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Published in:
Human-Computer Interaction – INTERACT 2023 - 19th IFIP TC13 International Conference, Proceedings

DOI (link to publication from Publisher):
https://doi.org/10.1007/978-3-031-42293-5_49

Publication date:
2023

Document Version
Early version, also known as pre-print

Building Teamwork: Mixed Reality Game for Developing Trust and Communication

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Abstract. Cultivating teamwork and a sense of empathy is an important part of boosting productivity and student and employee satisfaction and well-being. We present the initial development of a mixed-reality game using a LEGO block digitization system. Two participants collaborate, with one in real life and the other in VR. Our initial results indicate a positive impact on empathy and user involvement. Moving forward, we aim to create various teamwork experiences using different VR interactions with digitized LEGO builds both for children's educational purposes and adult teamwork.

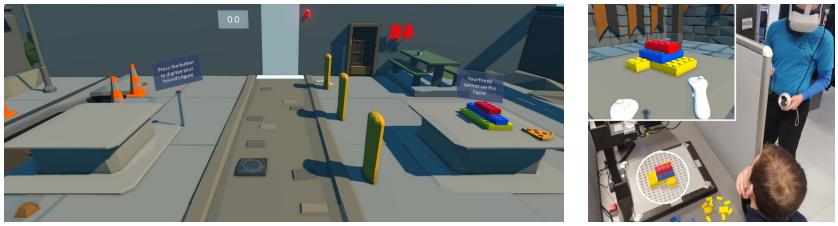
Keywords: VR · teamwork · 3D digitization · LEGO blocks · communication

1 Introduction and Motivation

Team building is a valuable tool in increasing the outcome of group-based tasks and bettering the psychological climate of those involved [7, 5]. While most team-building exercises are physical, virtual counterparts such as cooperative games [3] and XR applications [1] have shown similar effects, increasing motivation and educational outcomes [6]. This paper presents a VR application for cooperative team building through 3D digitization, which is the act of converting information into a virtual space [2] [8]. We use computer vision to digitize LEGO blocks, as they are easy to use and understand, and their color and shape are standardized, making them easier to digitize.

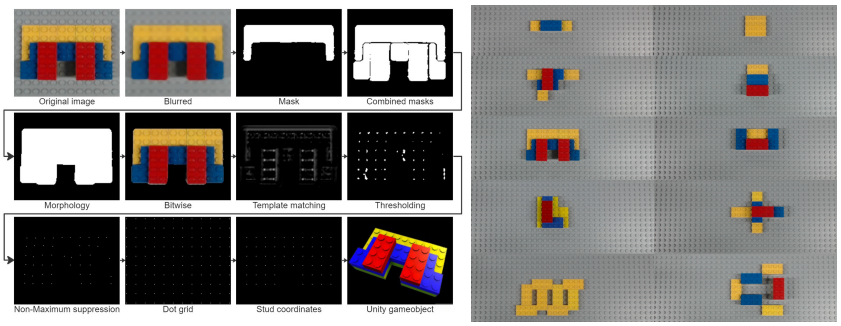
2 3D Digitization Application

To digitize the LEGO blocks we create a Python application using a downward-facing webcam and a designated building area. For detecting and segmenting LEGO blocks we use several image processing steps demonstrated in Figure 2a. The main steps start with pre-processing the images by blurring them and



(a) View of a VR level (b) User collaboration

Fig. 1: Figure 1a is a view from one of the puzzle rooms. The table on the right is what the VR player sees, while the table on the left is where the digitized brick shape made by the builder in the real world is shown. Figure 1b shows a sketch of the testing setup with the example interactions between the builder and VR player.



(a) Testing setup (b) Lego brick puzzles

Fig. 2: Overview of the 3D digitizing pipeline for LEGO blocks (Figure 1b), together with some of the brick puzzles that need to be solved (Figure 2b)

transforming them to an HSV color space and then using color segmentation. To simplify and constrain the process of color segmentation we have selected three different colored LEGO blocks. We segment blocks from different colors and morphologically process them to remove noise and holes. Studs from the segmented LEGO blocks are then detected using template matching and the duplicate detections are removed with non-maximum suppression. The X and Y coordinates of the studs are then captured and using prior information about the size of the LEGO blocks we estimate the Z coordinate. These coordinates are then sent to Unity and a 3D stud of the specific color is created at these positions.

3 Evaluation

We evaluate the proposed team-building mixed-reality game using the Game Experience Questionnaire (GEQ) [4]. As this is a proof-of-concept application

and we are interested in the social interactions and teamwork between players we focus on the Social-Presence module of GEQ (GEQ-SP).
The test is conducted with 9 pairs of people, 18 participants in total. In each pair, one participant is given the role of the builder and the other the role of the VR player. Each team of two is given 15 minutes to go through 10 rooms.

3.1 Game Overview

Figure 1b shows a sketch of the setup, with each room offering a teamwork puzzle of increasing difficulty. In each puzzle, the VR player is presented with a table and LEGO bricks arranged in a certain shape (Figure 2b). They need to communicate the position, shape, and color of the figure to the builder, who is sitting in front of the digitizing setup with access to various bricks and a building space. The builder recreates the shape and notifies the VR player when ready. The VR player then presses a button, and the shape built by the builder is shown in the virtual world. If the shapes match, the puzzle is complete, and they can proceed to the next room. If not, a sound is played, and they need to work together to fix any mistakes. The two participants in each group are separated by an additional barrier, to remove the possibility that the VR player might see the Lego brick structure and to emphasize the necessity of oral communication. Each room is created with a different background to make the experience more varied and interesting. An overhead view of the rooms can be seen in Figure 3.

Fig. 3: The ten different puzzle rooms built for the teamwork game seen from above. Each room has a different theme to keep the players engaged

3.2 Results Analysis

After the teamwork game, the builder and VR player receive the GEQ-SP module, which is then separated into three main categories - empathy (GEQ-E), negative feelings (GEQ-NF), and behavioral involvement (GEQ-BI). Table 1 shows the average score for each category for both types of participants. The scores indicate that both builders and VR players showed high levels of empathy and behavioral involvement, and their scores were similar. The negative feelings category had a below-average score, indicating that participants did not have a negative experience. Notably, VR players had higher GEQ-NF scores, likely due to their inability to directly influence the building process.

Table 1: Average empathy (GEQ-E), negative feelings (GEQ-NF), and behavioral involvement (GEQ-BI) scores, together with the maximum possible scores. The maximum possible score for GEQ-NF is smaller, as it has only 5 questions, compared to 6 for the other two categories.

Participant Type	GEQ-E	GEQ-NF	GEQ-BI
Builder	24.8/30	11.6/25	25.2/30
VR Player	23.4/30	12.3/25	26/30

The results for each of the categories for the builders and VR players can be visually compared through the bar plots in Figure 4. We can see that the scores are closely related, especially for the GEQ-E, while the GEQ-BI shows larger differences for three of the groups. We calculated Pearson's correlation between the scores of each category to examine any correlation between the experiences of both types of participants. The correlation coefficient for GEQ-E scores is 0.733, for GEQ-NF is 0.234, and for GEQ-BI is -0.702. This indicates a strong positive correlation between the empathy experiences of both types of participants, a strong negative correlation between their behavioral involvement, and a much weaker correlation between negative feelings.

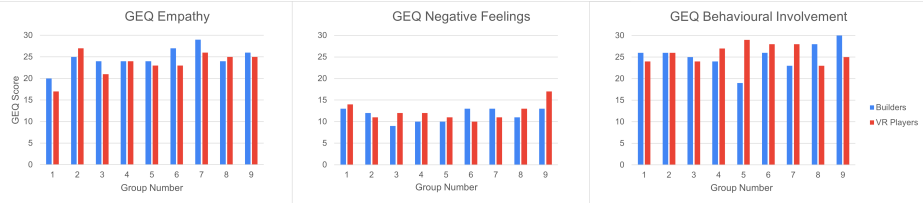


Fig. 4: The GEQ-E, GEQ-NF and GEQ-BI scores for each pair of builder and VR player

4 Conclusion

This initial development of a teamwork-based game showcases how digitization and mixed reality can foster teamwork, empathy, and interaction between players in both real and digital worlds. The developed digitization system gives a straightforward and easy way to generate digitized renderings of different LEGO block figures and objects. Next, we aim to create various collaboration scenarios and games, including level building, climbing, defeating enemies, and orientation, to gauge immersion, empathy, and willingness to collaborate on a larger scale. The straightforward nature of the proposed system and collaboration game can be useful to other researchers as a test bed and starting point for testing collaboration between real life and VR.

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