Finally, the last two levels introduce object scaling. The player learns how to enlarge and shrink objects via gestures. All levels are further detailed below.

Table Cleanup. This level introduces grabbing, moving and dropping objects. The player sees several blocks on a table. The goal is to tidy up the table and put them in a bin next to the table. The start of the level is depicted in Fig. 1a.



(a) Table cleanup (b) Tower building

(c) Tele-cleanup (d) Colour matching cubes

(e) Scale down (f) Scale up with mass

Fig. 1. Current game levels of Puzzle Playground.

Tower Building. This level helps players master the basic grabbing interaction of the previous level by requiring more precision to complete the objective.

The player starts in front of the same table with blocks, as before. The task is to build a tower taller than a given threshold, indicated with a green-tinted transparent plane. The final tower must stay stable for a few seconds after the player releases the controller grab button. The start of the level is depicted in Fig. 1b.

Tele-Cleanup. This level introduces the 'tele-grab' mechanic, which players can use to pick up objects too far away to be reached with their hands. Teaching this interaction early makes it easier for players to recover from mistakes at later levels, e.g. pick up an object without crouching, if they dropped it. Similar to the first level, the objective is to put a set of cubes into the bin to the right of the player. However, this time the cubes are scattered on the floor, out of the player's reach. The start of the level is depicted in Fig. 1c.

Colour Matching Cubes. This level introduces rotation, a new interaction for grabbed objects. The cubes on the table have six differently coloured sides; initially, they show a random side facing upwards. The objective of the level is to rotate all cubes so that they all show the same color facing upwards. Asking the player to rotate multiple cubes, should help remember how to use the rotation. Additionally, since the rotation is randomized, the player should not get bored with this repetition. A possible start of the level is depicted in Fig. 1d.

Scale Down. This level introduces the scaling interaction. Comparable to the first level, the task is again to place all blocks into the bin, but the objects are now oversized. So, to fit a block into the bin, the player must first scale the block down, by simultaneously grabbing it with both hands and then moving their hands closer together. Using a setup similar to the first level helps the player focus on the interaction. The start of the level is depicted in Fig. 1e.

Scale Up with Mass. This level focuses on scaling objects up rather than down. The player is challenged to solve a simple physics puzzle: flipping a balance scale with a heavy object on one side and a lighter one on the other. To flip the balance to the other side, the player has to scale up the smaller object, and place it back on the balance scale. The start of the level is depicted in Fig. 1f.

4 Game Implementation

Puzzle Playground was implemented in Unity Engine[1], using OpenXR[2] and the XR Interaction Toolkit[3], which includes the grab and tele-grab interactions

[1] https://unity.com.
[2] https://www.khronos.org/openxr.
[3] https://docs.unity3d.com/Packages/com.unity.xr.interaction.toolkit@2.5/manual/index.html.

by default. The rotation and scaling mechanics were manually implemented. Teleportation and other locomotion methods were entirely disabled to restrict the game to only interaction. The game environment uses the Kindergarten Interior Unity package[4] as a base, to which several other assets were added. For deployment and testing, the HP Reverb G2 Omnicept HMD[5] was used on various systems. All systems achieved a stable 90 FPS during testing. A short trailer[6] of Puzzle Playground illustrates its game mechanics and environment.

5 Conclusion

There is a significant lack of VR experience among educators, and solving this technological hiccup can drastically improve education in the near future. We presented Puzzle Playground, a VR game expressly designed and developed to teach players how to interact with objects in VR. The game approaches this in a structured, step-by-step manner, guiding players through basic VR interactions and letting them play through various puzzle levels. A preliminary evaluation of Puzzle Playground indicates that learning VR interactions with the game is more time-efficient than other methods, such as oral or written explanations.

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