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The psychological effect of gamification mechanism in XR immersive environment on user willingness to behave

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Abstract. With the rapid landing of Extended Reality (XR) technology in the fields of architecture, education, medical and other fields, how to effectively guide user behavior through interaction design and content mechanism has become the core topic of human-computer interaction research. This paper examines how gamification mechanisms in an XR immersive environment influence users' behavioral intentions. Drawing on self-determination theory as the overarching framework and incorporating spatial narrative structure and the Octalysis framework, it systematically examines the mediating roles of the three basic psychological needs—autonomy, competence, and relatedness—in the immersive experience. The study uses a combination of literature review and theoretical analysis, and constructs a theoretical model of "gamification elements → psychological needs to meet → willingness to act" through the depth analysis of typical XR cases such as medical training, building space guide, safety education and other types of XR cases. The study suggests that XR's distinctive sense of presence and interactivity may amplify the psychological effects of gamification drivers, such as a sense of mission and progression, while excessive competition and manipulative design may undermine intrinsic motivation.

Keywords: XR, gamification, self - determination theory, willingness to act, human-computer interaction

1. Introduction

Extended Reality (XR) technology has made significant advances in recent years at both the hardware and content levels, from early entertainment games to specialized areas such as architectural visualization, medical simulation, education and training and mental health intervention. However, technological level immersion is not naturally equivalent to optimization of user experience and the achievement of behavioural goals. A large number of practices show that the user's continued use of XR environment, learning effects and behavior changes depend more on the design quality of content mechanism and psychological motivation, rather than simply the picture reality or interaction accuracy.

In the field of gamification research, elements such as points, badges, progress feedback, narrative tasks and other elements have been confirmed to effectively improve user engagement in the two-dimensional interface [1], but the psychological mechanism in the 3D immersive space is still lacking in systematic discussion. Many existing studies focus on usability tests of individual interaction modalities, such as gestures or eye movements, while rarely integrating gamification mechanisms, spatial narratives, and XR-specific

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features into a unified psychological model. At the same time, although the field of architecture and environmental psychology has appeared in the field of XR space guided tours and behavioral guidance, there is still a lack of empirical explanations for user intrinsic motivation changes.

Based on the above research gaps, the study focuses on the theory of self-determination [2, 3] as the core perspective and integrates eight core drivers in the octagonal behavior analysis method [4], and presents two research questions: first, examining how gamification elements in XR environment influence users' behavior by satisfying autonomy, competence and relatedness; and second, exploring the regulatory or intermediary role of space narrative structure in the process. The study aims to build a psychological driven model for XR immersion scenarios, with a view to providing theoretical guidance for interdisciplinary XR application design such as psychology, human-computer interaction and architecture, while also reflecting on the ethical dimension of potential addiction and manipulation risks [5].

2. The core concept and theory foundation

Virtual Reality (VR) creates a fully immersive virtual environment in which users are isolated from the physical world; Augmented Reality (AR) overlays virtual information onto the real world, allowing the two to coexist without direct physical interaction; Mixed Reality (MR) makes the virtual object and the real-time physical interaction; XR is the general term covering the first three. In terms of hardware, VR requires all-enclosed headsets, AR/MR uses transparent glasses or mobile phone cameras, and MR extra requires high-precision space perception capabilities. In the interactive dimension, the three evolved from the handle operation to the natural interaction such as gestures, eye movements, voice, etc., but VR is limited to fixed space, AR/MR can be freely combined with the real scene. These technical features determine the difference in the path of influence of different XR morphologies on the user's psychological experience.

Gamification refers to the application of game-design elements, such as points, badges, tasks, and progress feedback, to non-game contexts [1]. The Octagon Behavioral Analysis method proposes eight core drivers: mission, progress, creativity, sense of ownership, social impact, scarcity, unperception and avoidance of loss [4]. Self-determination theory explains how gamification works from a psychological perspective [2, 3] – when autonomy ("This is my own choice"), competence ("I can get it") and relatedness ("I have a connection with others") are met, the inner motivation of a person is activated and the behavior is no longer dependent on external rewards. Two theories complement each other: the octagonal model provides a design toolbox, and the self-determination theory explains the mechanism of psychological action.

Space narratives are divided into branch narratives and environmental narratives [6, 7]. Branching narratives allow users to participate in story progression through choices at key narrative nodes, whereas environmental narratives rely on objects, lighting, sound, and other cues within the environment to convey information without explicit exposition. In XR environments, the unique value of space narrative lies in its emotional involvement effect with the presence of sensation, users drive stories through their own actions, and the binding of behavior to consequences can promote attitude change and behavior change than passive acceptance of information.

Immersion biases technical level (resolution, delay, interaction accuracy), whereas presence refers more specifically to the psychological experience of "feeling" that one is actually in a particular environment [8]. The sense of presence itself is a neutral tool, and the design that can be enlarged can also amplify the design of the ring [9]. The contribution of the presence to three major needs is to make social connections more real (relatedness), make physical action feedback more natural (competence), and make space choice more

autonomous (autonomy). But excessive stimulation or improper design can make the magnification effect anti-user psychological experience.

3. XR gamification affects the core path of user psychology

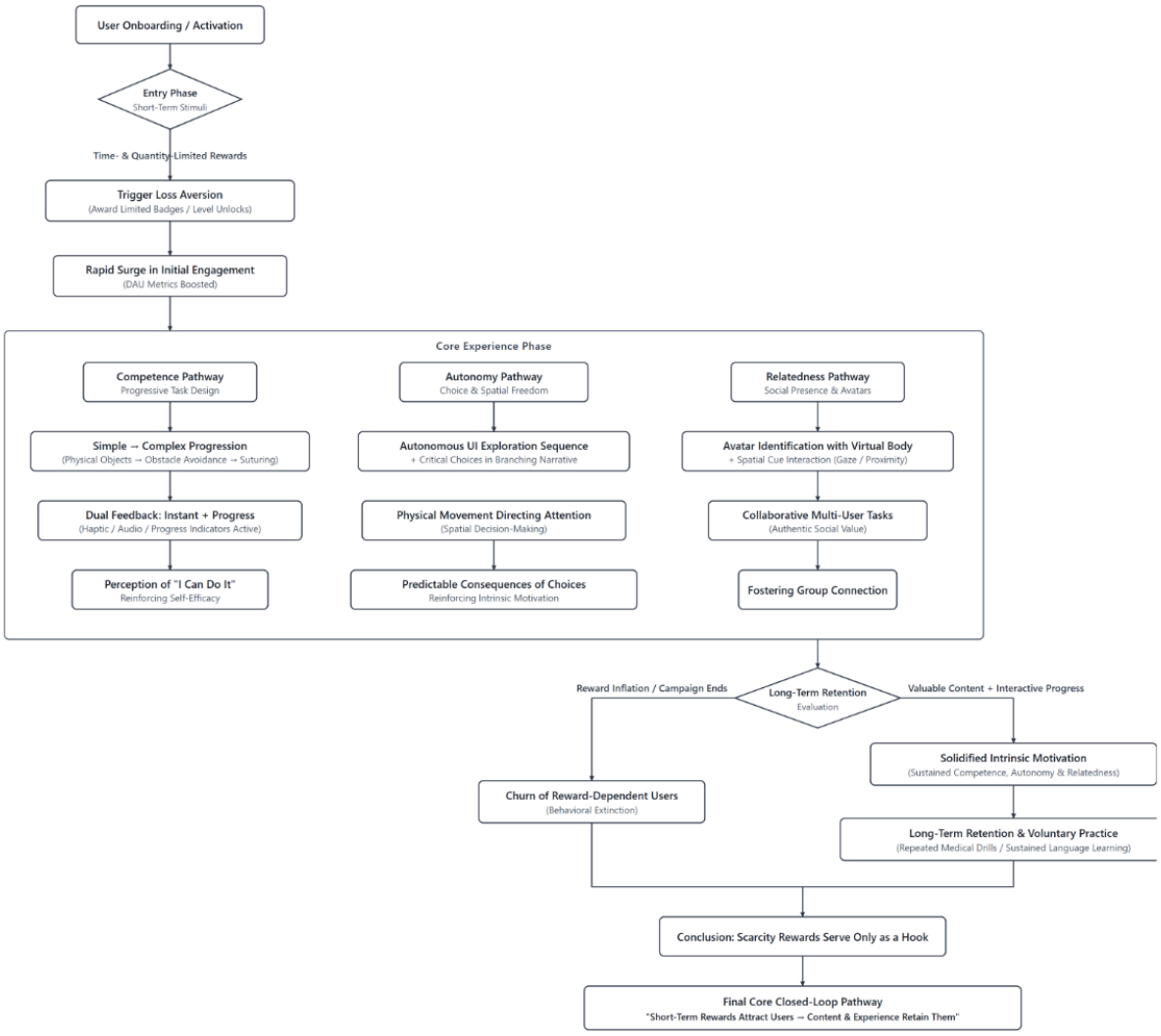


Figure 1. The core path of XR gamification

As shown in the above Figure 1, the core path of XR gamification affecting the psychology and behavioural willingness of users can be summarized as: gamification elements and space narratives by satisfying the sense of autonomy, competence and relatedness, thus affecting the user's willingness to behave; the temporary and physical interaction has a magnifying effect on the process, while excessive stimulation may limit its effectiveness.

3.1. Task and feedback → sense of competence

Progressive task design allows users to transition from simple operations to complex combinations, adding only a small amount of difficulty each step to avoid initial setbacks. Instant feedback (such as handle vibration, space sound) establishes a tight coupling of "action-result" to allow users to continue to perceive the effectiveness of their own actions; progress feedback (such as level completion, the indicator on the virtual wall) allows users to see the overall progress, strengthen the "I can" judgment. Too frequent or false feedback can weaken the sense of competence [2, 3]. For example, in XR-based medical training, a laparoscopic surgical simulator provides a representative case [10]. The training begins with the simplest task, "clamping an object into a specified position," accompanied by slight vibration feedback and a "completed" prompt. It then gradually progresses to more complex tasks, such as clamping a target in a constrained environment, avoiding obstacles, and eventually performing complete suturing. Each stage completed, the corresponding organ icon on the progress panel will light up. This ladder design allows medical students to clearly sense that "I'm progressing" and that competence is continuously fed, so they'll be willing to practice repeatedly until they're skilled.

3.2. Options and branch narrative → sense of autonomy

The choice at the interface level allows users to decide the order of exploration, while the branch narrative gives users the power to influence subsequent development at key nodes [6, 7]. When users see predictable consequences of their choices, the intrinsic motivation is reinforced [2, 3]. Space freedom in XR environments further expands the source of autonomy – users choose the object of concern through the body moves, a natural spatial decision making is more psychologically convincing than menu selection.

3.3. Social presentation and incarnation → sense of relatedness

Avonism enables users to see the virtual body as an extension of their own in the digital space [11], and social visibility gives real social value to interactions in multiplayer XR scenes. Spatial cues (such as line of sight, space distance changes) generate a sense of social presence that is much stronger than video calls [8], and the design of joint tasks further enhances the sense of group connectivity [3].

3.4. Scarcity rewards → short-term stimulus

Time-limited rewards leverage loss aversion to rapidly increase short-term participation rates [12] and may serve as an initial engagement mechanism during users' early stages of participation. But the scarcity reward does not meet any basic psychological needs [2, 3], and long-term dependence leads to reward inflation, which can even trigger an addiction once the reward stops user behavior subsequently. Its correct positioning is as an entry tool, gradually exit after the user builds the intrinsic motive. Today, many VR language learning applications are typical [13]. The new user logs in three days before registering, sending a limited-defined virtual badge daily, and unlocking additional practice levels. This mechanism can increase users' initial level of daily engagement. But three months later, data showed that the main reason for the use of those who remained to continue was that "the content of the course really was useful and interactive made me feel progressive" rather than because the badge was still being pursued – because the restricted activity was gone. This case shows that the scarcity reward is only responsible for bringing people into the door, and the real thing is the content itself.

4. The psychological effect amplification mechanism of XR environment and its boundaries

4.1. How to strengthen the psychological shock of gamification

When users perceive virtual scenes as real environments [9], the sense of accomplishment associated with completing a task is no longer limited to the experience of "clicking a button," but can become a more embodied experience of "actually accomplishing something." The sense of urgency in crisis situations and the sense of relief after task completion may both be intensified by the sense of presence. However, the sense of presence can also amplify negative experiences [9]. Frequent interactions that conflict with users' expectations may abruptly disrupt immersion and make it difficult to recover, suggesting that users may have less tolerance for interaction errors in XR than in conventional two-dimensional interfaces.

4.2. The combination of physical interaction to satisfy the needs

Users complete the operation through gesture grab, turning head observation, bending over picking up and picking up, and the action itself is the implementation of the intent. This "action-intent consistency" makes the sense of competence more solid, and the consolidation of physical memory is far more intense than pure visual learning [14]. The freedom of movement at the space level reinforces the sense of autonomy in the natural state. However, if the system forces the user to walk in a fixed order and trigger the plot in turn, even if the body moves, the sense of autonomy will still be destroyed.

4.3. Emotional involvement of spatial narrative and immersion superposition

Users choose, bear consequences, experience emotional fluctuations in narratives, and behavioral change is motivated by emotional memories of personal experience rather than informed rationally [7]. This cycle of "choice → consequence → emotion → re-selection" is well designed to effectively shape behavior while protecting the sense of autonomy. However, if the narrative causality is far-fetched or the consequences are excessively exaggerated, the user will form a defensive mentality, and the emotions are involved in the immediate break.

4.4. Risk of overstimulation: enlarged boundaries

The immersive experience of XR itself has consumed a lot of cognitive resources, and oversuperimposed gamification stimuli can lead to cognitive overloading. Newcomers, technology anxiety, high-sensitive populations and older adults have significantly lower tolerance to stimulation than experienced users. Excessive stimulation may undermine the three basic psychological needs in different ways [15]: frequent reward prompts may erode the sense of autonomy; an inconsistent difficulty curve may undermine the sense of competence; and excessive competition may weaken the cooperative atmosphere and, in turn, reduce the sense of relatedness. Zooping is a double-edged sword – it magnifies the effect while also amplifying the risk. An XR fitness app is used by users to spit out "too tired, not the body tired, is the heart tired". It also superimposes a variety of stimulus elements such as countdown, calorie rankings, hit hits, and limited-time double points. Newcomers often feedback: "I haven't figured out how to do it, there are four prompts on the screen that feel bombed." The loss rate also confirms this – the seven-day retention rate for new users is much lower than that of similar design more restrained products. This is the typical consequence of overloading of cognitive overload under the presence of excessive stimulation.

5. Conclusions

Based on the theory of self-determination [2, 3] and combined with the theory of space narrative [6, 7] and the framework of octagonal behavior [4], this paper systematically combed the psychological path of gamification mechanism in XR immersion environment affecting the user's willingness to behave. The following three conclusions are drawn:

First, the effectiveness of gamification elements in immersive XR environments may depend largely on the extent to which they satisfy the basic psychological needs for autonomy, competence, and relatedness [2, 3]. Step-style tasks and instant feedback mainly support the establishment of competence, selection and branch narrative maintain the user's independent experience, social situations and virtual avatars inspire the sense of belonging [11]. In contrast, limited-time rare rewards can only provide short-term external stimuli, not meeting any inner psychological needs, and long-term dependence can instead lead to reward inflation and motivation to fade [15]. XR's presence and physical interaction significantly amplify the above psychological effects [8, 9, 14] – good design will be magnified better and poor design will be magnified worse, a finding that designers must be highly sensitive to interaction details and quality.

Second, space narrative in XR experience is not only a carrier of information transfer, but also a function of regulating user's independent experience and behavior input [6, 7]. Branching narratives allow users to perceive the consequences and meaning of their actions through choices at key narrative nodes, while environmental narratives rely on clues in the scene to guide cognition and emotion. In the application scenarios such as building space guide, safety education and other scenarios, the synergistic design of narrative and gamification is more effective in guiding target behavior than a single mechanism. However, the causal relationship of the narrative must be reasonable, otherwise the user will form a defensive mentality, and the emotional involvement effect immediately breaks.

Third, the ethical bottom line of XR gamification design is to distinguish between "guide" and "manipulation". The guided approach is to inform the rules that leave decision-making power to users; manipulation uses loss aversion [12] and social stress to compress user choice space. XR's sense of presence reduces the psychological defense of people, and manipulative design in this environment is more harmful. The paper proposes four operational principles: transparency of rules, freedom of withdrawal, protection of vulnerable groups, long-term wellbeing orientation, which provides a basic framework for specific ethical decisions.

At the theoretical level, this paper connects gamification research in XR human–computer interaction with psychological theory and proposes an integrative model that can be examined through future empirical research. At the practical level, the proposed framework provides design guidance for XR applications in education and training, architectural behavior guidance, and health management.

References

[1] Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness: Defining "gamification". In *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments* (pp. 9–15). Association for Computing Machinery. https://doi.org/10.1145/2181037.2181040

[2] Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry, 11*(4), 227–268.

[3] Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55*(1), 68–78.

[4] Chou, Y. K. (2016). *Actionable gamification: Beyond points, badges, and leaderboards*. Octalysis Media.

[5] Werbach, K., & Hunter, D. (2012). *For the win: How game thinking can revolutionize your business*. Wharton Digital Press.

[6] Ryan, M. L. (2001). *Narrative as virtual reality: Immersion and interactivity in literature and electronic media*. Johns Hopkins University Press.

[7] Ryan, M. L. (2015). *Narrative as virtual reality 2: Revisiting immersion and interactivity in literature and electronic media*. Johns Hopkins University Press.

[8] Slater, M., & Wilbur, S. (1997). A framework for immersive virtual environments (FIVE): Speculations on the role of presence in virtual environments. *Presence: Teleoperators and Virtual Environments, 6*(6), 603-616.

[9] Slater, M. (2009). Place illusion and plausibility can lead to realistic behaviour in immersive virtual environments. *Philosophical Transactions of the Royal Society B: Biological Sciences, 364*(1535), 3549-3557.

[10] Marescaux, J., Clément, J. M., Tassetti, V., Koehl, C., Cotin, S., Russier, Y., Mutter, D., Delingette, H., & Ayache, N. (1998). Virtual reality applied to hepatic surgery simulation: The next revolution. *Annals of Surgery, 228*(5), 627–634. https: //doi.org/10.1097/00000658-199811000-00001

[11] Heng, S. P., Zhou, Z. K., & Sun, L. J. (2017). Avatar identification in video games. *Advances in Psychological Science, 25*(9), 1565–1578.

[12] Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica, 47*(2), 263–291.

[13] Dehghanzadeh, H., Farrokhi, M., & Pourali, S. (2021). Using gamification to support learning English as a second language: A systematic review. *Computer Assisted Language Learning, 34*(7), 934–957.

[14] Kilteni, K., Groten, R., & Slater, M. (2012). The sense of embodiment in virtual reality. *Presence: Teleoperators and Virtual Environments, 21*(4), 373–387.

[15] Deci, E. L., Koestner, R., & Ryan, R. M. (1999). A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation. *Psychological Bulletin, 125*(6), 627–668.