TARDIS: Tabletop Augmented Reality for Dynamic Immersive Storytelling

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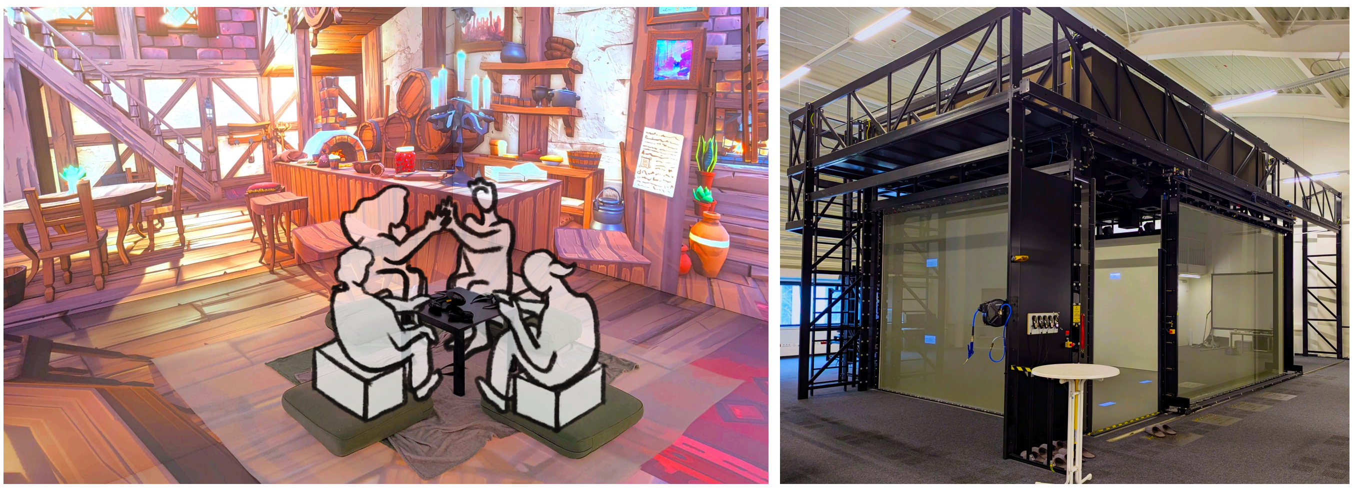

Figure 1: Our participants sat around a real table in a virtual environment (left) that was displayed in a room-sized VR CAVE system (right). While they played a collaborative tabletop role-playing game, matching scenes were projected on the walls and floor of the CAVE. Players thus did not need to wear any VR glasses that could impede social interaction. We varied the level of *matching* of the projected virtual environments: how accurately they represented the details of the world described verbally in the game.

Abstract

In tabletop role-playing games, players experience a shared story, coordinated by a game master. This relies heavily on immersion, social interaction, and creative freedom. We explore how VR can increase immersion without undermining these other qualities. We placed players into a CAVE VR system to display virtual environments (VEs) on the walls and floor without requiring glasses that might impede social interaction. We varied how closely VEs *matched* the game setting described verbally, from reflecting its general atmosphere to being true to details, and investigated impact on immersion, distraction, creativity, and role-play. Players feel more connected to their characters when seeing what their characters would see, but abstract, atmospheric VEs led to fewer problematic divergences and more creative freedom. Surprisingly, medium matching levels were often criticized because players could trust neither what they saw nor their "cinema of the mind". Our findings help integrate VR into shared collocated storytelling.

CCS Concepts

• **Human-centered computing** → *Empirical studies in HCI*; Empirical studies in collaborative and social computing; • **Software and its engineering** → *Interactive games.*

Keywords

CAVE, TRPGs, Collaboration, Immersion, User interviews, Storytelling

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1 Introduction

In tabletop role-playing games (TRPGs), a group of players play fictional characters and interact with the game world through a game master (GM). The GM describes a setting, the players improvise actions, and the GM describes the consequences [7]. A core goal of TRPG players is to immerse themselves in the game world. As Virtual Reality (VR) is a strong tool to create immersive group experiences [9], we investigated if VR could be added to TRPGs without undermining their important qualities like social interaction and creative freedom [7]. To this end, we placed three players and a GM around a table inside a five-sided, room-sized VR CAVE environment (Figure 1) [6]. CAVEs are capable of immersing users strongly in stories [10]. They also allowed us to display a shared virtual environment (VE) while keeping a shared physical space on the table for haptic interaction with physical props and without introducing barriers for social interaction, such as head-mounted devices.

VEs can match the verbally described game setting at various levels, from loosely invoking the atmosphere of a place to representing the exact game location in great detail. We wanted to understand how this level of *world matching* between VE and game world influences players' personal creativity, connection to their role, and immersion. We thus looked for any divergences between the VE and the game world, whether these discrepancies posed problems for players and, if so, how they could be mitigated. Since TRPGs are a popular form of collaborative storytelling [5], our findings help researchers and designers employ VR in these settings without impeding the physicality of the experience, social interactions, and creative freedom.

2 Related Work

For our discussion, we structure the physical setting of a TRPG into three concentric zones (Figure 2): The *table space* is a shared centered space for haptic interaction with physical elements, like dice, maps, or tokens. The *player space* with the players and GM is where social interaction and roleplay take place. Beyond that lies the *environment space*. This space is typically not used beyond the occasional use of lighting or decoration.

Niarchos et al. [11] used VR headsets to replace everything players see with a VR representation. This lets the GM dynamically change the *environment space*, but at the cost of losing the advantages of a physical *player space* and *table space* due to the isolating nature of VR headsets. The players either saw the playing location, a bird's-eye view of a map, or a virtual tabletop. We decided to adapt the playing location point of view, as this is best suited to be shown surrounding the players on the walls and floor of a CAVE. Other approaches used AR glasses to replace parts of the *player space* and *table space*, to incorporate virtual players [13] or map navigation [15]. Even actuated physical tokens for virtual players to make them feel more grounded in reality have been explored [13]. The True Sight Battle Grid [12] expanded the *table space* by adding a modular glowing map representation to provide players with information about the current game state. The authors observed that this reduced interruptions through misunderstandings, as all players had a clearer overview of what was currently happening. Focusing on tangible interaction, Buruk and Özcan [4] expanded the *player space* by introducing arm-mounted wearables and movement to the gameplay, allowing new game mechanics using gestures and intuitive game feedback on wearables. This strengthened players' sense of immersion and the bond with their character as similarities of player and character movement and sensations created a new kind of connection [4]. For remote play, players often use virtual tabletops like Roll20[1] to virtualize the *table space* and communication software like Discord[2] to virtualize the *player space* [14]. Players often use these tools to craft virtual environments using sounds and images to create a shared understanding [14]. Tools like Discord allow users to replace their background in video calls, which inspired us to try this in a collocated setting.

So far, works have primarily focused on the *table space* and *player space*. Players highly value social aspects of the game [1, 5] and show strong preferences for keeping haptic game elements like miniatures, props, gameboards, and dice rolling analog [13]. This led us to not virtualize *table space* and *player space*, but the less explored *environment space*.

3 User Study Design

We used a five-sided Cave Automatic Virtual Environment (CAVE) to project the VR environments. Our system provides a room-sized projection area of 5.25 m × 5.25 m at a height of 3.3 m, and uses 24 WUXGA[3] projectors across four walls and the floor. Based on a pilot study comparing head-tracked 3D, static 3D, and 2D, we decided to use 2D projections as this was preferred by participants, and because 3D shutter glasses would have heavily impeded social interactions. We controlled how detailed the VE and game world match and created four levels of *world matching* (Figure 3).

- **A, Generic:** An unrelated living room, serving as a neutral baseline.
- **B, Mood:** An atmosphere-matching variant capturing the general mood of the game world, without directly referencing it.
- **C, Reference:** A variant that represents the game world, but the exact location and objects are not actively matched by the GM during play.
- **D, Close Match:** A highly matching variant placing players directly into their characters' world. The GM updates the location based on the story, and pre-scripted events are triggered when they happen.

To reduce learning effects and to observe different modes of play, we used four different narrative game worlds in the study, resulting in 14 different VEs for counterbalancing.[4] Participants spent 20 to 30 minutes in each condition. We used Unreal Engine 5.4[5] and assets

[1] roll20.net *(last accessed January 2026)*
[2] discord.com *(last accessed January 2026)*
[3] Widescreen Ultra Extended Graphics Array, 1920×1200 pixels, aspect ratio 16:10
[4] The generic VE could be used in any constellation and did not need four versions. We added a game show VE for in-between conditions.
[5] unrealengine.com *(last accessed January 2026)*

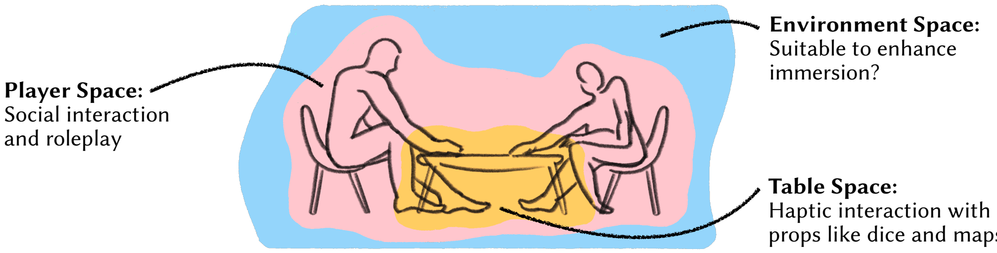

Figure 2: We classify the physical setting of collocated play in three concentric areas: *table space*, *player space*, and *environment space*. We argue that the *environment space* is underexplored and may be suitable to enhance immersive experiences.

Figure 3: Subset of VEs, letters equal conditions: a) Baseline living room, b) Unrelated cathedral to fit general story mood, c) Representation of the cemetery in the story, d) Live in-game event triggering lightning, player perspective matching character perspective

from Unreal's integrated marketplace, aiming for a coherent, realistic art style. We adapted a lightweight TRPG system with a narrative focus, a one-page *character sheet* (a sheet holding the main features, abilities, and inventory of the player's character), and simple mechanics, including dice rolls to determine the success of player actions. Participants selected one partially pre-generated character and personalized it. Participants first received a brief overview of the study, provided informed consent, and were introduced to the simplified rule system. The GM introduced a game show setting that tied the conditions together and invited in-character introductions. Players then visited the first VE. After playing, participants filled out a questionnaire while the corresponding VE remained visible. The same cycle was repeated for the remaining three conditions. After all conditions, participants left the CAVE to take part in a semi-structured group interview about the differences between conditions, personal preferences, and their perception of the entire experience. Our questionnaire comprised 16 items organized into six categories. We measure immersion, enjoyment, creativity, character connection, perceived role-playing performance, and overall assessment of the virtual environment using 5-point Likert-scale questions. To monitor discomfort at the end of the extended time period in the CAVE, we also adapted the Virtual Reality Sickness Questionnaire (VRSQ) [8] to measure *General discomfort*, *Fatigue*, *Headache* and *Eye strain*. Twelve participants (3 male, 9 female) aged 20–45 y (M = 25.5, SD = 6.75) with TRPG experience of 0–28 y (M = 3.30) and GM experience of 0 to 28 y (M = 2.67) took part in the study.

4 Results

We start with our descriptive quantitative questionnaire results, but then primarily focus on our qualitative findings from interviews and open-ended responses.

Participant Ratings: For items about condition advantages, mean ratings followed a positive trend for VEs, which matched the game world more closely (Figure 4, left). The largest change in ratings occurred comparing positions A (Generic) and B (Mood). Distraction scores tended to decrease for higher matching VEs, and surprisingly, none of the conditions was perceived as limiting creativity (Figure 4, right). 3 participants preferred condition B, 3 preferred condition C, and 7 preferred condition D. Most VRSQ ratings fell between "none" and "slight". The aggregated score averaged to 1.46 (SD = 1.43, range 0–5), indicating low discomfort.

Qualitative findings: We analyzed the group interviews and open-ended questionnaire responses using reflexive thematic analysis [2, 3]. After familiarizing with the responses, one of the authors coded the data in MaxQDA[6], then iteratively grouped codes into themes. User quotes have been translated if necessary. For each qoute we give group number and seating position, for example (2, A) refers to the person sitting left of the GM in group 2. For condition A (Generic), most participants did not feel strong immersion.

> "*I had to tune out the virtual world because it looked different than in my imagination*" (4, A)

[6]https://www.maxqda.com *(last accessed January 2026)*

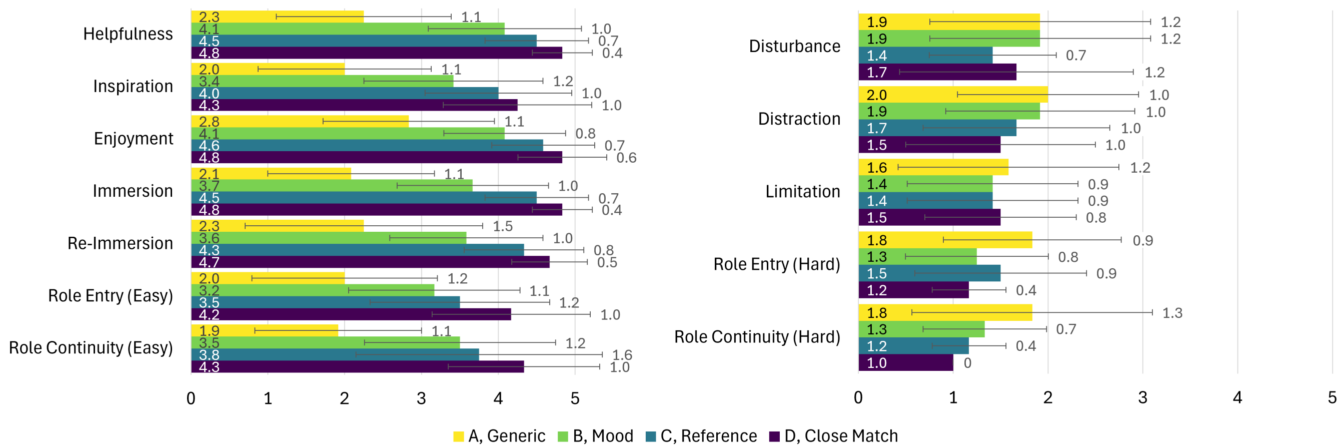

Figure 4: Participants' mean attribute ratings for all conditions. Whiskers with numbers denote standard deviations. Scales reached from 1 ("Does not apply at all") to 5 ("Completely applies"). Left: The stronger the match between VEs and the game world was, the better the ratings for the advantages of VEs became. The largest increase occurred between conditions A and B, when the VEs began matching the atmosphere of the story. Right: For ratings of VE disadvantages, we did not observe big differences between conditions B, C, and D. On average, condition A made roleplay relatively harder for participants.

But some also remarked that it provided a "*safe space for more interesting role play*" (10, A) and "*minimized relation to the real world*" (6, A) . In condition B (Mood), players saw a VE that was adjusted to fit the atmosphere of the game world.

> "*[The] similar mood of the story and the virtual environment helped fast immersion into the game world*" (6, B)

Participants also said that this already "*supported roleplay really well*" (11, B) . Increasing the match between the VE and the game world, condition C (Reference) "*helped to find into the game world and find ideas for the plot*" (5, C) .

> "*The virtual environment established the mood and atmosphere well and moved to the background when focusing on the story*" (6, C)

However, we also began to observe confusion, as there was a "*difficulty differentiating which parts of the virtual environment were not part of the game world*" (3, C) . Participants wanted to interact with visible features, misinterpreting them as elements of the game world, because "*They feel 'true'*" (7, C) . We identified two types of mismatch that participants found particularly disruptive. **Spatial Inconsistency:** Being in a different location within the virtual environment compared to where their character was supposed to be in the game world. **Phantom Objects:** Details that existed in the virtual environment but were not present in the game world. They were considered more distracting than missing virtual elements. This confusion effect was rarely observed in condition D (Close Match), which maximized closeness between VE and the game world. Participants noted that "*it was possible to refer to specific objects and therefore find new ideas*" (7, D) . Some participants felt like they could directly perceive what their character was seeing, effectively bridging the gap between player and character perspectives. Strongly matching environments seemed to enable participants to incorporate gestures and spatial references into role-playing. They could point to specific environmental elements during character interactions:

> "*I knew exactly where I had to point to better show what I wanted to do.*" (9, 3)

> "*I was so immersed by the fact that I see the same thing as my character that I even adopted my character's body posture without realizing it.*" (7, 3)

In addition, this seemed to increase the stability of the shared group imagination.

> "*You knew that everybody was imagining roughly the same thing*" (8, D)

But some players also felt restricted.

> "*As I could not imagine my own game world, I felt limited in my creativity*" (4, D)

After the study, players mentioned that animations made the VEs seem more alive and immersive, but that it became distracting when many things moved nearby (like falling leaves). They also expressed that the detail in VEs made them interact more with the game world, integrate objects they saw, and explore more. GM-controlled teleport points in condition D (Close Match) gave players the feeling of progressing in the story when navigating between different positions in the virtual space. This suggests that teleportation between predefined locations contributed to players' sense of narrative advancement.

5 Discussion

Based on user comments and ratings, TRPG players seem to profit from VEs in the *environment space* by experiencing increased immersion, ability to roleplay, and enjoyment. CAVEs allow this without impeding haptic interaction with props or social cues between players. In our study, the VE types **Mood** and **Close Match** were most promising. **Close Match** VEs give players the impression of seeing the game world through the eyes of their character. This supports roleplaying and increases immersion, but can also reduce players' imagination. The shared spatial reference frame grounds character performances [4] and provides spatial orientation, potentially reducing misconceptions that would hinder gameplay [12]. Constructing this type of VE is a time-consuming task for GMs, especially as they have to react to the unpredictable nature of TRPGs [7]. One has to expect that the game world will start to diverge from the VE during play because of spatial inconsistencies and phantom objects. We observed that this could confuse players and break immersion.

Mood VEs, on the other hand, are clearly not representing the game world and do not have this problem. They are also much easier to create, since they leave more creative freedom to players. Their positive effect on immersion and roleplay seems less pronounced, but was notably higher than for *Generic* VEs. Unrelated *Generic* VEs seem to distract players and immerse them less, but *Representative* VEs are also undesirable as they can cause confusion. In general, VEs can use distant or subtle animations to make the world feel more alive, and dynamically adjusting or replacing them can help strengthen the sense of narrative progression.

6 Limitations and Future Work

A follow-up study with a quantitative focus and more participants would allow us to further validate our results with significance analysis. This work also focused on the player perspective. In the future, it would make sense to explore the GM perspective and additional game mechanics that VEs might add to the game. While playing TRPGs in CAVE systems is not practically feasible for most players today, we expect our findings to be transferable to large screen backgrounds, virtual environments in remote collaboration, and projected environments using AR glasses. Our findings suggest that reducing the technological barriers to use VEs in this setting would be a worthwhile longterm goal. This could include support tools for GMs, less resource-intensive ways to display VEs, or speech recognition to automatically adjust the content displayed during play.

7 Conclusion

We presented TARDIS, an approach that augments a collocated TRPG session with virtual environments using a CAVE VR system. By only augmenting the surrounding environment, this approach does not introduce barriers to tangibility or social interactions that traditional VR would. By varying the level of *world matching* of the VE, we found that VEs should either closely match the game or serve only as a suitable atmospheric backdrop without direct representation of the game. High levels of matching provide stronger immersion and improve roleplay, but also introduce the risk of creating mismatches. Atmospheric matching tends to foster more creative freedom for players and is easier for the GM. Our findings contribute to the understanding of dynamic and collaborative storytelling in virtual environments and show that players enjoy exact representations but also atmospheric backdrops when immersing in a story.

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