Go Beyond Atmosphere Rendering: XR-Mediated Script Entertainment

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Abstract. Script Entertainment (SE), originating from murder mystery games, has flourished in China over the past decade. Beyond entertainment, it has gradually evolved into a brand new game genre and a vast industry integrating with education, cultural tourism, commerce and so forth. Against this background, extended reality (XR) has become a key driver for the digital transformation of SE industry. However, the current use of XR technology in SE remains simply enhancing visual and audio effects, with limited interactability and integration into game mechanics. In this Research-through-Design (RtD) study, we explored what aspects and how XR can mediate SE. First, we conducted expert interviews with 10 SE practitioners to gain industrial perspective and initial design insights. Second, we developed an annotated portfolio that comprises a set of game demos co-created with SE industry stakeholders and game creators. As a result, 4 actionable design implications were generated. Grounded in both our designerly practices and industry perspectives, we intend to contribute fresh and in-depth insights for future design and development of XR-mediated SE.

Keywords: script entertainment · murder mystery game · serious game · extended reality · research through design

1 Introduction

Murder mystery games (MMGs), which stem from live-action role-playing (LARP) games in the United Kingdom [15], center around a script while incorporating elements like reasoning, role-playing and puzzle-solving. Players primarily interact with each other through collocated social play in real-world venues, guided by a Dungeon Master (DM). During the past decade, it has undergone phenomenal popularity in China and become a new form of social entertainment among young generations, known as the Script Entertainment (SE). With the continuous growth of the market, SE has gradually expanded into a broader and more content-rich game genre, encompassing tabletop games and more hybrid, dynamic forms combining LARP and escape rooms.

Recently, the SE industry has witnessed a growing trend of integrating with extended reality (XR) technology, driven by the emergence of "Script Entertainment+" (SE+) and "Script Entertainment 3.0" (SE 3.0) models. Explicitly, SE+ refers to the cross-industry integration with sectors like education, cultural tourism and so forth. Meanwhile, SE 3.0 emphasizes more realistic settings and immersive gameplay, such as merging script with scenic spots and physical venues. Specifically fueled by the soaring demand from galleries, libraries, archives, museums (GLAM) and other cultural

tourism domains, the SE industry started to actively embrace XR technology, including but not limited to virtual reality (VR), augmented reality (AR), and mixed reality (MR). XR-mediated SE has become a key driver of the immersive experience economy. However, its usage remains to be an optional multimedia enhancement, primarily for amplifying the overall atmosphere of the gameplay.

In this study, we aim to address two research questions (RQs). **RQ1**: *What aspects of SE can be potentially mediated by XR technology?* Here, SE refers to not only a general game genre, but also the industry per se. **RQ2**: *How can we use XR technology to mediate SE experience?* This question looks for more practical guidance for the design and development of XR-mediated SE. Therefore, we carried out a Research-through-Design research. First, we conducted semi-structured expert interviews with 10 SE industry practitioners to elicit initial design insights from a practical, industrial perspective. A grounded theory method was adopted to iteratively collect and analyze the interview materials. Second, we conducted co-design workshops with industry stakeholders and game creators to co-create a total of 6 XR-mediated SE game demos, which were analyzed and summarized into an annotated portfolio. Finally, we synergized both the expert interview results and the annotated portfolio into 4 actionable design implications. Notably, these implications are not merely confined to a designerly reflection on the specific SE industry and its related cultural phenomena in a particular country or region. Rather, they can also be generalized and transferred to other serious domains where XR-mediated SE can be potentially applied.

2 Background

SE is a narrative-driven cultural experience emphasizing logical reasoning, combining scripts, mechanical puzzles and immersive real-world venues. A prominent genre, MMGs (known as "Jubensha" in China), originated from LARP in the UK and was introduced to China in 2013, marking the start of SE there. Most SE games involve deduction-based role-playing guided by a DM, and are played in physical venues, with fewer taking place on online platforms [15]. Similar to tabletop role-playing games (TRPGs), SE also emphasizes collocated social play. However, the difference is that SE features fixed plots and roles, while TRPGs typically involve open-ended storytelling, customizable characters and more complex rules.

By 2023, China's SE market reached approximately 19.5 billion RMB. As the industry matures, innovations such as the cross-industry "SE+" model, which integrates sectors like education and cultural tourism, have emerged. Moreover, SE has evolved from "SE 1.0," focused on deduction-based play, to "SE 2.0," involving clue searching in physical venues, and now to "SE 3.0," which further stages immersive role-playing in authentic settings like historical towns and scenic spots.

Current SE literature broadly embraces escape rooms [13], immersive theater [11], LARP [9] and pervasive or location-based games [2]. Some of these have already been applied in contexts such as education and training [11], GLAM [13] and tourism [4]. With the growing demand for immersive and interactive experiences in SE, recent state-of-the-art studies have increasingly tapped into XR technology to enhance player experiences. Although existing studies have proposed design frameworks for specific domains like social play [8], LARP [5] and pervasive games [1], there is still a lack of systematic investigation and practical guidelines tailored for SE.

As for development and authoring tools, existing research has introduced relevant tools and technology stacks to support the creation of XR-mediated SE. For instance, XR storytelling tools like *Jigsaw* [17] and *Story CreatAR* [10] facilitate interactive narrative design. XR (game) development toolkits by Svanæs et al. [12], Zarraonandia et al. [16], Kern et al. [7] and Xiao et al. [14] have been proposed. We adopted the technology stack proposed by Xiao et al. for this study due to: 1) its end-user-oriented design, which facilitates participatory design involving non-technical stakeholders; and 2) its cost efficiency, achieved through the use of lightweight, commercially available devices, such as Cardboard VR and passive Ultra High Frequency (UHF) RFID.

To summarize, although XR-mediated SE remains a niche research field, its industrial scale and phenomenal popularity demonstrate its potential value in fields such as culture, education and commerce.

3 Research Approach

The overall research followed an RtD method [18], and was structured into two phases corresponding to our two RQs respectively. The study was carried out with the approval of the Institutional Review Board (IRB) of the authors' affiliated institution.

For RQ1: "*What aspects of SE can be potentially mediated by XR technology?*", we conducted semi-structured interviews with 10 experts from different professions within the SE industry, ranging from script creator, publisher, industry association officer, to veteran player. We adopted a grounded theory method [6] to collect and qualitatively analyze the interview materials in an iterative and generative manner. Thus, we managed to familiarize ourselves with the industry landscape and gain preliminary design insights, which guided us to address our RQ2.

For RQ2: "*How can XR technology mediate SE experiences?*", we followed an annotated portfolio approach [3] and organized two co-design workshops to co-create XR-mediated SE game demos. According to the previous results of expert interviews, the two co-design workshops intentionally featured different participant groups and co-creation themes to generate complementary outcomes. The first workshop spanned 16 weeks with the theme of "fire safety education" to emphasize the applicability of XR-mediated SE in serious application scenarios. It involved 20 students with novice-level game creation skills, with the active engagement of multiple stakeholders from the SE industry and local fire department. In contrast, the second workshop adopted the form of a one-day Game Jam without specified themes, involving 10 professional game creators from a leading game company in China and 15 students with moderate or advanced game creation skills. A total of 6 game demos were generated.

Further, we synthesized industry perspectives from the expert interview analysis and empirical insights from the annotated portfolio into 4 major design implications. Due to the space limitation, detailed expert profiles and the full annotated portfolio are provided in the online supplementary materials (https://bit.ly/4ekzpsj).

4 Expert Interview

In this section, we present the qualitative results derived from our expert interviews. The aim was to identify design opportunities for guiding our next research stage, by

emphasizing the difference and similarity between the traditional SE and XR-mediated SE particularly. We adopted an iterative process of collecting, coding, and clustering following the grounded theory method. To ensure inter-coder reliability, the materials were analyzed by 2 to 3 independent coders, with discrepancies resolved through group discussions until a consensus rate over 99% was achieved. The resulting code set included 81 codes, forming 46 themes and 4 major categories. The four major categories each spotlight a different design dimension, further branching into subcategories and their subsidiary design themes. As shown in Fig.1, they were streamlined and organized in a hierarchical structure, with bracketed numbers denoting each theme's frequency in the raw interview materials.

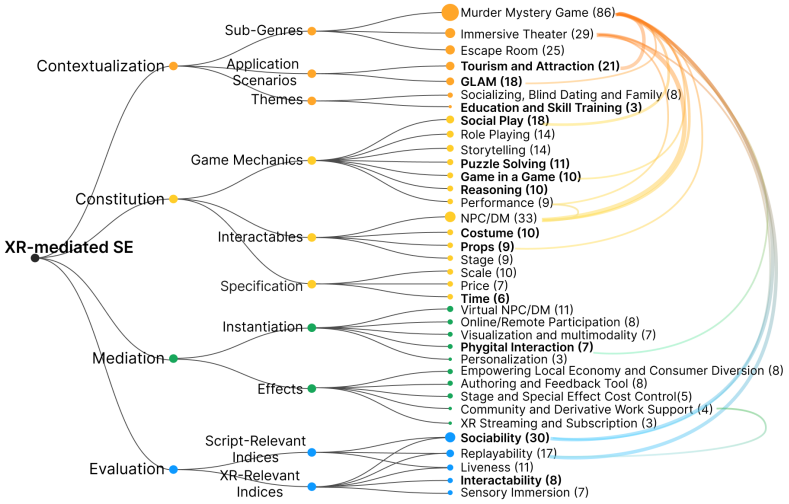

Fig. 1: Design Dimensions and Subsidiary Themes of XR-Mediated SE

1) *Contextualization* explores the sub-genres under XR-mediated SE, and the application scenarios and themes that our expert interviewees identified as more aligned with XR-mediated version compared to its traditional counterpart. It was commonly agreed that XR technology lends itself to application contexts like *Tourism and Attraction*, *GLAM*, and for themes related to Education and Skill Training.

2) *Constitution* focuses on the game mechanics, interactables and specifications of XR-mediated SE. Similar to traditional SE, *Social Play* remains the core game mechanic, while *Puzzle Solving*, *Reasoning* and *Game in a Game* were considered with the highest potential to be integrated with XR's technological affordances through interactables like *Costumes* and *Props*. In addition, the experts suggested that XR-mediated SE should have a shorter average play *Time* than traditional SE due to the concern about the limited wearability of current Head-Mounted Displays (HMD).

3) *Mediation* investigates the aspect of XR mediation. The typical instantiation of XR mediation includes *Online/Remote Participation*, *Visualization and Multimodal Enhancement*, both of which are common in traditional SE. *Virtual DMs*, the most mentioned instantiation, were cautioned by experts to be limited to certain scenarios such as GLAM or educational tours, where players primarily seek knowledge, mak-

ing the demands for DMs' storytelling and improvisational performance less stringent compared to those placed on human counterparts. *Phygital Interaction*, referring to the integration of physical and digital in-game elements, emerged as the most significant theme. We will leave the expected industry effects of XR mediation to Section 6.

4) *Evaluation* proposes metrics for XR-mediated SE experiences along two sub-dimensions: script-relevant and XR-relevant. Given that social play is the core game mechanics, *Sociability* emerges as the most salient index. Followed by *Replayability*, which the experts refer to as the "biggest bottleneck" for most MMGs, while *Liveness* refers to the emergent experience from situational interactions with human NPCs/DMs and game settings, that vary each game session, even following the same script. Many experts agreed that *Interactability* and *Sensory Immersion* are the experiential indices most likely enhanced by XR technology.

Particularly, some design themes, e.g., *Education and Skill Training*, *Game in a Game*, *Phygital Interaction*, have inspired and influenced the game design presented in the next section, which are highlighted in bold in Fig.1.

5 Game Design Overview

This section showcases the four representative game demos from the first workshop, with the remaining two are provided in the supplementary materials. Collectively, these demos presented a rich repertoire of game mechanics, player interactions, XR mediation and educational contents. For technical implementation used, please revisit Section 2.

1) Flame Within

Game Mechanics: In *Flame Within* (Fig. 2a), players **role-play** one of three witnesses to a mysterious fire and enter a virtual post-fire environment to investigate its cause. The game consists of two stages: Evidence gathering and presentation. During evidence gathering, players are given limited action points to investigate virtual objects and collect clues for their **puzzle-solving** and **reasoning**. After several rounds, players must present all collected evidence to establish a complete chain of reasoning (Fig. 2a top right). The game adopts a **non-linear narrative**, with story branches and endings shaped by player's decisions and whether key items are gathered.

XR Mediation: Each player wears a **cardboard VR headset** and interacts with virtual scenes and objects by pressing the headset's button. Notably, this game incorporates **tangible props** with RFID tags as action cards (Fig.2a bottom left). Scanning an action card consumes one action point to investigate a virtual item, then the card is turned into an evidence card for the later evidence presentation stage.

Player Interaction: The game supports turn-based play for 3 to 4 collocated players who can cooperate or compete. As the story progresses, the player who discovers they are the culprit behind the fire may hide key evidence to conceal their identity, while others may collaborate by sharing or revealing clues to identify the mastermind.

Educational Contents: This game mirrors real fire investigation process, where players are required to learn and apply their knowledge about flammable materials and potential fire risks to identify key items.

2) Burning Time

Game Mechanics: *Burning Time* (Fig. 2b) is a **narrative** based game featuring time slip. Players from different timelines collaborate to solve a fire investigation case. Based on **reasoning** and **puzzles solving**, players need to figure out the correct event

(a) (b)

Fig. 2: Game components and Gameplay of (a) Flame Within and (b) Burning Time.

sequence. It also adopts a **plot twist**: the player who appears to be a fire victim is later revealed to be his sibling, a firefighter undergoing post-fire psychological therapy.

XR Mediation: The VR player primarily interacts with virtual scenes and objects using basic cardboard VR functions, e.g. eye gaze and the headset button.

Player Interaction: The game involves two collocated players in different timelines—before and after the fire—who exchange key information and reason together to complete the puzzle and uncover the full picture.

Educational Contents: This game leverages a fictional time-slip story to reflect a real-life issue faced by firefighting personnel—post-traumatic stress disorder or other mental symptoms after major incidents. Through **narrative tricks**, it aims to evoke greater social awareness and understanding toward the firefighting profession.

3) XFGO

Game Mechanics: *XFGO* (Fig. 3a) divides 4 players into two opposing teams for a competitive firefighting drill: one is tasked with selecting the correct fire extinguisher to put out fires, while the opposing team must identify and ignite flammable or explosive materials. Each team includes an operative and a commander, and characters differ in abilities and parameters like vision range and capture skills, enabling **asymmetric confrontation** and various team strategies to compete for a higher **game score**. Each game lasts for 5 minutes, and the higher-scoring team wins at the end of the countdown.

XR Mediation: Players use the headset button to move or stop their avatars. One team's operative ignites virtual flammable objects by gazing, while the opposing operative wears an RFID-tagged firefighter uniform as a **costume**, with each tag representing a different type of extinguisher. A hand-held RFID reader is used to scan and select the correct extinguisher (Fig. 3a bottom left).

Player Interaction: The game supports collaboration-based competition among 4 collocated players. Each team's commander utilizes a broader vision to deliver critical information—like enemy positions and fire dynamics—to the operative, who follows instructions to act, such as capturing or escaping.

Educational Contents: The game's fire safety knowledge covers: 1) materials and their flammability; 2) fire sources, e.g. fuel-based fires; 3) extinguisher types, e.g. CO_2 and water-based etc. These are tightly interwoven into the game mechanics—for example, igniting less flammable objects requires longer gaze time, increasing the risk of detection and capture, thereby improving the strategic element and educational value.

4) Back into Fire

(a) (b)

Fig. 3: Game components and Gameplay of (a) XFGO; and (b) Back into Fire.

Game Mechanics: Two players collaborate in a cross-reality manner to rescue an infant trapped in a burning house, the stage for a VR **escape room**. Player A remotely operates a **firefighting robot** on a physical floor model (Fig. 3b bottom right), while Player B observes the fire scene in VR from a synchronized perspective with the robot and performs rescue operations. The game features **time-limited tasks** requiring quick responses, e.g. avoiding collapsing building parts, finding safe routes, picking up **collectibles** like fire mask etc.

XR Mediation: To enable cross-reality collaboration, this game relies on **tangible props**, i.e. a firefighting robot and a building floor model. The robot is an assembly of a remote controlled car, a Raspberry Pi with RFID module and a 3D-printed chassis. Multiple RFID tags are attached to the floor model, allowing real-time positioning of the robot. Thus, the other player's perspective in VR will be synchronized accordingly.

Player Interaction: The cooperative social gameplay requires both players to work closely as if they separately shared the robot's vision and mobility functions. For example, When the VR player discovers a blocked path, they must promptly inform the robot operator to replan the robot's route to the destination.

Educational Contents: This game showcases common fire hazards, e.g., low visibility, breathing difficulty and collapse, while promoting safety measures like using fire masks or damp cloth to cover the nose and mouth, and crawling to avoid smoke.

6 Discussion and Conclusion

In this section, we will discuss our four design implications and conclude our contribution of this study. Each implication is discussed with a consistent structure: starting from a general industry perspective (in response to RQ1) and progressively narrowing down to concrete prototypes and actionable design insights (in response to RQ2).

1) SE's Core Value: A Live Social Experience

All the experts reached the consensus that whether or not technology mediation is involved, the core value of SE experiences always lies in **sociability** and **liveness**. As P4, P9, P8 mentioned, SE is essentially social play, and players value the collocated dynamic social interactions and happenings that emerge improvisationally during each play. It is the interaction with real people in real world that fundamentally distinguishes SE from other games, e.g. multi-player online games. We argue that the engagement of XR mediation, instead of cutting off players' awareness of the outside world, must help establish and maintain the player's connections with other people and the surround-

ing. As P5 and P9 noted, "*For example, in immersive theater, the use of technology is supposed to make the human performers stand out, rather than replace them.*" Similarly, technology should be used to facilitate interactions between players and human NPCs/DMs. In particular social contexts or scenarios, virtual NPCs/DMs can also serve an important function. As P1 noted, "*Virtual NPCs/DMs are particularly suitable in specific contexts such as cultural tourism or GLAM.*" (RQ1)

Following the same thread, we believe that aside from sensory appeal and immersion, XR's potential to enhance SE lies in its capability to facilitate the overall social experience and encourage live interactions among on-site players, by supporting various social play modes. Representative game demos include *Burning Time*, *Western Cowboy Showdown* and *XFGO*. They have respectively demonstrated different social play modes, i.e. cooperation, competition and cooperation-based competition. In practice, AR, MR and projection mapping are some preferable technologies that attend to collocated interactions. (RQ2)

2) XR as Interfacing Technology Should Go Beyond Atmosphere Rendering

Several experts (P6-P9) mentioned that the current use of XR in SE is largely limited to rendering audiovisual effects to supplement the pre-written script contents, such as using VR or projection mapping to create a non-interactable story backdrop. However, these experts also agree that XR's application is expected to go beyond merely multimedia content enhancement or atmosphere rendering. Some in-game elements in SE can be possibly reformed using XR. For instance, P9 said: "*Virtual avatars may provide more personalized and customizable role-play experience than physical costumes.*" Moreover, to address MMGs' replayability issue, P9 further pointed out that: "*XR should engage player community and encourage secondary content creations, so as to improve the overall replayability.*" (RQ1)

Despite its constrained use in post-production phase currently, our annotated portfolio shows that XR can be proactively engaged from the beginning in script composition and game mechanics design. An example is *Flame Within*, where RFID technology was tightly merged into the investigation and evidence presentation stages of the game. While in *Back Into Fire*, the spatial mapping between the virtual environment and the physical floor map renders **cross-reality interactability** for the game. It hence entails SE creators to be aware of the technological affordances of XR, as an **interfacing technology** that communicates the virtual and the physical, and make full use of them. To this end, both P8 and P6 suggested: "*For MMGs that involve mechanisms as part of the crime, it would add more realism and persuasiveness, if a 3D exploded or cross-section model can be displayed in VR for players to understand and interact with the key mechanism behind the crime.*" P6 also added: "*For tabletop games with physical maps and player figurines, it's natural and more fun to blend with AR or MR.*" Considering its technical threshold, we believe that end-user development tools and generative AI can help lower the entry barriers for non-technical users to design and develop XR-mediated SE. (RQ2)

3) Low Tech, Rich Experience

When discussing about the factors hindering full-fledged XR-mediated SE, the concern shared among experts (P1, P4, P8, P10) is the technological limitations and cost: limited wearability, short battery life, motion sickness and fatigue due to prolonged use of heavy headsets etc. On one hand, XR may contribute to a reduced production cost by "*replacing real stages and installations by virtual settings*" (P8). On the other hand,

expensive XR equipment will also impose heavy initial investment and maintenance cost on specifically SE store owners (P1, P4, P6, P8). (RQ1) Therefore, **lightweight low-tech solutions** and **moderate use (against full use)** of XR turned out to be among the key principles that most experts agree on. As P4 highlighted, "*By prioritizing end user experience over technical implementation, we've achieved strong market performance.*"

Our annotated portfolio aligns with this insight, in the way that we adopted exclusively low-cost, low-tech components such as cardboard VR goggles and passive RFID tags. Notably, in *Wilderness Adventure* and *Western Cowboy Showdown*, everyday objects and crafts like water bottles and LEGO blocks, when attached with RFID tags, immediately turn into instant game controllers that render fun and meaningful bodily play. It again underlines that the adoption of any technology in SE needs to be self-explained and experience-driven. Moreover, by confining the use of XR to only key segments of the gameplay or "game-in-a-game", it can further avoid over-reliance on devices and reduce technical overhead. (RQ2)

4) SE+: Combination with GLAM, Tourism and More

Currently, the traditional SE industry in China is facing serious bottlenecks due to issues like post-pandemic recession and consumer downgrading. The experts generally agree that stand-alone businesses, e.g. script murder mystery and escape room stores, will struggle to maintain a sustainable business model. As P4, P6 and P7 pointed out, one way for SE to break through is to work hand in hand with the local real economy as a tactic for **traffic attraction** and **consumer diversion**. Many cultural, educational and commercial scenarios can employ XR-mediated SE to improve public engagement. To this end, the technological affordances of XR can empower traditional SE, by intelligently adapting to on-site, context-sensitive settings. Examples include location-aware contents along tour routes, or interactive experience centering physical museum exhibits, which traditional SE may find difficult to achieve alone. (RQ1)

Presumably, to accommodate high user traffic, future XR-mediated SE experience must feature **bite-sized, fast-paced** interactions. It will drastically differ from the traditional SE model, where a single session oftentimes spans from 2 to 8 hours. It will be accompanied by purposes beyond entertainment, including but not limited to education, cultural promotion, or commercial advertising. Consequently, SE creators need to always consider how to deliver the knowledge or information in a way that is seamlessly interwoven into the script and game mechanics, contributing to an experiential continuum. The first four game demos have set up some modest examples for future discussions. Meanwhile, for XR-mediated SE deployed in GLAM, scenic spots and similar application domains, we propose to further incorporate GPS- or beacon-based positioning to expand SE into a wider activity range. (RQ2)

Conclusions

This study intends to explore the technological affordances of XR and their potential impact on both future SE game experience and the industry per se. Our work did not cover the full spectrum of XR-mediated SE regarding the sub-genres and application scenarios. Due to practical limitations, we were also not able to traverse all possible XR technical components in our game development. Instead, by carefully scrutinizing available design options and narrowing down to a representative subset, we aimed to explore the research domain and extract transferrable and actionable design insights for facilitating future design and development of XR-mediated SE and beyond.

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