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An approach to creating immersive language learning environments for English language education

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SUMMARY: *Immersion language teaching has unique value and characteristics, which is rooted in the language's own characteristics and can save time and effort to cultivate students' foreign language proficiency. This paper proposes a new online university English teaching model, which utilizes the virtual reality features of the metaverse to build an interactive immersive learning environment for English education. Six classroom transcripts were selected as examples of the study lessons, which were analyzed quantitatively by S-T analysis, time series analysis, and the improved Flanders Interaction Analysis System and. The results of the study show that the effect of immersive learning environment on language learning has a certain relationship with the cognitive ability of individuals, and the fluctuation of the speech ratio between the teacher and the students in different teaching sessions is small, and the average Ch value of the lesson cases is 0.4080, and the overall teaching mode of the course is presented as a dialogic teaching mode, which proves that the immersive language learning environment designed in this paper is able to improve the interaction in the teaching of English.*

KEYWORDS: *immersive language teaching; iFIAS; teacher-student interaction; English education; meta-universe*

1 Introduction

As an important link in cross-cultural communication, English education, its educational quality and teaching mode are of great significance to students' future career development and cross-cultural communication. However, there are some problems in the current English teaching. On the one hand, some teachers still adopt the traditional teaching method of “indoctrination”, which lacks attention to the actual needs of students [1, 2]. Teachers explain the grammar rules and writing points in detail step by step, and then let students consolidate the grammar points through a large number of repeated training, this single teaching method lacks of interest and interactivity, which is easy to make students feel boring, unable to concentrate, and even resistant to English learning [3-6]. On the other hand, students' cognition is essentially meaningful learning accomplished in concrete situations. The knowledge of English grammar and listening itself is more abstract, but in traditional teaching, teachers are often detached from real-life situations, and the explanation of grammar rules is too boring, which leads to the fact that even if students memorize the grammar rules and English words, they don't understand their essential meanings, and then they can't use them correctly in actual communication or writing [7-11].

The immersion language teaching model advocates placing students in the whole English

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language environment, so that students can realize language acquisition through authentic interaction and contextual experience [12]. Immersion language teaching provides authentic language input and output opportunities for students to use English in real-life scenarios [13, 14]. It emphasizes the cultivation of overall language ability and focuses on the comprehensive development of listening, speaking, reading and writing [15]. At the same time, immersion teaching can stimulate students' interest and motivation in learning and increase the participation and effectiveness of learning [16, 17]. In addition, most importantly, immersion teaching takes students as the main body and advocates independent and cooperative learning [18].

With the development of information technology, teachers should actively promote the integration of English listening and speaking teaching with information technology, innovate teaching technology, improve teaching mode, broaden students' English learning channels, enhance students' interest in learning English, and improve the quality of English teaching [19-21]. Therefore, exploring the construction path of English immersive language teaching environment is not only an inevitable choice to comply with the development trend of education informatization, but also an important practice to break through the bottleneck of traditional teaching and improve students' comprehensive application ability of English, which has far-reaching significance in promoting the transformation of English teaching to the direction of intelligence and personalization [22-25].

Creating immersive language learning environments has been a hot topic in the field of education, and scholars have realized it through virtual reality, augmented reality, and 5G technology. Literature [26] constructed an immersive English speaking environment based on virtual reality, used wearable technology to collect physiological data such as students' EEG, and introduced the adaptive k-nearest neighbor algorithm and owl search algorithm to assess students' immersion and performance in this environment. Literature [27] proposed an immersive English learning environment based on a deep learning model integrated with virtual reality for enhancing students' communication skill acquisition, and used a novel two-way gated loop unit to assess students' interactive effects, virtual experiences, communication patterns, and learning progress. Literature [28] compared the learning outcomes of students using different scenarios (movable and fixed position in virtual space) in an immersive virtual reality application for English language learning through eye-tracking technology, and it is clear that students learn better in an immersive virtual space that is movable. Literature [29] integrated an interactive virtual reality environment into English language teaching to create an immersive learning atmosphere, and combined machine learning algorithms and principal component analysis to analyze students' learning data in this environment to achieve personalized feedback and customized content. Literature [30] combines 5G technology and virtual reality technology to build an immersive virtual classroom teaching system and develops a teacher-student interaction model in contextual English teaching teaching scenarios, which effectively improves the teaching effect. And literature [31] integrated 5G technology, extended reality technology, and reinforcement learning to develop an immersive extended reality teaching system and designed an immersive teaching model, which improved students' learning effect, participation, and experience over traditional teaching methods. Literature [32] created an immersive learning environment with the help of augmented reality based Assemblr EDU application, and comparative experiments showed that students' motivation, vocabulary building, and comprehension were strengthened with multimodal interactions. Literature [33] created immersive augmented reality learning environments for students with hearing impairments, which improved students' reading scores, performance of interactivity oriented behaviors, problem solving skills, and creative constructing skills, which provided high-quality support for the teaching of hearing impairments. Literature [34] combined project-based learning and immersive virtual reality to create immersive English learning environments with real-world scenarios for students, and students' speaking, pronunciation, grammar, vocabulary, discourse management, and interactive communication skills improved. Literature [35] developed an immersive English listening and speaking training platform based on virtual reality and maximum information coefficient algorithm, which improves students' training effectiveness by recognizing subtle differences in students' pronunciation and intonation, and giving feedback ratings ah improvement strategies. Literature [36] embedded the U-Net algorithm and an immersive network with 3D layout into an online visualization teaching system, and applied the system to English teaching, which significantly improved students' independent learning ability.

The study first provides a new immersive learning environment for English teaching based on the "educational meta-universe" of virtual reality technology, and then builds an immersive virtual language learning classroom. Then the study combines S-T analysis and time series analysis to investigate the impact of immersive language learning environment on language learning from behavioral, ERP and correlation analysis. Six research examples were selected and the improved Flanders Interaction Analysis System was used to analyze the characteristics of classroom teacher-student verbal interaction behaviors as well as teaching behaviors in a multi-dimensional way. Through the systematic research, it helps learners to improve their language proficiency, and also provides a new teaching idea for the English teaching mode.

2 Immersion English Language Learning Environment Creation

2.1 An Architecture for Language Teaching and Learning Based on the Intelligent Metaverse

To design an intelligent language teaching technology architecture utilizing meta-universe infrastructure and AIGC technologies. In addition to the traditional meta-universe technology stack such as infrastructure, virtual platform, virtual terminal, etc., we also utilize artificial intelligence technology (including various segmentation functions) and big data technology to support the new functions of intelligent language teaching. Teachers design language teaching and learning environments based on teaching objectives, which is the actual application scenario. The architecture of language teaching and learning based on intelligent meta-universe is shown in Figure 1.

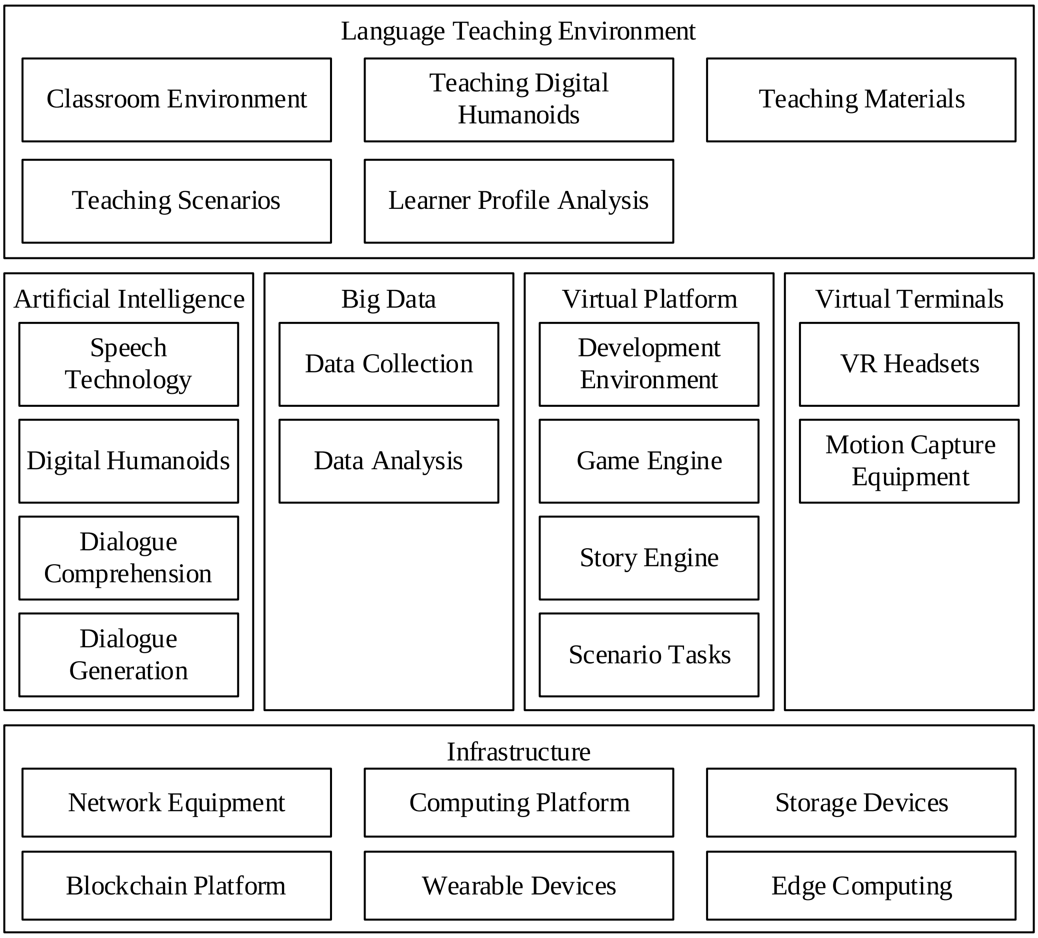


Figure 1: Language Teaching and Learning Architecture Based on Intelligent Metaverse

Teachers can build libraries of materials to share and use with other teachers, including prompt texts, batch-generated images, videos, and avatars, in order to reuse them in future classes and avoid re-generation. In the meta-universe environment, the conversations between students and digital people can be recorded in full, and the conversational speech can be converted into text to facilitate the analysis of the effectiveness of offline English teaching. The basic physical facilities required for the meta-universe can be based on the school's multimedia classrooms or centralized servers to build local or online meta-universe teaching environments, where students can use VR headsets or VR glasses or computers to enter the English teaching environment.

2.2 Development of language teaching activities based on intelligent meta-universe

Slightly different from the process of offline teaching and learning activities, in a meta-universe environment, language teaching and learning activities can be carried out according to the following steps as shown in Figure 2.

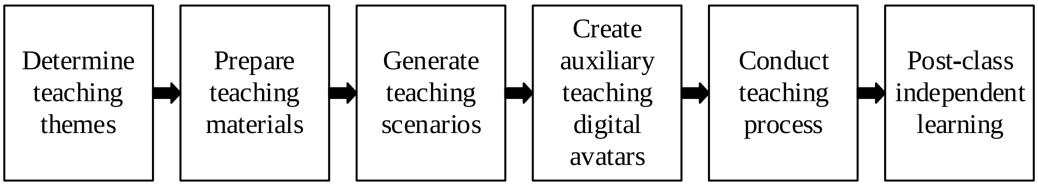


Figure 2: Intelligent metaverse teaching process

When generating teaching scenarios, visual generation technology can be utilized to provide short text descriptions based on the teaching topics, generate relevant pictures or videos, and make constant corrections. When generating a teaching-aided digital person, theme-related information can be set in advance through ChatGPT, provided to the digital person, so that the digital person is in an English teaching context, and a series of dialog processes can be designed according to the teaching objectives. The following is a simple example of a dialog flow design designed to help students practice common interrogative sentence patterns. Teachers can use prompts to help teaching digitizers understand the specified dialog rules.

2.3 Immersive Virtual Classroom Architecture

Immersive virtual reality classroom consists of virtual teaching scene, teaching content, teaching interaction, teaching roles and other elements, and the traditional classroom is somewhat similar to the immersive virtual classroom is also by the teacher, students together, and in the immersive virtual classroom, teachers and students are completely free from any interference of anything in the real environment, and completely immersed in the classroom. The architecture of the immersive virtual classroom is shown in Figure 3.

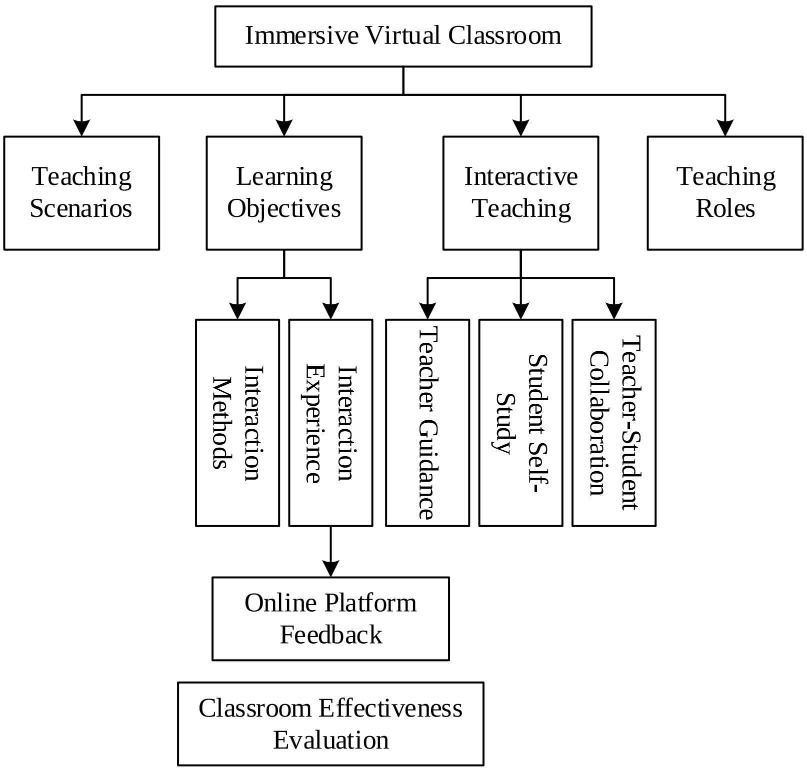


Figure 3: Basic architecture of immersive virtual classroom

3 Design of Teaching Practices for Immersion English Language Learning Environments

3.1 Research lesson information

The lessons under study are all from the excellent demonstration lessons of the “National Competition of Basic Teaching Skills of Primary School English Teachers and Teaching Observation Seminar”. The teachers were selected by the education and research departments of all provinces (autonomous regions and municipalities directly under the central government) and the Xinjiang Production and Construction Corps. The lessons have been polished and perfected in many rounds, and are the crystallization of the wisdom of many front-line excellent teachers. The quality lessons of six lecturers were randomly selected as samples for research and analysis, and the basic information of the research subjects is shown in Table 1.

Table 1: Basic information of study subjects

Course number	Teacher	Lesson Name	Duration
01	A	Dinner ready	35m
02	B	Robots will do everything	39m33s
03	C	Where are you going?	42m51s
04	D	In a nature park	42m
05	E	Meet my family	39m45s
06	F	Yesterday I went to sam's school my school calender	39m60s

3.2 Subjects

A total of 35 college students were recruited to participate in the experiment, of which 6 subjects could not be included in the statistical analysis due to excessive EEG artifacts. Therefore, the number of valid subjects in this experiment was 29 (6 males and 23 females), with an age range of 18-24 years old. The results of the linguistic background questionnaire showed that all subjects were native speakers of Chinese, all had English as their second language, and none of them had any experience in learning German. Using a 7-point Likert scale (1=very low proficiency, 7=very high proficiency), all subjects were asked to self-assess their language proficiency in four areas: listening, speaking, reading and writing. The paired t-test results of Chinese and English proficiency showed that the subjects were unbalanced bilinguals and Chinese was the dominant language ($ps<0.01$). All subjects were right-handed, had normal visual acuity or corrected visual acuity, and were not color blind or color weak. All subjects participated in this experiment voluntarily, signed an informed consent form before the experiment, and were paid accordingly after the experiment was completed.

3.3 Experimental materials

This experiment used a one-way within-subjects design, with the independent variable being the immersive learning environment containing an immersive virtual reality-based environment. The dependent variables were the English learning effect, i.e., response time and correctness in a four-choice forced-choice task, and the corresponding EEG metrics (N2, P2, and P3 components).

3.4 Experimental Design and Procedure

In order to simulate a language learning environment in a real environment, this experiment utilizes Unity3D software to create a virtual reality learning scenario and incorporates the use of an HTC vive head-mounted display and an operating handle for human-environment interaction and learning. The virtual reality scene created in this study contains student dormitories and classrooms. Subjects could walk around freely in the virtual environment and point the laser beam at the target object by operating the joystick, and could hear the English name of the selected object for vocabulary learning.

3.5 EEG Data Acquisition

The experiment consisted of a learning phase (days 1-3) and a testing phase (day 4). In the learning phase, all subjects were required to learn 40 English vocabulary words, of which 20 words were learned in a teacher-student interactive learning environment and 20 words were learned in a virtual reality learning environment, with the learning materials balanced among subjects. In the testing phase, all subjects were required to complete a four-choice forced-choice task, and EEG data were recorded. Artifacts such as blinks and cardiacs were corrected by ICA (Independent component analysis) analysis, and continuous EEG data were segmented according to the time periods of 200ms before and 800ms after stimulus presentation, with baseline corrections referring to the -200ms-0ms of EEG activity before stimulus presentation. Only EEG data from correctly responding trials were included in the statistical analysis.

On the ERP data, P2 (150-250ms) and N2 (250-350ms) were significantly observed in prefrontal, middle frontal, and midbrain regions, and the average of nine electrode sites (F1,FZ,F2,FC1,FCZ,FC2,C1,CZ,C2) was used as the observed values. Second, the P3 component (350-500ms) was more pronounced in the middle frontal, middle and parietal brain regions, so the average of 9 electrode points (FC1,FCz,FC2,C1,CZ,C2,CP1,CPz,CP2) was used as the observed value.

3.6 Research tools

3.6.1 Timing analysis methods

Time-series analysis, as applied to educational research, is a method of noting and analyzing the teaching and learning process based on the process-outcome model of teaching and learning, which represents the interaction between teachers and students in the teaching and learning process mainly through time, actors, and categories of behavior.

3.6.2 S-T analysis methodology

S-T analysis is mainly used for quantitative analysis of the teaching process. Generally, the behaviors in classroom teaching are divided into student (S) behavior and teacher (T) behavior, for which the definitions are shown in Table 2. However, some scholars have defined another behavior (D) for the sake of more detailed differentiation, which refers to the behavior of interactive dialogue between teachers and students, and the teaching behavior is divided into two kinds of S and T because the iFIAS system was used to analyze the teacher-student interaction behavior in this study.

Table 2: Classification of teacher and student behavior

Type	Definition	behavioral expression
T action	Teacher behavior	Teachers lecture, demonstrate, write on the board, etc
S action	student behavior	Student discussion, practice, silence, etc

3.6.3 iFIAS interactive analysis system

American scholar Flanders firstly proposed a classroom behavior analysis technique - Flanders Interactive Analysis System, which contains 10 kinds of interactive behavior coding and is a method for observing the teaching process for post-coding analysis. With the development of the times, many scholars have improved it, specifically in the optimization of the coding, and constructed the Information Technology-based Interaction Analysis Coding System under the new classroom concept, referred to as ITIAS. iFIAS changed the number of codes to 14. iFIAS not only retains the traditional FIAS analytical function, but also optimizes the ITIAS system, which helps the researchers to be more objective and specific in the analyze the teacher-student interaction in classroom teaching. Therefore, iFIAS was chosen as the research tool.

The analysis process of iFIAS:

(1) Coding

According to the coding rules, the teaching process was coded every 3 seconds, and the reliability should be tested after the coding was completed, and the test method was the same as the reliability test method of S-T method. Although the definition of coding in iFIAS has been very clear, the teaching behaviors in the actual classroom are very complex, and it is difficult to determine the type of coding for certain behaviors, so scholars such as Flanders have developed some special coding rules.

(2) Constructing the matrix

First of all, connect adjacent codes into sequential pairs, for example: 12, 3, 1, 5, 7, 14, combine this set of data back and forth into sequential pairs, i.e., 12-3, 3-1, 1-5, 5-7, 7-14, and then count the number of the same sequential pairs and fill them into the analyzing matrix, and finally, count the total of each row and column.

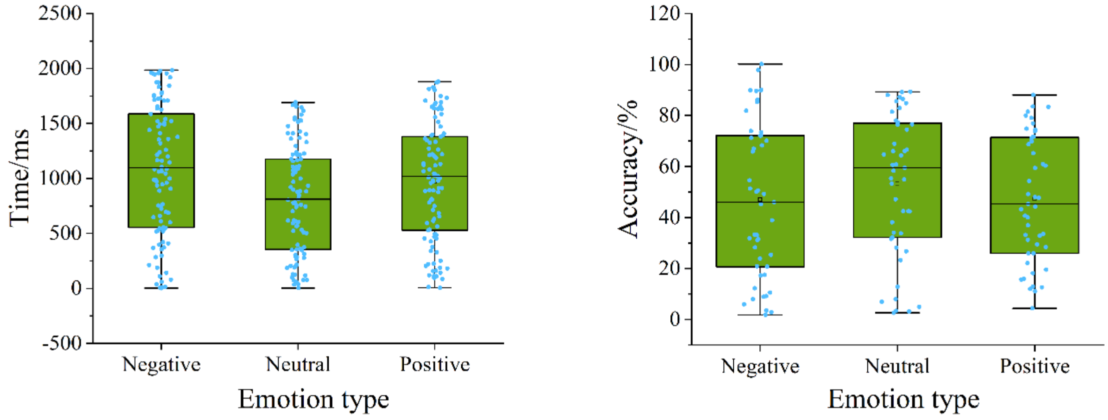
4 Findings and analysis

4.1 Mechanisms of immersive language learning environments on language learning

4.1.1 Behavioral outcomes

1. Behavioral results

A one-way repeated measures ANOVA on response time for the three emotional potencies is shown in Figure 4. The results showed that the main effect of response time for positive context vocabulary, negative context vocabulary, and neutral context vocabulary was not significant for positive context vocabulary: M=1458, SD=293; neutral context vocabulary: M=1308, SD=230; and negative context vocabulary: M=1299, SD=258, F(2,58)=0.38, p=0.75, η^2=0.01. The difference in the main effect of correctness for positive The main effects of correctness for positive, negative, and neutral context vocabulary were not significantly different: positive context vocabulary: M=0.88, SD=0.13; neutral context vocabulary: M=0.87, SD=0.16; and negative context vocabulary: M=0.84, SD=0.20, F(2,58)=0.96, p=0.41, η^2=0.05.

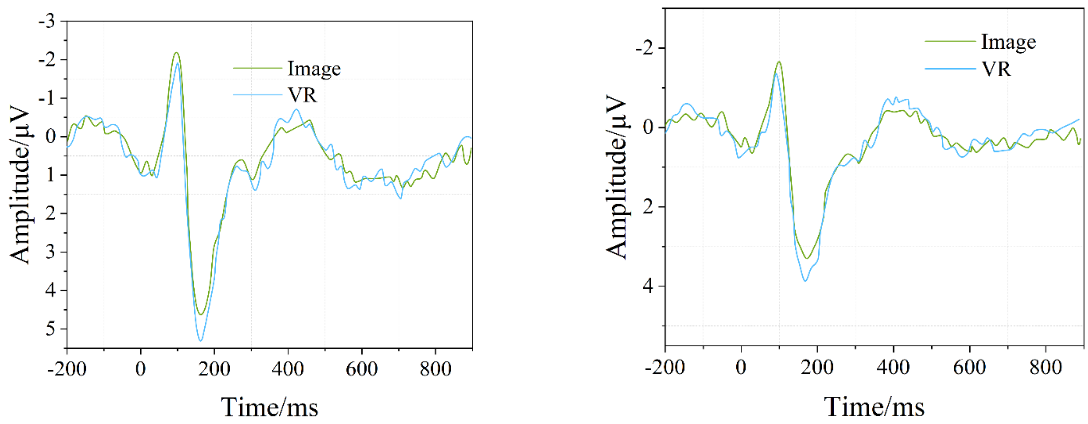


(a) Time reaction (b) Accuracy rate

Figure 4: Mean response time versus accuracy

4.1.2 ERP results

According to the steps of EEG data analysis, this study performed paired-sample t-tests on the mean wave amplitudes of the P200 and N400 time windows, respectively. The average wave amplitude plots for the VR condition of the translation task during the immediate test phase are shown in Fig. 5. The analysis results of the P200 component (150-250 ms) showed a significant effect of the learning environment (=-2.3,p=0.023) and the wave amplitude induced by the VR condition (M=7.24 μ V). However, the analysis of the N400 component (400-600 ms) showed no significant difference in the amplitude of the waves induced by the different learning contexts (t=-0.59,p=0.59; VR=0.08 μ V, PW=-0.12 μ V). This result suggests that the facilitating effect of immersive virtual learning environments on English vocabulary learning is mainly reflected in the P200 component.



(a) P200 component (b) N400 component

Figure 5: Average amplitude plots under VR conditions and figure-word conditions

4.1.3 Results of correlation analysis

In order to examine whether there is a relationship between the facilitating effect of the virtual reality environment and the individual's cognitive level, so the correlation between the individual's cognitive abilities (inhibition, alertness and orienting ability) and the performance of the VR vocabulary under the immediate test phase was calculated.

The results of Person correlation analysis are shown in Table 3, where it can be found that there is a significant positive correlation (r=0.40,p=0.03) between the response time indicators of inhibition and the P200 component. Since smaller values of the indicator of inhibitory capacity indicate a more efficient inhibitory network, this positive correlation suggests that as an individual's inhibitory capacity increases, words learned in the VR environment may induce smaller P200 components. In addition, there was a significant negative correlation between the reaction-time metric of alertness and the P200 component (r=-0.44,p=0.03). In the Flanker task variant, the larger value of the indicator of alertness ability indicates the higher efficiency of the alertness network, and this negative correlation result suggests that the higher the individual's level of alertness, the P200 amplitude induced by the translation task shows a tendency to decrease. In conclusion, the improvement of individual cognitive ability may reduce the P200 wave amplitude, especially in the inhibition ability and vigilance ability.

Table 3: Correlation matrix between individual cognitive ability and translation task

	RT metric			ACC metric		
	Restrain	Vigilance	Directional	Restrain	Vigilance	Directional
Translation task ACC	-0.21	0.13	0.03	0.31	0.14	0.95
Translation task RT	-0.09	-0.03	-0.09	0.19	0.17	-0.01
ERP P200	0.40*	-0.44*	0.14	-0.08	-0.12	-0.19

Note: *, p<0.05

4.2 Analysis of Teacher-Student Verbal Behavior Interaction in Immersion Classroom

4.2.1 Category analysis

In order to facilitate statistical analysis, Flanders divided teacher-student interaction behaviors into a total of four regions, ABCD, and the specific meanings of the codes contained in each region have been interpreted in detail in the coding instructions in the instrument base. On the basis of this tool, the data results were organized and a comparison of the category ratios was produced according to the differences in the category ratios as shown in Table 4.

Region A in the table represents the teacher's verbal interaction behavior, which is further subdivided into two regions, A1 and A2, with region A1 containing codes 1-4, representing the teacher's indirect influence on the students, and region A2 containing codes 5-7, representing the teacher's direct influence on the students. Area B represents students' verbal interaction behaviors and contains code 8, code 9, and code 10. Region C represents silence or chaos in teaching and contains codes 11 and 12. Fourth, Region D represents teacher and student manipulation techniques, including code 13 and code 14.

The mean value of the percentage of code 1 is 0.33%, and the percentage of the six lessons is within 0.1%-0.6%, which is a small and balanced overall value. It shows that the teacher expresses emotional care for the students in every lesson but the percentage is not high, meaning that there is less emotional communication with the students. It indicates that teachers sometimes care about students' psychology but focus more on advancing the content. The mean value of the percentage of code 9 is 9.01% and its overall distribution is uneven. The highest value was 12.14% for course 1 and the lowest value was 7.11% for course 6. Overall, the percentage of beneficial silence generated in the six courses was more balanced. The reason for this is that when students answer a question, they usually need some thinking time and a certain amount of silence is generated between the opening of the mike and the answering of the question. This is necessary for the teaching and learning process and is beneficial to the smooth progression of teaching and learning activities. The mean value of the percentage accounted for by code 14 is 2.01%, the highest percentage is in course 4 with 3.95%, where the lowest percentage is in course 6 with 0.85%. This indicates that as a whole, students are less likely to use technology manipulatives. From the classroom observations, students' use of technology was mainly focused on opening the microphone to answer questions, sending private messages to the instructor, and sharing their pictures in the class group as well as joining discussion groups.

Table 4: Category ratio comparison

Analogy Scale (%)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Class 1	0.37	4.57	0.75	8.72	31.12	2.04	0.22	6.16	12.14	9.20	0.75	11.42	7.50	3.55
Class 2	0.11	3.5	0.85	6.02	31.28	3.14	0.12	5.52	10.55	8.20	1.40	13.60	13.64	1.70
Class 3	0.22	2.40	1.10	6.40	26.25	3	0.35	7.09	11.40	9.50	2.35	14.10	12.55	1.80
Class 4	0.42	3.40	0.60	9.11	33.82	0.80	0.22	3.41	9.50	6.55	1.60	9.80	15.42	3.95
Class 5	0.28	3.60	0.55	6.65	32.60	5.10	0.31	11.57	8.03	6.91	1.35	13.73	7.85	1.45
Class 6	0.60	4.20	0.59	9.30	35.24	2.43	0.32	7.90	7.11	8.85	0.85	12.46	9.05	0.85
Mean	0.33	3.4	0.71	7.88	31.98	2.83	0.3	7.49	9.01	7.95	1.54	12.52	11.22	2.01

4.2.2 Matrix analysis

In order to visualize the proportional distribution of the different interactive behaviors and how they are produced over a continuous period of time, so that the different interactive behaviors can be summarized and analyzed, a matrix analysis table was conducted as shown in Tables 5 and 6. The total value of the positive integration grids for course 1 is 15 and for course 2 there are a total of 11 pairs of positive integration grids. As a whole, the positive integration grids of the courses are all greater than the values of the negative integration grids, which indicates an overall favorable classroom climate. Once the behavior of emotional interaction occurs, the overall emotional tendency is positive, the teacher-student relationship is cordial, there is no tension, and there is no teacher-student conflict or forceful critical educational behavior.

Table 5: Lesson 1 Vocabulary Part 1 Matrix Analysis

Analogy	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Amount
1	3	0	0	0	1	0	0	0	0	0	0	2	0	0	6
2	0	5	0	0	6	27	0	0	1	0	0	4	8	0	51
3	0	4	5	0	1	0	0	0	0	0	0	0	0	0	10
4	0	1	0	42	0	0	0	7	8	0	0	28	1	3	90
5	0	8	1	35	251	2	0	1	8	1	0	1	22	3	333
6	0	0	0	1	0	15	0	0	0	0	0	8	0	0	24
7	0	0	0	0	1	0	1	0	0	0	0	0	0	0	2
8	0	8	0	0	4	0	0	46	1	0	0	1	2	0	62
9	1	16	5	2	17	0	1	0	89	0	0	3	3	0	137
10	0	0	0	0	0	1	0	0	0	83	1	15	0	0	100
11	0	0	0	0	0	1	0	0	0	0	5	1	1	0	8
12	0	1	0	3	2	2	0	10	27	17	1	44	5	1	113
13	1	3	0	8	22	2	0	1	5	0	0	2	35	5	84
14	0	1	0	0	9	2	0	1	0	0	1	0	0	22	36
Amount	10	96	21	186	636	74	3	131	276	200	15	221	152	49	1056
Rate(%)	0.95	9.9	1.99	17.61	60.23	7.01	0.28	12.41	26.14	18.95	1.42	20.93	14.40	4.64	

Table 6: Lesson 2 Grammar and Vocabulary Part 2 Matrix Analysis

Analogy	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Amount
1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
2	0	4	0	3	21	0	0	0	1	0	0	0	5	0	34
3	0	2	4	0	0	0	0	0	0	0	0	0	1	0	7
4	0	1	0	25	0	0	0	0	9	0	0	31	0	0	66
5	0	8	2	21	234	1	0	0	9	0	0	4	56	1	336
6	0	0	0	0	0	25	0	4	0	0	0	7	0	0	36
7	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
8	0	5	0	1	1	0	0	43	5	0	0	8	0	0	63
9	1	7	1	0	16	0	1	0	69	0	0	15	4	1	115
10	0	0	0	0	0	1	0	0	0	69	2	9	1	0	82
11	0	0	0	0	0	0	0	0	1	1	8	3	0	0	13
12	0	3	1	2	6	6	0	15	29	13	0	53	3	2	133
13	0	0	0	13	49	2	0	0	2	0	0	5	60	1	132
14	0	0	0	0	5	0	0	0	1	2	0	1	0	11	20
Amount	1	30	8	65	334	35	1	62	126	85	10	136	130	16	1039
Rate(%)	0.1	2.89	0.77	6.26	32.15	3.37	0.10	5.97	12.13	8.18	0.96	13.09	12.51	1.54	

4.2.3 Ratio analysis

In order to better study the classroom interactive behaviors and analyze the percentage of different interactive behaviors in the classroom, the interactive behavior variables were counted and calculated, and the results of the ratio operation of the 14 variables for the six courses are shown in Table 7.

The ratio of students' verbal interaction in course 1 is 28.08%, the ratio in course 2 is 24.75%, the ratio in course 3 is 29.35%, the ratio in course 4 is 19.37%, the ratio in course 5 is 27.38%, and the ratio in course 6 is 24.09%. It can be seen that the ratio of teachers' verbal interaction is lower than the normative data in both the vocabulary lessons and the classrooms in which texts and grammar are taught, which shows that the ratio of teachers' speaking in immersion classrooms is much higher than the ratio of teachers' speaking in traditional classrooms, which is a great progress to change the filler classrooms.

In terms of the teacher questioning ratio, the teacher questioning ratio is 17.64%, 13.51%, 14.84%, 18.15%, 12.64% and 17.94%, which is lower than the normative data of the Flanders experiment by 26%, which shows that the teachers didn't choose a large number of question scaffolds. From the actual observation of the classroom, most of the teachers chose to be in an immersive virtual classroom, which can avoid the classroom being too rigid and increase the flexibility of the classroom.

Table 7: Variable ratio

Analogy	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6
Teacher speech interaction ratio	48.93%	45.59%	40.8%	50.34%	50.59%	54.68
Student speech interaction ratio	28.08%	24.75%	29.35%	19.37%	27.38%	24.09%
Beneficial teaching silence ratio	10.68%	13.24%	13.18%	9.63%%	12.42%	11.23%
Technology adoption rate	10.27%	13.66%	13.64%	19.38%	7.81%	9.18%
The ratio of indirect and direct influence of teachers' language on students	42.4%	28.86%	34.49%	39.11%	28.42%	38.48%
The proportion of teachers' language in the interview	17.64%	13.51%	14.84%	18.15%	12.64%	17.94%
Student language: percentage of students who speak actively	46.36%	45.85%	41.52%	50.45%	30.22%	29.44%
Teacher's technology manipulation ratio in information technology application	68.11%	89.39%	88.41%	81.1%	85.64%	90.82%
The proportion of students operating technology in information technology applications	32.96%	11.69%	12.94%	19.66%	14.69%	8.69%
The ratio of open-ended questions to teachers' questions	66.52%	58.04%	13.32%	22.1%	51.6%	49.19%
The ratio of students 'active responses to students' active speech	81.73%	78.34%	95.58%	75.61%	90.95%	90.51%
The ratio of students 'active questioning to students' active speaking	18.19%	21.05%	5.04%	24.94%	8.64%	9.99%
The percentage of student responses that were initiated by students	63.73%	61.93%	62.28%	68.75%	37.73%	44.88%
Steady state zone ratio	61.89%	59.41%	60.87%	64.09%	70.34%	70.27%

4.3 Analysis of Teaching Behavior Based on S-T Approach

The study applies the original codes for conversion to S-T coding, the coding conversion rule is as follows: codes 1~8 in the improved ITIAS analysis system belong to teacher behaviors and are converted to code T as a whole, codes 9~13 are student behaviors and will be converted to code S, and code 14, which is not a teacher or student behavior, will not be converted, and the resulting S-T data series of teaching behaviors can be obtained. It has been tested that the Rt value calculated by the S-T coding system has an error of <0.5% with the teacher activity rate in the TBAS system, which is almost non-existent, so this coding conversion rule can be applied. Thus, the Rt, g, and Ch values of the classroom can be calculated. Among them, Ch value indicates the teacher-student behavior conversion rate, the size of Ch value can indicate the frequency of teacher-student interaction, the larger the CH value, the more frequent the teacher-student interaction in the classroom. The results of the calculations are shown in Table 8, with a Ch mean of 40.80% and a variance of 0.00264129451 for the six lesson examples. As can be seen from the data results, the overall teacher-student behavioral conversion rate in immersive language learning instruction is higher than 40%, and the teacher-student interaction is significantly improved.

Table 8: Rt and Ch values of the lesson study

	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6
g value	321	259	263	243	309	304
Rt value	39.28%	34.65%	40.09%	40.84%	44.17%	50.14%
Ch value	51.43%	37.53%	3357%	31.18%	45.31%	45.77%

According to the data in the above table, the following distribution diagram of teaching modes is drawn, in which the horizontal axis indicates the Rt value and the vertical axis indicates the Ch value, and the Rt-Ch diagram is obtained according to the judgment criteria of teaching modes, as shown in Figure 6.

From the figure, it can be seen intuitively that the six English teaching lessons are distributed in the hybrid and dialogic teaching modes, and the lessons are mostly in the dialogic teaching mode, and most of them fall in the area of dialogic classroom teaching mode, where the teachers pay attention to mobilizing the enthusiasm of students' active participation and emphasize the promotion of students' thinking and inquiry and communication and interaction through the form of questioning. From the data in the figure, it can be found that there are no cases in the lecture-type teaching mode, which shows that teachers no longer spend most of the classroom time on lecturing when teaching English, and this behavior has been gradually reduced, and more teachers' behaviors are expressed in questioning behaviors and feedback behaviors.

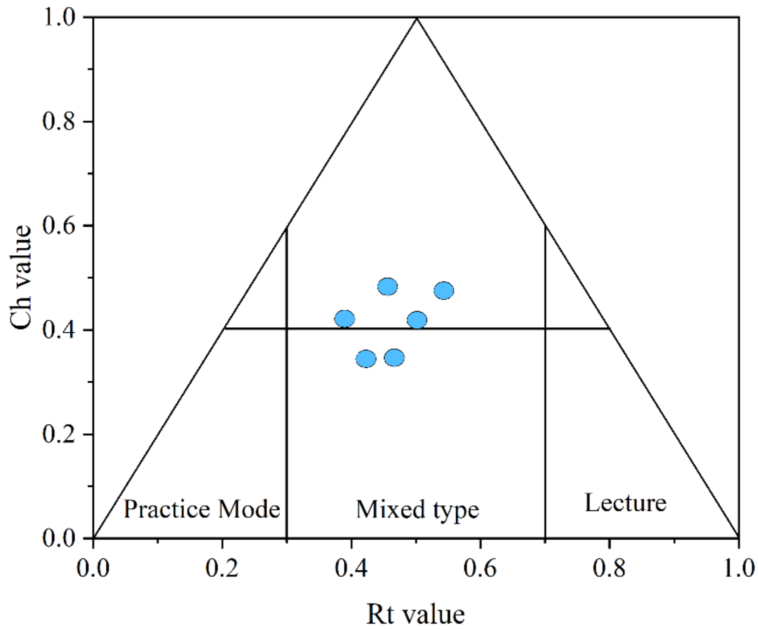


Figure 6: Distribution of teaching models

5 Conclusion

This paper proposes a new language teaching model and technical framework to establish an immersive virtual classroom for English education using the virtual reality characteristics of the metaverse. It also reveals the temporal dynamic characteristics of brain activity through ERP and uses the improved iFIAS classroom behavior analysis system and S-T analysis to explore the teaching behavior characteristics of immersive virtual classroom teaching. It was found that emotional valence has a potential effect on vocabulary recall, the rate of students' verbal interactions fluctuated between 28.08% and 24.09%, and the teacher's speech fluctuated around 5%, which indicates that the fluctuation of the rate of speech between the teacher and the students in different teaching sessions was small. The average Ch value of the six lesson examples is 0.4080, and four lesson examples fall in the region of dialogic teaching mode, where dialogic interaction between teachers and students is significantly enhanced.

About the Author

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