

Supplementary Information
For
Guiding the Unseen: A Systems Model of Prompt-Driven Agency Dynamics in
Generative AI Enabled VR Serious Game Design

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Supplementary Table S1. Prompt type, complete structural features and representative examples.

Prompt	Structural features	Examples
Information retrieval prompt (P01)	Question type: Open-ended questions to obtain specific information. Keywords: “Introduce...”, “List...”, “Need to include...”. Instruction style: Request description, enumeration, provide factual data, content and basis. AI response form: Detailed description, list form, data summary, information source display.	<i>Introduce VR technology currently used in museum exhibitions and games, especially the technical information of head-mounted display devices currently widely used in the market. (U11)</i>
Creative ideation prompt (P02)	Question type: Imaginative, open-ended questions, encouraging creative thinking. Keywords: “What do you think if...”, “Is it possible...?”. Instruction style: Encourage brainstorming to stimulate divergent inspiration. AI response form: Innovative ideas, diverse creative suggestions.	<i>If this historical process is presented in VR, simulating envoys from different periods of Persian history and communicating with people of different cultures, what do you think? (U06)</i>
Idea integration prompt (P03)	Question type: Guiding questions, requiring integration or fusion of ideas. Keywords: “Try to integrate...”, “What will happen if you add...”. Instruction style: Requires integration of different elements or addition of new elements to avoid content fragmentation. AI response form: Coherent description of integration, comprehensive plan after fusion.	<i>Try to describe the details of scene one in detail, and integrate it with the popular science and production of tiles, etc. to prevent the content from being split and looking like two themes. (U01)</i>
Contextual simulation prompt (P04)	Question type: Context-based questions, requiring simulation of specific in-game interaction scenarios or usage situations. Keywords: “If... the player will encounter”, “Simulate the user’s use of...”. Instruction style: Request for description of user behavior	<i>If the player takes some representative gifts from the Tang Dynasty and travels to the Western Regions along the Silk Road, what specific trade, cultural exchanges, and folk activities will he</i>

	and experience in specific scenarios. AI response form: Detailed description of user reactions and behaviors and reactions.	<i>encounter on the road?</i> (U03)
Stepwise narrative prompt (P05)	Question type: Step-by-step questions, with a clear order, requiring the narrative to be improved step by step. Keywords: “First...Secondly...Thirdly...please improve the plot”, “... chapters, give the script”, “... tasks, improve them in turn”. Instruction style: Step-by-step guidance of narrative development, chapter-by-chapter design. AI response form: Step-by-step plot design, chapter-by-chapter improved narrative framework.	<i>The game has three chapters. The first one... the second one... the third one... Please improve the plot design for these three chapters.</i> (U07)
Role-driven prompt (P06)	Question type: Requires to design tasks from the perspective of the character. Keywords: “Players...characters...please formulate...”. Instruction style: Character creation, task design, clue setting. AI response form: Detailed character background, task description and level design.	<i>Players travel to the State of Jin in the role of a bird and phoenix, and experience the history and cultural stories of the time... Please formulate game clues and mission levels.</i> (U30)
Multi-sensory fusion prompt (P07)	Question type: Request to integrate multi-sensory interaction elements. Keywords: “Picture... space... vibration feedback... sound communication... smell... gesture selection... and other forms of interaction”. Instruction style: Request novel multi-sensory interaction design. AI response form: Comprehensive multi-sensory interaction plan, specific sensory feedback mechanism, technical implementation method.	<i>Do you have any ideas about the interactive form? For example, what special functions does the bronze mask have, such as eye tracking, tactile feedback, voice communication and other forms of experience.</i> (U07)
Reflective co-creation prompt (P08)	Question type: Make judgments, evaluations and reflections based on previous answers, and then propose more precise optimization tasks. Keywords: “...very good, continue to improve”, “...deviated from the main task, returned to the main plot, and optimized again”, “...too difficult to achieve, give a more reasonable path”. Instruction style: request the affirmation of AI answers, require expansion and deepening, or give criticisms and require improvement. AI response form: detailed problem identification, optimization suggestions and improvement strategies.	<i>The third scene you proposed seems to have deviated from the serious XR game and is more like a cultural experience activity in reality. Please correct it.</i> (U01)
Future adaptive prompt	Question type: Prediction of problems in future use. Keywords: “Predict system operation under...”, “Predict peak time...”, “Analyze differences and impacts under...”	<i>In the next three months, system load testing, peak hours, simultaneous online users, and</i>

(P09)	Instruction style: Request prediction and analysis of system performance and user behavior in future scenarios. AI response form: Multi-dimensional prediction analysis and response strategies.	<i>functional pressure point analysis.</i> (U18)
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Supplementary Table S2. Additional representative prompt examples.

Prompt	Representative prompts
Information retrieval prompt (P01)	(1) Introduce the general categories of museums. (2) Introduce VR devices. (3) Could you describe and list the key characteristics of two typical user personas in detail? (4) What collections does the Hunan Provincial Museum have? (5) Please describe the ceramics collection stored in the Hunan Provincial Museum. (6) Among traditional medicinal materials, which herb is the most fundamental? Which other herbs need to be combined with it to achieve the best efficacy? (7) Which medicinal herb is the most indispensable component in all traditional decoctions? (8) What are the common combinations involving licorice in traditional medicine? (9) Please share some popular science videos about traditional medicinal materials from Gansu. (10) Please introduce the life story of Mr. Taofen.
Creative ideation prompt (P02)	(1) Come up with a name for this game that has an ancient Chinese time-travel style. (2) Generate several creative concepts for a poster for this VR game, highlighting different artistic styles and visual themes. (3) Give me some suggestions on the forms this VR game in the Shanxi Museum could take. Please describe the design plan. (4) What items from these collections do you think could be used to design a popular science VR game? (5) What innovative ideas do you have for designing a VR interaction game that lets players build their own virtual museum (sandbox style) with artifact creation and archaeological experiences? Please suggest possible game features and visual styles. (6) How could a murder mystery style VR game be developed? (7) I want to create a popular science VR game about the “Along the River During the Qingming Festival” painting in the form of a murder mystery. Please provide a complete design plan.
Idea integration prompt (P03)	(1) I am aware that the natural history museum includes environmental interaction elements such as maps and navigation, interactions with natural elements, and ecological observations of specimens. In the game, players can collect some of these plants and animals as specimen-like items in the system. There is also a combat and evasion interaction mechanism. Please generate a simulated gameplay image that integrates all these interaction elements I just described. (2) I would like to create a VR game. Please generate a simulated AR effect image that combines all the content and interactive elements I just described, ensuring they are integrated into a cohesive visual design. (3) Try to describe the details of Scene One in more depth and integrate them better with the popular science and production of the roof tiles, to avoid the content feeling fragmented

	like two separate themes.
	(4) Please explain in detail this sentence: “He will use the selection of different ingredients and cooking methods as an analogy for the selection of materials and processes in roof tile production.” How can the roof tile production be linked to the selection and preparation of ingredients? (5) I haven’t thought of a suitable artifact for the third step involving drumming and playing wind instruments. Could you suggest an appropriate cultural artifact for this game and describe how it could be combined with the overall gameplay process to create a coherent experience? (6) “The Wild and the City: Traces of Nature Beneath Skyscrapers”, how can this theme be integrated with the concept of the Guardian to create a more sophisticated and cohesive design that unifies both ideas?
Contextual simulation prompt (P04)	(1) The game should include a dining scene where the master craftsman making the roof tiles sits with apprentices (the players) to eat before starting work, while providing educational explanations. The meal should feature authentic Six Dynasties recipes. (2) Please write additional lines of dialogue for players to urge their teammates during gameplay to create a tense atmosphere, and briefly describe the scenario in which these lines would appear. (3) If you want participants to quickly experience the Zenghouyi Bells through VR, what are some effective ways to limit each person’s usage time to two minutes?
Stepwise narrative prompt (P05)	(1) Based on the three worldviews and three storylines you just described, please list the necessary interaction elements step by step. (2) There is a VR device that first features a display screen for visitors to choose the type of virtual porcelain they want to create. Next is a series of touch buttons that guide visitors through specific production actions, such as crushing, washing, and sifting the clay, and shaping the porcelain using molds or handcrafting. Then, VR imaging shows the process. Finally, gesture interactions allow visitors to select glazes and decorations before placing the virtual porcelain into a kiln for firing. (3) Regarding the level design of the game, for example, which artifacts should be used first and which ones later to connect the storyline, please provide a step-by-step solution plan. (4) I haven’t figured out how the interaction in the fourth step of the game should work. Please describe the entire process in detail, step by step, without being too brief. (5) For the game’s review stage, please design the final level and rewards step by step.
Role-driven prompt (P06)	(1) I need to refine my idea. In this game, the roles are characters related to museum content. For example, in a natural history museum, the protagonist could be an explorer; in a cultural relics museum, the role could be an archaeologist or a scholar; in an art museum, I would like the role to be a restorer. Based on these three roles, please refine three different worldviews and storylines. (2) Using licorice as the protagonist, who sets out to find companions and defeat viruses together, please design the game mechanics and content. For example, which other medicinal herbs can be combined with licorice to overcome common viruses and colds? The difficulty should progress from easy to hard, with rich content, varied gameplay, and concise, engaging design.

	(3) For a popular science game using astragalus as the main character, please design the storyline, game mechanics, and content. The design should be concise, clear, and logically coherent. (4) Let the role that the user plays be a more mysterious and dynamic character. Please also design tasks and background stories that highlight the unique traits of this role. (5) The game should include puzzle-solving elements and a first-person perspective. Based on this character, please design appropriate tasks and challenges.
Multi-sensory fusion prompt (P07)	(1) Yes, what you described are general interaction plans. What I want are specific forms of interaction, such as eye-tracking, haptic feedback, voice communication, and other hardware-based VR experiences. (2) I want to create a VR popular science game to promote the Zenghouyi Bells. I hope to deliver an immersive exhibition experience through multi-sensory interactions. Please design a complete VR game plan for this purpose. (3) Could you provide a more detailed explanation of the haptic interaction methods used with controllers in the VR game?
Reflective co-creation prompt (P08)	(1) Yes, I think you have provided an answer, but based on your previous response, I would like this site to be the existing Yinxu Museum. Which specific area in this museum would be most suitable for creating this VR experience? (2) I am concerned that your plan may have cultural sensitivity issues. For example, your proposal to freely manipulate the colors and figures in the murals could offend local heritage institutions or violate cultural preservation principles. From the perspective of cultural protection and local community perception, could you identify these potential issues one by one and propose appropriate warnings? (3) What you just mentioned reminded me, could we make this cold, inanimate bronze artifact come alive? For example, design a cartoon or personified character that acts as a guide to help visitors experience Sanxingdui culture, or simulate its transformation from clay into a bronze object. What do you think?
Future adaptive prompt (P09)	(1) In the next year, as this game enters markets in different countries, please predict how cultural differences will affect the acceptance of game content, differences in user interaction preferences and behavior patterns across cultural backgrounds, and variations in regulations and privacy protection requirements.