An Investigation into the Long-Term Retention of English Vocabulary in an Immersive Online Scenario

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ABSTRACT Online foreign language teaching has become a normalized instructional approach. Immersive online situational teaching constructs a complete language application environment via multimedia, virtual scenarios and interactive tasks, transforming the vocabulary learning logic of isolated memorization. This study takes Grade 8 junior high school students as research subjects. An experimental class adopts immersive online situational vocabulary teaching, while a control class follows conventional online vocabulary recitation. A 12-week teaching experiment is carried out. Data are collected through immediate tests, delayed long-term vocabulary assessments administered 1 week, 4 weeks and 8 weeks later, learning motivation questionnaires and classroom behavior recording forms. Independent sample ttests and analysis of variance are applied to compare differences between the two groups in vocabulary retention scores, forgetting rates and subjective learning experiences. Experimental data indicate that the experimental class achieves significantly higher average scores in long-term vocabulary tests across all time intervals, exhibits milder vocabulary forgetting and stronger intrinsic learning motivation. The research verifies that the immersive online situational mode can significantly improve the long-term retention of English vocabulary and slow memory decay. Combined with teaching data, this paper summarizes three practical drawbacks of the mode, namely mismatched equipment, slow renewal of situational materials and difficult online interaction management. Optimization approaches including layered situational design, lightweight online interactive tools and home-school collaborative supervision are proposed, providing implementable references for long-term online English vocabulary instruction.

INDEX TERMS immersive online situation, English vocabulary, long-term memory retention, online foreign language teaching, forgetting curve

I. INTRODUCTION

A. RESEARCH BACKGROUND

With the widespread access to internet devices, online teaching in primary and secondary schools is no longer an emergency alternative but a regular supplement to offline classes[1, 2]. English vocabulary lays the foundation for language input and output, and vocabulary reserves directly determine students' comprehensive competence in listening, reading and writing[3]. At present, most online vocabulary learning software and web-based courses still follow a standardized procedure of "word definitions + repeated reading and dictation"[4]. Students recite words by fixed daily mechanical drills to finish daily tasks in the short run, yet lack authentic language usage contexts. Numerous frontline teaching observations reveal that students can temporarily memorize spellings and Chinese meanings of words, but tend to confuse word definitions, collocations and applicable scenarios after an interval, resulting in poor long-term vocabulary retention[5]. Relevant studies in memory psychology argue that pure mechanical memorization belongs to shallow processing, where information only stays in short-term memory. Vocabulary without contextual, logical or emotional associations cannot be stored in long-term memory[6]. The immersive teaching concept advocates fully immersing learners in a target-language environment to complete indepth information processing through sensory stimulation and situational interaction[7]. Advances in digital technology enable online classrooms to construct various virtual scenarios such as virtual shopping malls, campus dialogues and outdoor trips, allowing students to practice vocabulary application online without offline real-life settings[8, 9]. It carries strong practical research value to explore whether integrating immersive situations with online vocabulary teaching can alleviate students' rapid forgetting and short retention cycle of vocabulary. From a policy perspective, the Compulsory Education English Curriculum Standards explicitly require English teaching to reduce mechanical recitation, strengthen contextual and

practical language learning, and attach importance to students' language application ability and long-term knowledge retention[10, 11]. How to implement contextual vocabulary teaching in online settings and extend vocabulary retention cycles has become a key teaching difficulty for frontline English teachers, which constitutes the core starting point of this research.

B. RESEARCH SIGNIFICANCE

First, it provides standardized teaching schemes for online English vocabulary instruction in primary and secondary schools. The research designs a complete 12-week immersive online situational vocabulary teaching process, with supporting situational materials, online interactive tasks and long-term assessment methods that can be directly adopted by general teachers.

Second, it eases students' learning burden of repeated recitation followed by rapid forgetting. Immersive situations enable students to memorize words through practical application, cutting down meaningless copying and recitation assignments and mitigating students' resistance to English learning.

Third, it offers optimization directions for the development of online teaching platforms. Based on the drawbacks of equipment, materials and interaction identified in the experiment, suggestions for lightweight situational function design are put forward to upgrade online vocabulary learning tools..

C. RESEARCH STATUS

Overseas immersive language teaching has an earlier origin, with early studies focusing on offline full-English immersive campus education[12]. Scholar Brown proposed that the memory effect of language learning is directly correlated with the depth of information processing; situational interaction and language output tasks can deepen vocabulary processing and extend memory retention[13]. After the popularization of digital online teaching, foreign researchers began to build virtual online scenarios and conduct controlled experiments on vocabulary learning. Most studies confirm that online virtual scenarios with character dialogues, animated scenes and instant feedback generate higher short-term test scores among students compared with plain text recitation groups. However, most experiments last no more than 4 weeks, lacking long-term tracking data over extended periods. Some foreign scholars point out limitations of online immersive situations[14, 15]: network latency and poor device image quality weaken immersive experience; standardized virtual scenarios fail to match the learning demands of students with varying English proficiency, and the absence of layered design reduces the overall improvement of memory retention. Domestic research on long-term vocabulary memory is mostly centered on offline classrooms, while controlled experimental papers combining online immersive situations with long-term vocabulary memory remain scarce, creating a research gap that this study intends to fill..

D. RESEARCH CONTENTS

1. Construction of a risk entity classification system for

1. Sort out core theories related to immersive online situations and long-term vocabulary memory, and establish the theoretical analytical framework of this research.
2. Design an immersive online situational vocabulary teaching scheme and a conventional online vocabulary teaching scheme, and conduct a 12-week controlled teaching experiment.
3. Develop multi-cycle long-term vocabulary test papers, learning motivation questionnaires and classroom behavior observation forms to collect complete data from the experimental and control classes.
4. Adopt statistical methods to compare vocabulary test scores of the two groups in immediate, 1-week, 4-week and 8-week delayed assessments, calculate differences in forgetting ranges, and analyze disparities in students' learning motivation and classroom participation behaviors between the two groups.
5. Summarize the internal mechanism through which immersive online situational modes improve long-term English vocabulary retention based on statistical experimental results, sort out existing teaching problems, and propose targeted optimized teaching strategies.

E. RESEARCH METHODS

1. Review domestic and international relevant literature, organize theories on immersive teaching, memory processing and forgetting laws, and determine the research framework and experimental design.
2. Select two parallel Grade 8 classes with similar foundational levels as experimental subjects, divide them into an experimental class and a control class, and administer a unified pre-test to guarantee consistent initial experimental conditions.
3. Implement immersive online situational vocabulary teaching in the experimental class and traditional online vocabulary recitation in the control class for 12 consecutive weeks.
4. Conduct vocabulary tests on the day of class completion and after delays of 1 week, 4 weeks and 8 weeks; distribute learning motivation questionnaires mid-experiment and record classroom learning behaviors throughout the period.
5. Collate all data and conduct descriptive statistics, independent sample t-tests and one-way analysis of variance via SPSS to compare data differences between the two groups.
6. Analyze the functional mechanism of the mode based on statistical results, summarize teaching problems, propose optimization strategies and complete thesis writing.

II. EXPERIMENTAL DESIGN AND IMPLEMENTATION PROCESS

A. SELECTION OF EXPERIMENTAL SUBJECTS

This research selects two parallel Grade 8 classes from two public junior high schools in a city as experimental samples,

labeled the experimental class (46 students) and the control class (45 students) respectively.

Screening criteria: To ensure the validity of this controlled experiment, strict screening and baseline balancing measures were implemented prior to formal research. Specifically, the two participating classes shared the same English instructor, with consistent weekly in-class teaching hours and identical online assignment arrangement durations for English courses. Before the commencement of the experiment, all students from both classes took a unified vocabulary proficiency pre-test, and both versions of the test were scored on a full scale of 100 points.

Exclusion criteria: Students with long-term absences, no stable online equipment at home or extreme gaps in English proficiency are excluded to guarantee complete and valid experimental data. Data in Table 1 reveal that the average pre-test score of the experimental class is 62.37 points, compared with 61.85 points for the control class, with a gap of less than 0.6 points. The P-value of 0.678 exceeds the 0.05 threshold, indicating no statistically significant difference between the two groups. The similar initial vocabulary proficiency eliminates the interference of foundational gaps on experimental results, verifying the rationality of sample selection.

TABLE 1. Comparison of pre-test vocabulary scores between experimental and control classes (N=91)

Group	Number of Students	Average Score	Standard Deviation	t-value	P-value
Experimental Class	46	62.37	7.42	0.416	0.678
Control Class	45	61.85	7.19	—	—

B. CONTROL OF EXPERIMENTAL VARIABLES

1. Independent variable: Online English vocabulary teaching mode. The experimental class adopts immersive online situational vocabulary teaching; the control class adopts conventional online vocabulary recitation.

2. Dependent variables: Four observation indicators: immediate vocabulary test scores, long-term test scores after delays of 1/4/8 weeks; vocabulary forgetting rate; students' vocabulary learning motivation scores; online classroom learning behavior indicators.

3. Control of extraneous variables: Uniform instructor; fixed weekly vocabulary learning volume (40 core curriculum words per week); unified online learning duration (one 40-minute online vocabulary session twice weekly); identical test papers, questionnaires and observation forms; no additional offline word copying assignments to eliminate interference from extracurricular training.

C. IMPLEMENTATION SCHEMES OF THE TWO TEACHING MODES

1) Control Class: Conventional Online Vocabulary Recitation Mode

The fixed three-step classroom procedure contains no virtual situational interaction:

Step 1 (10 minutes): The teacher projects words, phonetic symbols and Chinese definitions online, reads aloud word by word and guides students to follow.

Step 2 (20 minutes): Students independently complete definition matching and multiple-choice dictation tasks on a vocabulary learning mini-program, with automatic answer checking by the system.

Step 3 (10 minutes): The teacher uniformly explains wrong questions and assigns post-class repeated recitation tasks, with no situational dialogue or vocabulary application assignments. All words are listed separately without linking to real-life contexts, relying entirely on mechanical memorization via text and audio.

2) Experimental Class: Immersive Online Situational Vocabulary Teaching Mode

Complete situational classrooms are built via online interactive teaching platforms and virtual animated scenario materials. Each 40-minute class is divided into four stages, with all vocabulary embedded in situational tasks:

1. Situational Introduction (8 minutes): Play virtual animations corresponding to weekly themes (e.g., supermarket shopping), where animated dialogues naturally introduce the 40 core weekly vocabulary words for students to receive audio-visual input.

2. Situational Interactive Tasks (20 minutes): Students join the same virtual scenario in online groups to complete role-play dialogues, item word selection and situational description tasks. Students are required to write sentence responses using target words, with instant correctness feedback from the platform; teachers monitor group dialogue content online.

3. Situational Review and Sorting (8 minutes): The teacher replays key scenario clips, extracts high-frequency vocabulary collocations and distinguishes different definitions of words across scenarios.

4. Lightweight Consolidation Tasks (4 minutes): Students complete simple fill-in-the-blank word selection within the current themed virtual scenario, without separate word dictation exercises. A brand-new online situational theme is updated weekly, and the same vocabulary reappears in subsequent themed scenarios to achieve spaced repetition reinforcement and deepen long-term memory processing.

D. DESIGN OF EXPERIMENTAL TESTING TOOLS

1. Vocabulary Test Papers: Four sets of papers for immediate assessment and delayed assessments after 1, 4 and 8 weeks.

2. Vocabulary Learning Motivation Questionnaire: 15 multiple-choice questions covering three dimensions: intrinsic learning interest, resistance to recitation and long-term learning self-confidence, scored on a 5-point Likert scale with a total score range of 15-75. Higher scores represent stronger vocabulary learning motivation. The questionnaire passes reliability and validity tests with a Cronbach's α coefficient of 0.831, guaranteeing credible data.

3. Online Classroom Behavior Observation Form: Records each student's number of interactive speeches, distracted duration and task completion speed per session, converted into a classroom participation score out of 20 points.

E. COMPLETE EXPERIMENTAL IMPLEMENTATION CYCLE

The total experimental period spans 19 weeks with clear phased arrangements:

Week 1: Administer pre-tests, collect baseline questionnaire data and complete grouping.

Weeks 2–11: Officially launch the two online vocabulary teaching modes with two 40-minute sessions weekly and simultaneous classroom behavior recording.

End of Week 11: Administer immediate vocabulary tests after class.

Week 12: Conduct 1-week delayed long-term vocabulary tests.

Week 16: Conduct 4-week delayed long-term vocabulary tests.

Week 19: Conduct 8-week delayed long-term vocabulary tests.

Learning motivation questionnaires are uniformly distributed in Week 6 (mid-experiment), with 91 valid questionnaires recovered and no invalid samples.

III. STATISTICAL ANALYSIS OF EXPERIMENTAL DATA AND RESULTS

A. COMPARISON OF LONG-TERM VOCABULARY TEST SCORES ACROSS TIME INTERVALS

Four vocabulary tests are arranged at different time points to compare short-term and long-term vocabulary retention gaps between the two groups. Table 2 summarizes test scores and statistical test data for each cycle. Three intuitive conclusions can be drawn from Table 2 data:

First, the experimental class achieves higher average vocabulary scores than the control class in all test cycles, with the score gap widening as the delay lengthens.

Second, the P-values of independent sample t-tests for all four tests equal 0.000, lower than the 0.05 critical threshold.

Third, scores of both groups decline as the delay extends, consistent with the forgetting curve law, yet the control class experiences a far steeper score drop than the experimental class.

TABLE 2. Statistics of vocabulary test scores for experimental and control classes across cycles

Test Cycle	Group	Number of Students	Average Score	Standard Deviation	t-value	P-value
Immediate Test	Experimental Class	46	86.41	5.28	7.852	0.000
	Control Class	45	74.63	6.12	—	—
1-Week Delay	Experimental Class	46	79.26	6.03	8.117	0.000
	Control Class	45	63.58	6.74	—	—
4-Week Delay	Experimental Class	46	71.35	6.81	9.243	0.000
	Control Class	45	52.14	7.06	—	—
8-Week Delay	Experimental Class	46	65.72	7.15	8.965	0.000
	Control Class	45	43.89	7.41	—	—

B. COMPARISON OF VOCABULARY FORGETTING RATES BETWEEN THE TWO GROUPS

To quantitatively measure the impact of the two teaching modes on forgetting speed, vocabulary forgetting rates for different delayed intervals are uniformly calculated, with comparative data presented in Table 3. Data in Table 3 clearly reflect disparities in forgetting rates:

1. The control class records higher forgetting rates across all intervals. After a 1-week delay, the control class forgets 14.81% of vocabulary compared with only 8.27% for the experimental class; after an 8-week delay, nearly 40% of vocabulary is forgotten by the control class versus less than 24% for the experimental class.

2. The gap in forgetting rates between the two groups expands over time, rising from 6.54% after 1 week to 17.25% after 8 weeks. Traditional mechanical online recitation lacks in-depth contextual processing, yielding unstable memory retention and unmitigated large-scale long-term forgetting. Immersive situations bind vocabulary to scenarios, creating multiple memory cues and markedly slowing forgetting.

TABLE 3. Vocabulary forgetting rates of experimental and control classes (%)

Delay Interval	Forgetting Rate of Experimental Class	Forgetting Rate of Control Class	Rate Difference
1 Week	8.27	14.81	6.54
4 Weeks	17.43	30.14	12.71
8 Weeks	23.94	41.19	17.25

C. COMPARISON OF VOCABULARY LEARNING MOTIVATION QUESTIONNAIRE DATA

To explore the mode's influence on students' subjective learning states, average motivation scores across three core dimensions are statistically analyzed to comprehensively compare psychological differences between the two groups, as shown in Table 4. Analysis of questionnaire data yields the following findings:

First, the experimental class achieves significantly higher average scores than the control class across all three subdimensions and the total score, with all P-values below 0.05, representing statistically significant differences.

Second, the control class attains low scores in the resistance-to-recitation dimension, indicating widespread aversion to repetitive word dictation and mechanical reading. The experimental class relies on situational interaction for vocabulary learning with reduced mechanical drills, drastically lowering recitation resistance.

Third, gamified and real-life oriented interactive tasks in virtual scenarios boost classroom learning pleasure, simultaneously elevating intrinsic learning interest and long-term vocabulary learning self-confidence.

TABLE 4. Comparison of learning motivation questionnaire scores between experimental and control classes

Evaluation Dimension	Group	Average Score	Standard Deviation	t-value	P-value
Intrinsic Learning Interest	Experimental Class	24.62	3.15	6.934	0.000
	Control Class	18.17	3.62	—	—
Resistance to Recitation (Reverse Scoring)	Experimental Class	22.38	2.97	7.216	0.001
	Control Class	15.43	3.28	—	—
Long-Term Learning Self-Confidence	Experimental Class	21.75	3.04	6.581	0.001
	Control Class	16.21	3.35	—	—
Total Questionnaire Score	Experimental Class	68.75	7.22	8.472	0.000
	Control Class	49.81	8.05	—	—

D. COMPARISON OF ONLINE CLASSROOM LEARNING BEHAVIOR DATA

Objective quantification of classroom concentration and participation gaps between the two groups is achieved via standardized unified observation criteria to calculate classroom participation scores, with overall quantitative comparative data presented in Table 5. The experimental class earns an average participation score of 16.34 points versus merely 9.68 points for the control class, with P=0.000 indicating an extremely significant difference. The control class centers on independent dictation and passive reading with limited channels for student speeches and interaction, leading to frequent online distraction and idle window hanging. The immersive online situational mode sets group dialogue and word-selection multi-person interactive tasks requiring every student to output English online, greatly elevating classroom concentration and active participation frequency.

TABLE 5. Comparison of online classroom participation scores (full score: 20)

Group	Number of Students	Average Score	Standard Deviation	t-value	P-value
Experimental Class	46	16.34	2.17	9.741	0.001
Control Class	45	9.68	2.63	—	—

IV. INTERNAL MECHANISM OF IMMERSIVE ONLINE SITUATIONS BOOSTING LONG-TERM VOCABULARY RETENTION

Combining levels of processing theory, situated cognition theory and experimental statistical data, four core functional pathways are summarized to clarify how the mode extends vocabulary retention cycles.

A. MULTI-SENSORY INPUT ENABLES IN-DEPTH INFORMATION PROCESSING OF VOCABULARY

Traditional online vocabulary classrooms only adopt two input channels: text and audio, constituting single shallow stimulation. Immersive online situations synchronously integrate animated images, character voices, scenario operations and instant text feedback, delivering vocabulary information via simultaneous visual, auditory and operational multi-sensory stimulation. Multi-sensory stimulation creates multiple memory traces in the brain. When students later recall words, they can retrieve memory through multiple cues including scenario images and dialogue voices, lowering memory extraction difficulty and reducing long-term forgetting. Multi-sensory input directly upgrades vocabulary memorization from shallow to deep processing, aligning with the core viewpoint of levels of processing theory.

B. SCENARIOS BIND VOCABULARY TO BUILD STABLE CARRIERS FOR LONG-TERM MEMORY STORAGE

Situated cognition theory states that vocabulary knowledge cannot be stably stored detached from usage contexts. Under conventional recitation modes, students only memorize one-to-one correspondences between words and Chinese definitions without contextual associations. After an interval, the brain lacks retrieval cues, easily triggering definition confusion. Online virtual scenarios such as shopping malls, campuses and trips embed words into complete life logic. While memorizing words, students simultaneously retain their applicable scenarios. Even after two months, exposure to similar real-life scenarios enables rapid retrieval of corresponding vocabulary memory, drastically stabilizing long-term retention.

C. INTERACTIVE TASKS ENHANCE INTRINSIC MOTIVATION AND PROMOTE INDEPENDENT REVIEW CONSOLIDATION

Questionnaire experimental data prove that interactive tasks in immersive online situations cut tedious copying work, raising students' learning interest and lowering resistance. Students with stronger intrinsic learning motivation voluntarily revisit online situational animations and complete situational vocabulary exercises after class, increasing review frequency autonomously. Voluntary review further deepens long-term memory traces and forms a virtuous cycle; students in the control class resist mechanical recitation and rarely review independently after class, leading to rapid fading of short-term memory traces and poor long-term retention.

V. OPTIMIZED IMPLEMENTATION STRATEGIES FOR IMMERSIVE ONLINE SITUATIONAL LONG-TERM VOCABULARY TEACHING

Targeting the four practical drawbacks outlined above and combining successful teaching experience from the experiment, four actionable optimization strategies are proposed to amplify the mode's positive effects on long-term vocabulary retention

A. PROMOTE LIGHTWEIGHT ONLINE SITUATIONAL TOOLS TO LOWER EQUIPMENT AND NETWORK BARRIERS

First, teachers prioritize low-data lightweight virtual situational mini-programs with standard-definition and high-definition animation modes. Students with poor network connections switch to standard-definition versions to reduce lags.

Second, static scene images paired with audio materials are released in advance before class. Students experiencing network failures can complete contextual vocabulary learn-

ing via graphic and audio materials to compensate for lost immersive experience caused by animation stuttering.
Third, simplify scenario operation steps to adapt to small mobile phone screens, mitigating hardware restrictions on immersive experience and guaranteeing all students receive complete multi-sensory vocabulary stimulation.

B. ESTABLISH LAYERED AND CLASSIFIED ONLINE SITUATIONAL MATERIAL LIBRARIES WITH REGULAR UPDATED EXPANDED THEMES

First, English teaching research groups across schools jointly build shared online situational material libraries categorized by curriculum units, seasonal festivals, campus life and outdoor expansion, releasing 2–3 new dynamic scenario sets monthly to avoid content homogenization.
Second, simple scenario production templates are provided; teachers only need to import weekly core vocabulary to rapidly generate customized virtual dialogue scenarios matching their class's vocabulary teaching progress.
Third, miniature short animated scenarios are individually produced for less frequent curriculum vocabulary to embed all words in contexts for deep memory processing, eliminating the drawback of mechanical recitation for partial vocabulary.

C. DESIGN THREE-TIER GRADIENT SITUATIONAL TASKS TO ADAPT TO STUDENTS WITH DIVERSE VOCABULARY PROFICIENCY

Each set of online situational tasks is divided into basic, intermediate and advanced tiers for students to select independently according to their capacity:
1. Basic Tier: Scenario word recognition and simple definition selection for students with weak vocabulary foundations to first bind vocabulary to contexts.
2. Intermediate Tier: Situational short dialogues and fixed collocation fill-in-the-blanks for most class students to realize fundamental vocabulary application.
3. Advanced Tier: Independent writing of long situational dialogues and expansion of synonymous vocabulary substitution for advanced students to complete in-depth output practice. Layered tasks enable students of all proficiency levels to match their capabilities for vocabulary application, facilitating in-depth information processing for every learner and synchronously lifting overall long-term vocabulary retention standards.

D. BUILD MULTI-DIMENSIONAL ONLINE CLASSROOM SUPERVISION MECHANISMS TO ELIMINATE IDLE WINDOW HANGING

First, situational tasks adopt timed submission rules, popping up short vocabulary quizzes every 10 minutes that students must complete to continue watching animations, automatically screening idle students.
Second, random mic connection and group screen sharing modes are adopted; teachers randomly access group virtual scenario dialogue screens to monitor student participation in real time.
Third, a classroom participation point system is established with points awarded for situational interaction and task completion, with weekly public point rankings to positively guide active student engagement in scenario tasks. This ensures every student receives full immersive situational vocabulary training and guarantees the realization of long-term retention improvements.

V. CONCLUSIONS

A. MAIN CONCLUSIONS

1. The immersive online situational mode can significantly improve long-term English vocabulary retention among junior high school students. Long-term vocabulary test data after delays of 1, 4 and 8 weeks reveal consistently higher average scores for the experimental class, with the score gap widening over time. The mode delivers stable positive effects on long-term vocabulary retention.
2. The immersive online situational mode effectively slows vocabulary forgetting rates. Across identical time intervals, the experimental class records far lower vocabulary forgetting rates than the control class using conventional online mechanical recitation. Three pathways including contextual binding, spaced repeated usage and multi-sensory processing jointly inhibit memory decay.
3. Immersive online situational vocabulary teaching improves students' subjective vocabulary learning states. Students demonstrate elevated intrinsic learning interest and long-term learning self-confidence alongside reduced resistance to mechanical recitation; active interaction and focused participation in online classrooms rise significantly, forming a positive cycle of "intensive participation – in-depth processing – long-term memory retention".
4. Four practical bottlenecks currently restrict immersive online situational vocabulary teaching: equipment and network limitations, slow material renewal, lack of layered design and difficulties in online classroom management. Optimization strategies including lightweight tools, layered gradient scenario tasks and multi-dimensional classroom supervision can address these shortcomings and further strengthen improvements in long-term vocabulary retention.

B. LIMITATIONS

1. Experimental samples are limited to Grade 8 students from two public junior high schools. The adaptability of the mode for primary school, senior high school and vocational college students requires follow-up repeated experiments with expanded samples to verify the universality of conclusions.
2. The longest long-term tracking cycle of this experiment spans only 8 weeks; vocabulary retention status beyond two months is not continuously observed. Future research can extend tracking cycles to 12 weeks or half a year to record long-term vocabulary forgetting and consolidation patterns comprehensively.

3. This study only counts overall long-term vocabulary retention scores without distinguishing memory disparities among nouns, verbs and adjectives. Follow-up research can further explore differentiated effects of online situational modes on different word categories.

C. FUTURE RESEARCH PROSPECTS

1. Expand experimental samples to cover primary, senior high and vocational education stages, comparing differential effects of the immersive online situational mode on long-term vocabulary retention across age groups.
2. Extend long-term tracking cycles to conduct half-year or full academic year longitudinal vocabulary retention experiments to fully document long-term vocabulary forgetting and consolidation variations.
3. Conduct grouped comparisons segmented by vocabulary part of speech and difficulty to explore differentiated impacts of online situational modes on long-term retention of diverse word types.

Fourth, construct intelligent immersive online scenarios with AI virtual digital humans and study the optimization effects of real-time AI interactive scenarios on long-term vocabulary retention, enriching innovative paths for online vocabulary teaching..

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