Proceedings of CONF-MLA 2025 Symposium: Intelligent Systems and Automation: AI Models, IoT, and Robotic Algorithms
DOI: 10.54254/2755-2721/2025.LD30428

Immersion and Memory Effects of Explicit and Implicit Gamification in VR Applications

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Abstract. This present study comprehensively explored the differential effects of implicit and explicit gamification techniques upon user immersion and information retention, immediate and delayed, in virtual reality (VR) educational contexts. A 2×2 mixed experimental design was executed involving 40 college-aged students (18-25 years) who were randomly assigned to either the explicit gamification (n = 20) or implicit gamification (n = 20) condition. Subjects participated in learning activities in the VR exhibition hall built in Unreal Engine. Data was gathered using the Internet Experience Questionnaire-Short Form (IEQ-SF) immersion questionnaire and memory tests, and analyzed with independent samples t-tests, mixed design ANOVA, and bootstrap mediation analysis. Results suggested that the implicit gamification condition resulted in significantly greater immersion scores than the explicit group. No significant difference was found in the immediate recall test, yet the implicit group did significantly better in the delayed recall test. Mediation analysis suggested that immersion significantly correlated with and partially mediated the relationship between manipulation of gamification strategy and delayed memory. Results suggested that implicit gamification designs, as compared to explicit reward-based designs, produce a heightened degree of immersion in the VR experience and thus greater long-term retention of information.

Keywords: Virtual Reality, Explicit Gamification, Implicit Gamification, Immersion, Memory Effect

1. Introduction

With increasing interest in virtual reality technology, issues of user commitment and the effectiveness of instructional methods through gamification have been the focal point of much research [1,2]. Particularly, this area has been the emphasis on information recall of the external motivation factors of explicit gamification features such as point systems and leader boards [3]. However, the literature about information retention of VR, information retention of environments, or a written summary of the results of the intentional and instantaneous immersion of environments is still in need of systematic study and empirical evidence [1-3]. This neglect has, in fact, unnecessarily

DOI: 10.54254/2755-2721/2025.LD30428

limited the conceptualization of DVR with respect to the understanding of the different methods of gamification and gamified VR systems, regarding psychological or thought responses of users to them [4,5]. Filling this gap presents a large void which could lend significant understanding to the instructional design of gamified environments or virtual reality systems, if one adjusts for the understanding of user satisfaction and/or enhances users' recall of information [5,6]. The present research is aimed at filling theoretical gaps in connection with the representation of implicit and explicit gamification features with respect to immersion and information recall in VR scenarios, through an experiment. This research is to be centered around the following three research questions.

RQ1: What differences exist in the level of explicit and implicit gamification to a user's immersion in VR applications?

RQ2: What differences exist in the effects of explicit and implicit gamification on a user's immediate and delayed recall in VR applications?

RQ3: What role does user immersion play in the mediating effect of gamification strategies on the delayed recall of users?

This research implements a hybrid experimental approach concerning the Virtual Reality (VR) exhibition context which is developed in Unreal Engine. Participants will accomplish surveys, questionnaires, and learning tasks performing under varying degrees of immersion and gamification. It is posited that internal, implicit gamification (e.g. autonomy and flow) will produce deeper immersion and enhanced memory retention than surface-level gamification [7,8], given the same context. The results will help in determining appropriate gamification methods for specific educational objectives, maximizing the educational effectiveness of VR experiences.

2. Related works

In the fields of educational technology and cognitive science, the integration of virtual reality (VR) into gamified learning has emerged as a key area of research. It is based on a central proposition: that because it encourages active, immersive participation and deep engagement, it can enhance the motivation to learn and the retention of long-term memories. This section is about this. It is a synthesis of the relevant literature on gamified approaches to education, the cognitive psychology of attention that is engaged and absorbed, and the empirical literature on VR and memory. This will sharpen the focus and articulate the unique contribution of this work.

2.1. Gamification strategy: the differentiating effect of explicit and implicit design

The analysis of design strategies in gamification is approached through a graded spectrum, which ranges from an implicit form of gamification to an explicit one. The literature has been more focused on external explicit gamification through external visible reward structures that promote user interaction through points badges and leader boards [9]. These designs do improve engagement and are inclined towards promoting user response. However, an implicit gamification approach, which is narrative design, embedded designs, environmental feedback, and character interaction, appears to offer a greater promise for sustained engagement and deep learning [10]. The literature has pointed to the existence of differential effects of the two strategies. For instance, Roth et al. found in a sports rehabilitation study that implicit feedback improved users' degrees of natural engagement more, while explicit feedback was more attention-grabbing for a short duration [11]. Voinescu and David have also pointed out that in VR, explicit and implicit memory collaborate on different task types, thus performing the role of complements [9]. However, the gap in the literature is the systematic investigation of the two strategies of gamification on a single VR learning task, and their differential impacts on memory across different time dimensions (immediate and delayed).

2.2. Immersion in VR and its psychological mechanisms as a learning catalyst

The application of virtual reality (VR) technology in education has great benefits in education [12]. Working in an immersive world, as shown in Bujić et al. [13], provides students with a flow experience, which significantly improves their educational process. Flow taken together with immersion creates a state in which students can enhance their retention of contextual memory, as presented in Safari Bazargani et al. [14]. Retention in this case is a direct result of the engagement in VR educational games, as listeners are likely to remember more of the information presented in a game than in a class. Overall, this highlights the tremendous potential that VR immersive activities have in retaining contextual memory, while also showcasing the positive aspects of learning games.

2.3. Empirical basis of VR and memory preservation

The possible advantages VR can offer to memory retention have been attested to by various practical research works. As an instance, Ijaz et al. immersed learners in a VR setting to gauge their ability to memorize spatial layouts [15]. Redlinger et al. discovered that the inclusion of visual elements in a game can enhance performance on working memory tasks in virtual reality [16]. More specifically, Zhang and Robb's research noted that the immersion of participants in a game and the inclusion of gamification in the study can tremendously enhance performance on tasks that require memory recall [17]. These researchers, among others, have substantiated that VR cognitive training and educational tools have shifted from anecdotal to verifiable facts regarding retention ability within learners. Nonetheless, most of the memorization works in cognitive psychology and VR gamification; still literature is focused on immediate recall. In VR literature, the integration of gamification and VR has been extensively researched. The inclusion of both explicit and implicit gamification on the same level of VR immersion in relation to memory retention (immediate and delayed) is still an open area for further research inquiry. Many researchers on retention of virtual reality emanate memory from motivation, immersion, or primary level gamification, thereby failing to acknowledge the distinct memory-counting moments of the other tier gamification strategy.

Hence, this study seeks to address this issue by meticulously exploring the differential effects of explicit and implicit gamification on user immersion, immediate memory, and delayed memory in VR spaces, alongside immersion's potential mediating effects, using robust experimental frameworks.

3. Research design

3.1. Experiment design

This study adopts a 2 (gamification strategy: explicit vs. implicit) × 2 (testing time: immediate memory vs. delayed memory) mixed experimental design. Among them, the gamification strategy is an inter-group variable, and participants are randomly assigned to either the explicit gamification group or the implicit gamification group; the testing time is an intra-group variable, and all participants are required to complete both immediate and delayed memory assessments.The study aims to systematically compare the differential impacts of two different gamification strategies on users' sense of immersion and information memory in a VR learning environment.

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3.2. Participant

A total of 40 college students (aged 18–25) were recruited for this experiment. All participants had no history of severe VR motion sickness and had less than 2 hours of previous VR usage experience to avoid learning effect bias caused by prior experience on the experimental results.

After participants voluntarily signed the informed consent form, they were randomly assigned to either the explicit gamification group ($n = 20$) or the implicit gamification group ($n = 20$)using a random number generator. Balance between the two groups of participants was achieved with respect to baseline characteristics such as age, gender, and familiarity with VR.

3.3. Experimental materials and environment construction

3.3.1. Hardware and development platform

The experimental hardware includes the Meta Quest 3 head-mounted display (monocular resolution: 1832 × 1920, refresh rate: 90Hz, field of view : 100°), with the original controller supporting 6 degrees of freedom (6DoF), allowing participants to navigate the environment with natural head movements through hand actions. The virtual 3D learning scene was developed based on Unreal Engine 5.4. The project uses the built-in NVIDIA PhysX physics engine and Chaos rendering system to ensure the authenticity of environmental interactions and visual authenticity. The scene assets were built using Unreal Fab's standard 3D model library, to ensure efficiency in development and consistency with visual style.

3.3.2. Virtual learning scenarios

The virtual environment simulates a real exhibition hall, which consists of two themed exhibition areas: Scene1 (Sculpture Exhibition Area) and Scene2 (Oil Painting Exhibition Area).

1) Sculpture Exhibition Area (Scene 1): There are 10 sculptures placed in the exhibition hall and there is enough distance left between the exhibits for the participants to facilitate a complete 360-degree observation of them all ways.

2) Oil Painting Exhibition Area (Scene 2): There are 10 oil paintings placed in the exhibition hall, and their spatial positions correspond to those of the sculptures in the sculpture exhibition area, to ensure that the observation points and potential movement paths of the two groups of participants are basically consistent.

To ensure a high degree of consistency between the two groups of experimental environments and reduce behavioral deviations caused by spatial differences, this experiment adopts a standardized open single-room layout (rectangular exhibition hall). The entrance and exit are set at both ends of the same wall, guiding users to naturally form a "U-shaped" visiting flow. The 10 exhibits are evenly distributed along this preset path.

3.3.3. Control of learning content

The learning content for the two groups of participants was completely identical. The interaction method was uniformly set as follows: when a participant's handle touched (or approached) an exhibit, the system would automatically trigger a voice narration, introducing the name of the artwork and its creative background to the participant. In addition, the number of exhibits for both groups (10 in total), the information presentation method (text + voice), and the total exploration time were all kept consistent. The total task duration was limited to 10 minutes, with the system automatically timing in the background and reminding participants with a soft prompt tone 30 seconds before the end.

3.4. Experimental conditions: operational implementation of gamification strategies

3.4.1. Explicit gamification group

This group (Scenario 1: Sculpture Exhibition Area) adopts an external incentive design based on a "task-reward" closed loop. Central to the operation of the system is a prop collection paradigm where learning tasks are called prop collection when props randomly appear at any sculpture's location, where participants should touch the sculpture (to launch learning materials) before props can be collected. On collecting a prop, the next new prop will be refreshed in another sculpture's location until all 10 props are collected. To provide real-time UI feedback, a semi-transparent UI panel (occupying about 10 % × 15 % of the visual field) is permanently displayed in the top right of the HMD view of the participant and this panel will feature a prop counter that is kept current, that shows the props gained (i.e. 'Gained: 8/10), a blue-filled progress bar that increments by the amount of props collected (0% - 100%), and a badge achievement icon that will be opened and shown under the counter after the collection of the first prop. Finally, after 10 minutes (or else) exploration of the experience, or a completed collection of 10 props the system should, immediately, open a ranking interface (10 seconds duration) that increases the gamers' sense of visibility and competition by showing the score of the participant in that session, total time elapsed, and rank of percentage of players defeated (i.e. ' defeated XX% of players').

3.4.2. Implicit gamification group

This group (Scenario 2: Oil Painting Exhibition Area) promotes the intrinsic motivation of the participants through narrative embedding and dynamic environmental feedback, avoiding the use of scoring systems or rewards in UI form. Its basic functions are a narrative clue system presenting exploration activity as a narrative task of “awakening sleeping artworks”. Each interaction by participants is not aimed at gaining points, but rather at "lighting up" a piece of art, gradually restoring vitality to the exhibition hall.

At the same time, the system provides rich dynamic environmental feedback: in terms of light and shadow changes, the initial lighting in the exhibition hall is relatively soft. Every time a participant interacts with an exhibit (i.e., touches to learn), a brief, soft halo effect will emanate around that exhibit, and the overall ambient brightness of the exhibition hall will increase slightly accordingly. When all 10 exhibits are "awakened," the lighting in the entire exhibition hall will reach the brightest and warmest state. In terms of background sound effects, the initial scene only has slightly ambient sounds (such as the quiet wind indoors). Each interaction with an exhibit will add a soundtrack to the background music (for example, a piano note, a section of string music). When all exhibits are activated, these independent tracks will converge into complete and harmonious background music, creating a sense of fulfillment and accomplishment.

Regarding the feedback at the end of the exploration, after completing interactions with all 10 exhibits, the system does not display any ranking lists or scoring interfaces. Alternatively, a final environmental feature is introduced, which is that an abstract artistic light sculpture made of light particles will inhabit the centre of the exhibition hall. This light sculpture serves the purpose of being a meta reward for having completed the exploration. This will take the form of a slow dissipation of the light sculpture (lasting 10 seconds) symbolically rewarding exploration and

DOI: 10.54254/2755-2721/2025.LD30428

imparting the user with a non-utilitarian intrinsic satisfaction feeling together with a feeling of aesthetic satisfaction.

3.5. Experimental environment and process control

3.5.1. Environmental control

The experiment was conducted in an independent, noiseless laboratory (with its area ≥ 15㎡). The indoor environment was kept constant at a temperature of 24±2℃ and a humidity of 50%±5%. Anti-skid mats were put down on the ground to protect all the participants when they moved in VR. The laboratory was equipped with soundproof wool (with a noise reduction ≥ 30dB) to obviate interference from outside sounds.

3.5.2. Device and data control

To ensure hygiene, all head-mounted display devices are disinfected with 75% alcohol wipes before use, while each participant receives a disposable sweat-absorbing mask to keep them clean and reduce discomfort while using the equipment. Before the experiments are conducted with each participant, they first receive assistance from the experimenter in calibrating their interpupillary distance (IPD range 54 mm–74 mm) and setting the Oculus Guardian system to create a 2m × 2m safe gaming area on the ground. To avoid VR stutters affecting the effects of immersion, all the experimental devices are stripped of any unnecessary background processes to ensure that the frame rate (FPS) of the VR scene itself remains stable throughout the testing period at 90Hz, with fluctuations of this range controlled within ± 5 Hz. Additionally, the system records automatically in the background full detailed logs of user interactions as they occur, which include gaze point coordinates, number of controller button presses, and exploration path coordinates. Data is recorded at a sampling frequency of 1Hz, with the data exported in a CSV format, stored for subsequent analysis of the behavioral data.

3.6. Control variables and interference elimination

To control individual differences and prevent potential motion sickness, participants' VR usage experience and visual health status were collected as covariates via questionnaires before the experiment (table 1). For scene interaction, "teleportation" was adopted instead of smooth movement, and the camera rotation speed was limited to no more than 60 degrees per second. All participants signed the Informed Consent Form for VR Motion Sickness Risks and were allowed to pause the experience at any time if they felt unwell.

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Table 1. Explicit and implicit gamification elements and operationalization method

Dimensions	Explicit Gamification Group	Implicit Gamification Group
Core Mechanism	External, surface-level reward mechanisms that users can directly perceive	Intrinsic incentives embedded within narrative and environmental feedback loops
Psychological Basis	Extrinsic motivation (achievement, competition, recognition)	Intrinsic motivation (autonomy, curiosity, flow, emotional engagement)
Typical Elements	Points counter, progress bar, collection tasks, badges, leaderboards, and real-time score display	Narrative cues, environmental light/music feedback, progressive atmosphere change, symbolic completion events
Operational Goal	Encourage short-term goal pursuit and task completion through visible progress and competitive stimuli	Foster self-driven exploration, emotional resonance, and long-term cognitive engagement without overt reward cues

The gamification strategy (explicit = 1; implicit = 0) serves as the independent variable. The dependent variables are immediate memory and delayed memory (both measured as recall and recognition scored out of 100 the task as well as after one week). The level of immersion is described as the mediating variable. immersion is quantified as the IEQ-SF total score representing the five dimensions of the strategy (cognitive engagement, dissociation, challenge, emotional engagement, and the sense of control) of the gamification strategy, and its delayed memory outcomes.

3.7. Experimental process

The experimental protocol consisted of six successive steps to control potential order effects and ensure internal validity (figure 1). Participants provided informed consent and proceeded to screen for VR sickness susceptibility. Participants were then randomly assigned, via a random number generator, to the explicit or implicit gamification condition. Participants then proceeded to a 10-minute VR learning task, followed by the IEQ-SF immersion questionnaire and an immediate memory test. The delayed recall test occurred online one week later, within a 24-hour window. This sequential design adheres to standard practices in cognitive and immersion research using VR methodologies.

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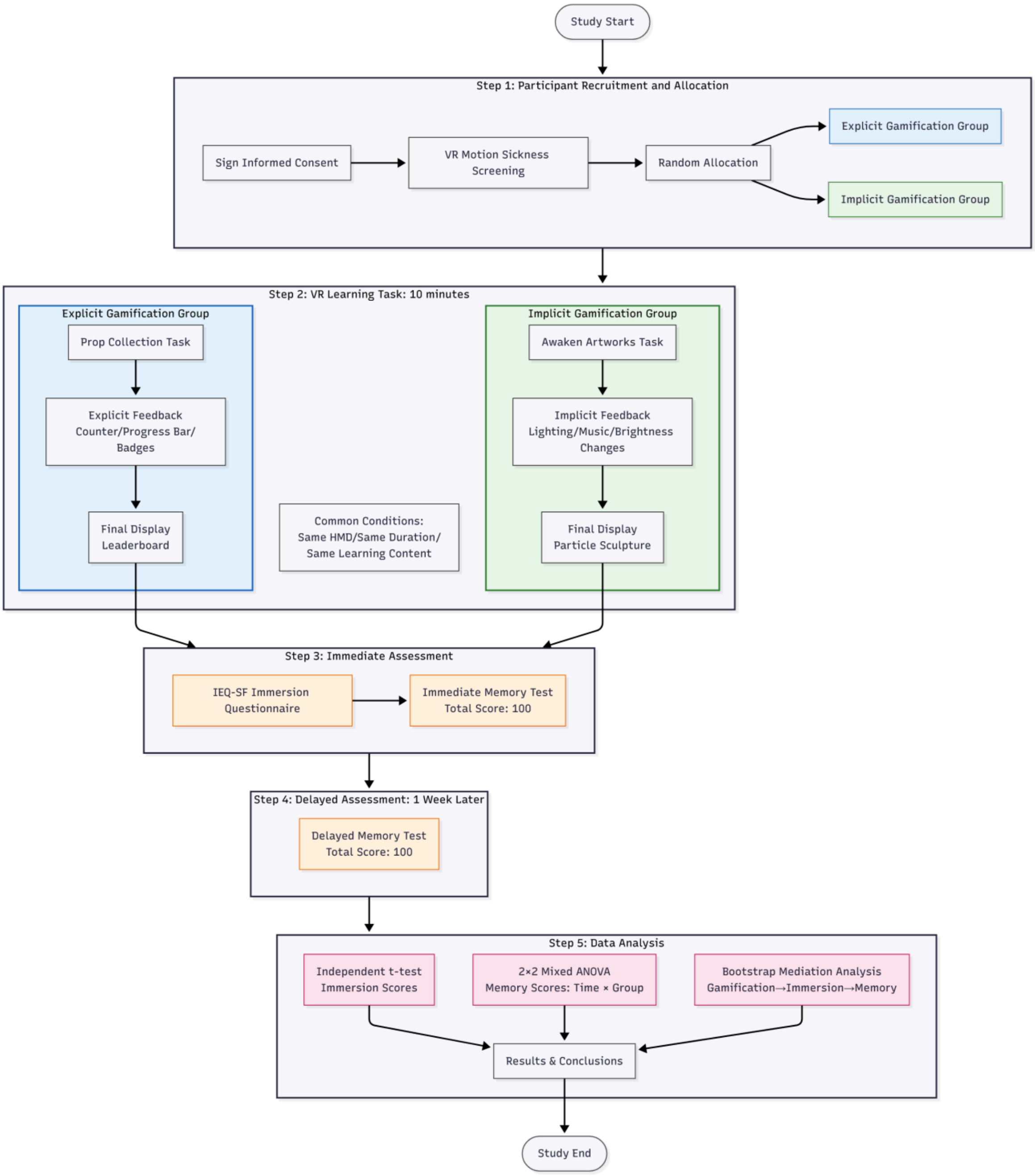

Figure 1. Experimental flowchart

3.8. Data analysis methods

All statistical analyses were conducted using IBM SPSS Statistics 26.0 and the PROCESS Macro 4.0. Immersion levels of the explicit and implicit gamified conditions were examined via independent samples t-tests on total IEQ-SF scores. A 2× 2 mixed design ANOVA was conducted to assess memory performance where the between subjects' factor was gamification (explicit/implicit) and the within subjects' factor was test timing (immediate/delayed). Where appropriate Bonferroni adjusted post hoc comparisons were conducted. In addition, a mediation analysis was conducted using a non-parametric bootstrap method with 5,000 resamples to investigate the indirect effect of

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immersion on the relationship between gamification and delayed memory performance employing established mediation modelling procedures [5,18,19].

3.9. Research ethics and controls

All experimental procedures were reviewed and approved by the Institutional Review Board (IRB) of the researcher's affiliated college, in accordance with the Declaration of Helsinki for ethical principles in human research. Participants were fully informed about the purpose, procedures, and potential risks of the study and provided written informed consent before participation. They were also informed of their right to withdraw from the experiment at any time without penalty. Figure 2 shows the experimental scene diagram.

In order to control against possible confounding variables, a number of control techniques were implemented. The experiment was performed under quiet, isolated circumstances that also restricted all possible external distracting variable influences. To control physiological variability, the subjects were instructed to avoid alcohol and caffeine at least twelve hours before experimentation. All VR devices were uniformly calibrated to guarantee that headset resolution, frame rate, and controller latency were constant throughout all subjects from session to session to guarantee an equivalent learning experience for all subjects. Finally, random assignment and standardized task instructions were utilized to control for learning and ordering influences. Table 2 shows explicit and implicit gamification and their psychological effects.

Table 2. Explicit vs. implicit gamification and psychological effects

Gamification	Definition	Typical Elements	Main motivation focus	Expected impact on participation/learning
Explicit Gamification	Reward mechanisms that users can directly perceive	Points bar, badges, leaderboards, mission objective hints, and countdown timer	External motivation (rewards, recognition)	Instant task completion, goal-oriented behavior
Implicit Gamification	Incentives hidden in narrative or environmental rules	Progressive plot, emotional threads, environmental feedback, adaptive difficulty, and autonomous choices	Intrinsic motivation (autonomy, mastery, purpose, flow)	Deeper immersion, sustained engagement, and long-term memory retention

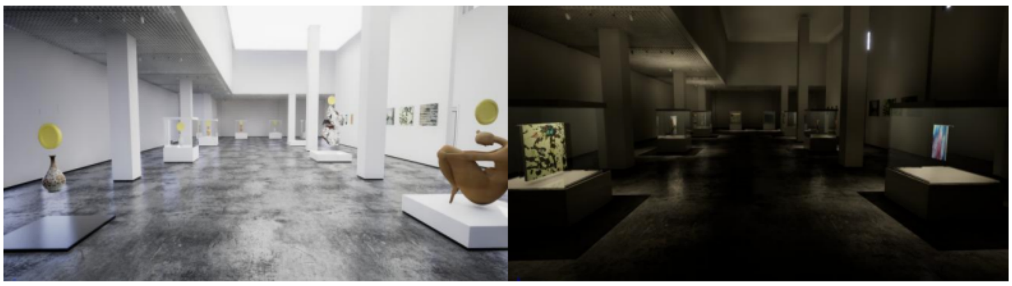

Figure 2. Experimental scene map

4. Experimental results

This study involved comprehensive analyses of forty valid respondents (twenty respondents in each bi-partite, explicit, and implicit). Comparison analyses on baseline characteristics of both cohorts

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was conducted using independent t samples analytic procedure on group metrication pairs in the question categorization group age parameterization base ($M\_explicit$ = 21.35, SD = 1.84 vs. $M\_implicit$ = 21.60, SD = 2.01; t (38) = − 0.45, p = 0.655) versus Virtual Reality (VR) experience ($M\_explicit$ = 0.85 hours, SD = 0.45 vs. $M\_implicit$ = 0.90 hours, SD = 0.50; t (38) = − 0.33, p = 0.743) and group remark verbalism experience time allotment participation base. Also, the results from the chi-square tests confirmed that the proportion of both samples divided by gender was the same $(\chi\,\hat{}\,2(1, N = 40) = 0.10, p = 0.752$), which suggests that the randomization in this study was successful and the baseline characteristics of both cohorts were synchronized.

4.1. Descriptive statistics

This paper carried out hypothesis tests only after conducting an overview statistical evaluation on all dependent variables. The average (M) and standard deviation (SD) of Immersion (IEQ-SF questionnaire score) and immediate and delayed memory scores for both explicit and implicit gamification groups are summarized in Table 3.

Table 3. Descriptive statistics for each group on the main dependent variable

Variable	Gamification Group	Participants Number (N)	Mean (M)	Standard Deviation (SD)
Immersive Experience (IEQ-SF)	Explicit Group	20	75.20	9.10
	Implicit Group	20	85.50	8.20
Instant Memory Score	Explicit Group	20	82.00	7.50
	Implicit Group	20	80.50	7.00
Delayed Memory Score	Explicit Group	20	65.00	8.00
	Implicit Group	20	75.00	7.80

4.2. RQ1: the impact of gamification strategies on immersion

To address RQ1, the study employed an independent sample t-test on the total scores on the IEQ-SF questionnaire obtained from the two groups.

The means and standard deviations the authors reported were as follows: implicit gamification ($M = 85.50, SD = 8.20$), whereas for the explicit gamification, ($M = 75.20, SD = 9.10$). The differences were statistically significant. $t(38) = -3.98, p < 0.001, Cohen\text{'}sd = 1.26$. This suggests that implicit strategies are more effective than explicit ones in gamification as they increase user immersion in VR.

4.3. RQ2: the impact of gamification strategies on immediate and delayed memory

In addressing RQ2, this study utilized a 2 (group: explicit vs. implicit) × 2 (test time: immediate vs. delayed) mixed ANOVA.

Main Effect:

Participants' memory scores significantly declined between the immediate ($M = 81.25$) and the delayed test ($M = 70.00$) with the instant memory test scores considered, regardless of the gamification condition administered. This is evident as the study notes that the main effect of test time $F\,(1{,}38) = 85.22, p < 0.001, \eta_p^2 = 0.69$ was highly significant. Mean memory scores did not significantly differ between the explicit and implicit groups, as the main effect of gamification group

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was not significant $F(1{,}38) = 1.15, p = 0.290, \eta_p^2 = 0.03$, thus implying that memory scores did not differ with respect to both time frames.

Interaction Effect:

The interaction effect between group and test time was significant $F(1{,}38) = 12.50, p = 0.001, \eta_p^2 = 0.25$, which is important. This suggests that the effect of the gamification strategies on memory is not the same at both immediate and delayed time points.

Post-hoc Comparison (Bonferroni Correction):

The simple effects analysis has an interaction effect analysis focus. In the immediate memory test, the performance of the explicit group ($M = 82.00, SD = 7.50$) and the implicit group ($M = 80.50, SD = 7.00$) was not statistically significant ($p = 0.550$) within the defined boundaries of the interval. During the delayed memory test, the performance of the explicit group ($M = 65.00, SD = 8.00$) was significantly lower compared to the performance of the implicit group (M =75.00, SD = 7.80) and brought about some statistically significant distinction ($p = 0.002$), which was astonishing.

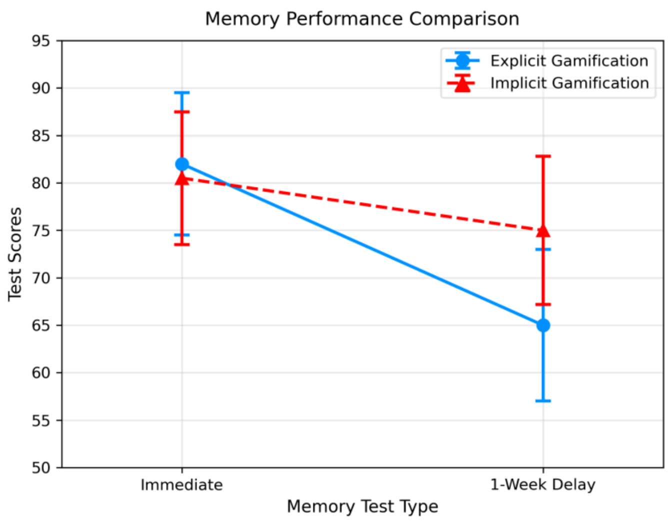

Figure 3. Interaction effect of gamification strategy and test time on memory score

The two categories were fairly balanced in immediate recall, as shown in Figure 3, but after a week, the explicit group showed a noticeable decline in memory scores, while the implicit group maintained high scores.

4.4. RQ3: the mediating effect of immersion

In response to RQ3, the Bootstrap method was utilized to test the mediation effect involving gamification strategy, immersion, and delayed memory. The sample size was 5000, and the model consisted of a gamification strategy (independent variable, explicit = 1, implicit = 0), immersion (mediating variable), and delayed memory (dependent variable).

The data (see Figure 4) illustrates the following:

1). Path a ($X \rightarrow M$): Gamification strategy has a predictive immersion effect ($b = -10.30, t = -3.98, p < 0.001$) and is predictive (note the coefficient is negative, explicit = 1 and implicit = 0, thus greater immersion is in the implicit group).

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2). Path b ($M \rightarrow Y$): Gamification strategy controlled, immersion in the model has a significant positive predictive effect on the delayed memory ($b = 0.55, t = 4.20, p < 0.001$) and scores.

3). Path c' ($X \rightarrow Y$, direct effect): After controlling for the mediating variable of immersion. The Effects of Gamification on Delayed Memory are significant ($b = -4.34, t = -2.10, p = 0.042$).

Most notably, the indirect effect bootstrap 95% confidence interval (CI) for the effect $[-8.90, -2.45]$. Since 0 is not contained in this interval, it means immersion has a strong partial mediating effect on the relationship of gamification strategies and delayed memory (Indirect Effect=-5.67).

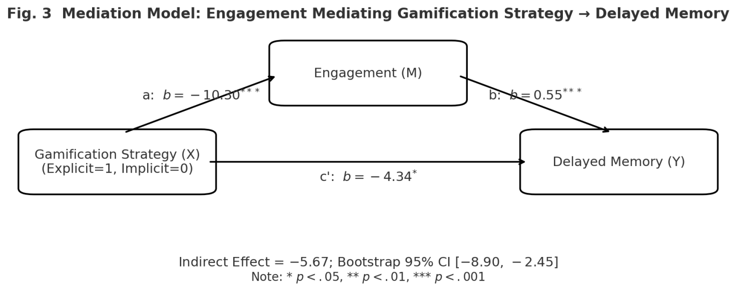

Figure 4. Mediation model path of immersion in the relationship between gamification strategies and delayed memory

5. Analysis and discussion

The study investigated the effects of explicit vs implicit gamification on immersion and memory performance in a VR learning environment which disentangled the neurocognitive and emotional differences of the two strategies. The results indicated that implicit gamification markedly augmented immersive experience and showed a greater benefit in delayed memory retention, in which immersion served as a partial mediator. This finding not only reaffirms the distinct importance of implicit gamification in fostering deep learning but also significantly contributes to the framework for designing VR educational systems and instructional training.

5.1. Mechanism analysis of differences in immersion

The implicit group showed results of higher immersion than the explicit group ($p < 0.001, Cohen's d = 1.26$). Consequently, with regard to VR-situatives, intrinsic motivation of story and environmental feedback is more effective than extrinsic motivation of points and rewards with regard to the users' psychological engagement. This is consistent with the immersion theory proposed by Jennett et al. [5], since the degree of immersion is a function of cognitive investment, sense of involvement and disassociation from reality. Gamification contributes to the immersion experience due to the optimal effective use of interface externalizations and situation coherence. Finally, implicit characteristics may also be clarified through the so-called "flow theory". Studies carried out by Hassan et al. [7], published in Front Psychology Journal [8], states that an optimum combination of task difficulty and user's skills is a high probability of flow state, where the user transcends time and himself and deeply dives in his task.

In this experiment, implicit group has created narrative and environmental changes that yielded progressive feedback, which may have been why they gained higher scores on the IEQ-SF questionnaire. Explicit gamification has features like frequent reward stimuli and leaderboards that

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may break attention and decrease a feeling of the psychological fluidity related to immersion. This research is in line with findings of Roth et al. [11] in respect to VR rehabilitation, who found that implicit feedback leads to natural levels of engagement, but that explicit rewards lead to better performance at the cost of dislodged engagement. The results of this study concerning immersion, then are in Roth et al.'s results in that they represent differences in psychological mechanisms put forth but also indicate the need to avoid "overly explicit design" in any type of deep media effective immersion.

5.2. Temporal differences in memory performance

Within the domain of memory dimension, no significant difference between explicit and implicit gamification for immediate memory was found ($p = 0.550$). However, the implicit group performed better than the explicit group regarding delayed memory ($p = 0.002$). Thus, explicit rewards can be used to optimize sustained attention and information retrieval, while implicit tactics promote better retention of information over longer periods of time. This corroborates the work of Voinescu and David [9], who emphasized that the neural systems of explicit and implicit learning diverge during the consolidation of information. In their account, explicit learning requires the provision of a stimulus, while the implicit learning framework posits that context aids in association and stabilizes memory traces. Also, the works of Bujić et al. and Safari Bazargani et al. show that immersive contexts can increase emotional engagement and thus enhance the retention of contextually based memories, termed long-term contextual memory [13,14]. In the case of this experiment, implicit gamification encouraged emotional engagement and self-directed exploration through progressive light, shadow, and sound feedback. This emotional arousal mechanism is the primary means through which memory consolidation is enhanced. In addition to this, Redlinger et al.

As noted by Redlinger et al. [16], contextualized game elements and visual game elements can aid in working memory performance, and Zhang and Robb noted that contextual immersion can engage multiple senses, which helps improve the depth of encoding and memory processes [17].

Nonetheless, the memory advantage delay of implicit gamification can be conceived as the user's "deep processing pathway": the non-explicit motivation structure encourages more Learning Use instead of Learning Response behavior bottom-up in the gamified system. This has implications for designing educational virtual reality systems—when the focus is on long-term retention of the information taught, the esoteric design elements like immersive storylines or responsive environments should take precedence.

5.3. The mediating effect and cognitive explanation of immersion

Mediation analysis demonstrated that immersion has a meaningful partial mediating role concerning the gamification strategies and delayed memory (Bootstrap 95% CI = [-8.90, -2.45]). In other words, the positive impact implicit gamification has on long-term memory is, at least in part, a function of the higher levels of immersion it provides. This is in line with the Jennett et al. and Smith & Mulligan studies [5,12], which noted that "presence" and "psychological immersion" in VR learning environments foster memory retention indirectly by augmenting situational and self-reference engagement. This phenomenon can be understood through the cognitive-affective integration framework: with increased immersion, attention, and emotional investment in the mental processing of the information increases, thereby facilitating the transition of that information from working memory to long-term memory [6]. Thus, implicit design is not as passive as it seems. It can

DOI: 10.54254/2755-2721/2025.LD30428

modulate learning in a behaviorally passive manner and simultaneously modulate the emotional channels of the memory consolidation process.

Regardless of the mediating role of immersion, its value in gamification enhancing memory still stands ($b=-4.34, p=0.042$), suggesting that the motivational, self-determining factors, and other energizing processes not accounted for in [7, 8] might also be at play. The neural coupling of immersion to the immersing-memory nexus also stands to be uncovered in future studies by means of physiological correlations like skin conductance response and EEG.

5.4. Theoretical and design inspiration

In virtual reality and other immersive environments, constant external evaluation can be an impediment to cognitive dissonance and the flow state so and thus context-relevant, implicit feedback is recommended. It is recommended that designers include narrative environments, 3D audio, and lighting feedback to target emotional engagement, which in turn increases the likelihood of information retention and ease of access as needed. If the aim of the learning experience is the completion of a task in a short time frame (as in training or when a quiz is administered immediately) gamification, in its explicit form is still beneficial; on the other hand, if the aim is to internalized knowledge and stored long term, the gamification in its implicit form is more valuable from an educational stand point.

This study verified the advantageous path of implicit gamification in VR learning, that is, promoting delayed memory retention by enhancing the intrinsic motivation of immersive appreciation activities. This result provides empirical support for the psychological mechanism model of future VR education systems and offers a theoretical basis for the design of multimodal learning interfaces.

6. Conclusion

The focus of this investigation was to examine the divergent effects of gamification elements on total immersion and retention of information (immediate and delayed) that users exhibited while learning in an immersive virtual reality environment. A mixed-model experimental design was implemented in which forty 18 to 25-year-old college students were asked to complete instructional assignments in a virtual reality museum constructed in Unreal Engine.

The main findings are as follows:

Immersion (RQ1): In the case of the add-on gamification group, the immersion score was ($M=82.00$) and the score for the implicit group was ($M=80.50$) which illustrates a difference in which the participants in the literature on the immersion score, the participants in the add-on gamification case immersion score, underline on ($M=82.00$) and for implicit group was ($M=80.00$) but the difference was less than the case in the delayed literature. In the case of the delayed literature, the group scored a significantly higher score of ($M=80.00$) as opposed to the ($M=65.00$) in the literature, which means the participants were able to rest for a period of time, and again in the memory test, their response was significantly better to the large extent of 15.

Memory Performance (RQ2): There was a higher score in the literature, which suggests that the participants on the delayed test were able to score higher in the implicit group on the test a week later and scored significantly more in comparison to the opposite group. In this case, this means that the more participants were able to rest in the memory test, the better score and response they were able to give in the test, which supports their long-term memory retention.

Mediation effect (RQ3): Immersion had a significant partial mediating effect on the relationship between gamification strategies and delayed memory. The Bootstrap 95% confidence interval did not include 0 ([-8.90, -2.45]) supports the evidence on promoting the effect of implicit gamification on long-term memory, in part, due to the greater level of immersion it offers.

This study has certain restrictions. With a sample that was only 40 college students, future study in this area should focus on a wider range of ages and educational levels for better relatability. This experiment was conducted in a VR art gallery; other fields (e.g., STEM or vocational training) may have different impacts from implicit and explicit gamification. As I mentioned, immersion was only reported by participants (IEQ-SF) and, in the future, more objective instruments (e.g., EEG, skin conductance) should be employed. Also, immersion only partially mediated the effect on delayed memory. This implies other more influential factors like intrinsic motivation may be in play. Future studies should focus on these psychological factors to better the existing models pertaining to VR learning efficacy.

Authors contribution

Zongan Guo, Yutong Su, Xiaoran Yu contributed equally to the conceptualisation, design, and development of this study. Author names are listed in alphabetical order to reflect equal contribution. Jintong Yang is listed as the second author and contributed to the literature review, manuscript revision, and finalisation of the manuscript.

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