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A Long-Term Tracking Study of the Cognitive Effects of a Generative Artificial Intelligence-Supported English Language Teaching Model Innovation on Language Acquisition

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Abstract With the current acceleration of globalization and the increasing prominence of English as an international common language, the traditional English teaching mode is facing many challenges. The digital era has put forward higher requirements for language learning, and it is necessary to cultivate students' intercultural communicative competence and critical thinking. This study investigates the impact of English teaching mode supported by generative artificial intelligence on the cognitive effects of language acquisition. Adopting a quasi-experimental research design, two classes of University S with a total of 89 students were selected as the research subjects, and 44 students in the experimental group and 45 students in the control group were set up to implement the English teaching mode based on generative artificial intelligence for the experimental group, and the control group adopted the traditional teaching method, for a one-semester long term tracking study. The cognitive effects of students' language acquisition were measured through four dimensions: language thinking, language and culture cognition, language comprehension and language application. The results showed that there was no significant difference between the two groups of students in each test before the experiment ($P>0.05$). After the experiment, the average scores of the experimental group in language thinking, language and culture cognition, language comprehension and language application reached 24.26, 23.41, 22.84 and 23.48 respectively, which were significantly higher than those of the control group of 16.03, 16.85, 15.67 and 16.11, and the difference between the groups was statistically significant ($P<0.001$). All the abilities of the experimental group were significantly improved compared to the preexperiment, while there was no significant change in the control group. The study shows that generative artificial intelligence technology can effectively improve the cognitive effect of students' English language acquisition, which provides an important reference for the innovation of English teaching.

Index Terms generative artificial intelligence, English teaching model, language acquisition, cognitive effects, long-term tracking, personalized learning

I. Introduction

English education is an important part of modern education, which plays a vital role in the growth and development of individuals [1]. In today's globalization, English has become an international common language, and mastering English can not only broaden the horizons, but also improve personal competitiveness [2]. However, the traditional English education model has not adapted to the development of today's society, and pure knowledge teaching not only fails to improve the teaching knowledge, but also makes students bored and makes their learning more passive [3], [4]. Therefore, teachers should innovate the teaching mode according to the new educational background, focusing on the cultivation of students' abilities in all aspects, and the application of generative artificial intelligence promotes the innovation of English education mode, and plays a great role in improving the cognitive effect of students' language acquisition [5]-[8].

As one of the important branches of AI, generative AI is not only widely used in the fields of art and literature, but also shows innovative application prospects in the field of education [9], [10]. Generative AI is a technology based on machine learning, which generates new content, such as images, music, text, etc., by learning a large amount of data [11]-[13]. Generative AI can achieve personalized teaching, automatic assessment and feedback, and cross-cultural communication in English education, which is important to help students better master English, understand their strengths and weaknesses, and improve cross-cultural awareness and language communication skills [14]-[17].

In this study, we constructed a framework for the innovation of English teaching mode based on generative artificial intelligence, and adopted a quasi-experimental research method, choosing 89 students from two classes

in University S as the research subjects, and setting up an experimental group and a control group for a comparative study. The research process is divided into three stages: firstly, a pre-test is conducted to ensure that there is no significant difference in the initial language proficiency levels of the two groups of students; secondly, a semester-long teaching intervention is carried out, with the experimental group adopting an innovative teaching model incorporating generative AI technology and the control group maintaining the traditional teaching method; and finally, a post-test is conducted and the data are analyzed to assess the four dimensions of language thinking, language and cultural cognition, language comprehension, and language application. Teaching Effect. This study expects to verify the application value of generative AI technology in English teaching through systematic empirical analysis, and provide theoretical basis and practical guidance for the digital transformation of English education.

II. English Teaching Model Innovation Based on Generative Artificial Intelligence

II. A. Generative Artificial Intelligence in English Language Education

Generative AI refers to interactive robots based on large vector databases that utilize techniques such as natural language processing (NLP) and machine learning algorithms (ML) to simulate human conversations [18]. Existing generative AI (e.g., ChatGPT), with the support of a large corpus and advanced machine learning algorithms, is able to highly aggregate user interaction needs and achieve real-time and human-like high-quality responses. With the further development of generative AI, the link between generative language modeling based on natural language processing and artificial intelligence and English language teaching centered on “language acquisition” is getting closer and closer. Therefore, AI-assisted English teaching has become a hot spot and a focus of attention for scholars and frontline teachers, and its potential and application prospects in English teaching are very broad.

II. A. 1) Generating teaching resources

Artificial Intelligence Generated Content (AIGC) can assist teachers in syllabus generation [19], [20]. In practical applications, teachers are able to instantly generate syllabi based on different topics according to the demand, and most of the generated syllabi contain many specific teaching contents, which are easy to be used by teachers and students in actual teaching scenarios. At the same time, the details and information in the generated syllabus can be modified in a timely manner by continuously giving follow-up instructions, and different language versions can be generated at the same time. In addition, depending on the requirements of the course and the level of the students, teachers can utilize the AIGC tool to automatically generate appropriate teaching materials. For example, for students of different grades, AIGC can generate reading comprehension passages or grammar practice questions of moderate difficulty to ensure that each student can learn at a level of difficulty that suits him or her. In addition to textual content, AIGC can also generate video clips or audio dialogues suitable for classroom discussion to help students improve their listening and speaking skills and enhance the effectiveness of their listening and speaking training. Teachers can also adjust and update the teaching resources as the course progresses and students' feedback is received. AIGC can quickly generate new teaching content according to the latest teaching needs, ensuring that the teaching materials are current, relevant and applicable.

II. A. 2) Supporting Teaching and Feedback

AIGC can play the role of a virtual teaching assistant in the classroom, answering students' questions and providing additional explanations and demonstrations in a timely manner, which not only reduces the burden on the teacher, but also ensures that every student receives timely help. This not only reduces the teacher's burden, but also ensures that every student receives timely help.AIGC is also able to make positive and negative judgments, analyze the causes of errors, and make objective comments on the completion of students' exercises. This diagnostic and evaluation function has a high application value and provides a technical guarantee and foundation for the construction of full-process automated teaching evaluation. Based on students' learning performance and data analysis, AIGC can provide personalized learning suggestions and resource recommendations for each student. For example, for students with weak grammar, the system can recommend relevant practice questions and learning materials to help them learn and improve in a targeted way. Through natural language processing technology, AIGC can also participate in classroom discussions, asking questions or guiding the direction of the discussion, facilitating interactions between teachers and students as well as among students, and enhancing classroom participation and learning effects. It can be seen that AIGC can provide support and assistance to teaching and learning in the aspects of teaching design, resource generation, evaluation and feedback of English teaching, so as to improve the quality and level of English teaching and learning.

II. B.Specific measures for teaching

II. B. 1) Design of adaptive learning paths

The planning of adaptive learning paths is not just about simple course adjustments, but also about profiling students' learning data and behavioral patterns. For example, in English writing classes, the AIGC system can recommend specific learning content and exercises based on students' strengths and weaknesses in grammar, vocabulary, and writing structure to meet each student's individual learning needs. This kind of personalized planning not only helps students improve their learning effectiveness in the short term, but also develops their ability to learn independently and their motivation for continuous improvement in the long term.

II. B. 2) Personalized Learning Resources Recommendation

For a student who prefers to learn through video, the AIGC system can recommend multimedia resources that incorporate English listening and speaking training, such as English news videos, English movie clips, etc., to enhance his/her listening and speaking skills. For a student who prefers to learn in writing, the system may recommend English literature or academic articles that match his/her reading level and interests to help him/her improve his/her reading comprehension and writing skills.

II. B. 3) Real-time language understanding and error correction

In the area of real-time language comprehension, AIGC is able to quickly understand students' oral expression through speech recognition technology, and then analyze the accuracy of grammatical structure, semantic logic, etc. When students practice speaking, the system can instantly recognize and correct pronunciation and grammatical errors, and give real-time feedback and suggestions to assist students in improving their expression. When students practice speaking, the system instantly recognizes and corrects errors in pronunciation and grammar, and gives real-time feedback and suggestions to help students improve their expressions, and the AIGC system analyzes students' written texts, detecting grammatical errors, spelling mistakes, and semantic inappropriateness, and then gives detailed suggestions for corrections.

II. B. 4) Application of grammatical and semantic analysis tools

With the AIGC system, teachers and students can utilize advanced natural language processing technology to deeply analyze students' language use, thereby improving grammatical and semantic comprehension. Grammar analysis tools help students understand and apply English grammar rules accurately. For example, the system analyzes sentence structure and grammatical errors in students' writing, and identifies and suggests corrections for errors in tense, morphology, and sentence patterns. With the AIGC system, students are supported with more in-depth semantic analysis when comprehending and expressing themselves.

II. B. 5) Interactive Language Generation and Dialogue Modeling

The interactive language generation model motivates students to actively participate in language exchange by simulating real conversation scenarios. In the virtual learning environment, the AIGC system can act as a conversation partner and practice real-time oral conversations with students. The system not only understands students' linguistic input, but also provides timely feedback and corrections to help students improve their expressions and enhance their language fluency. Conversation modeling can also promote the development of students' language use skills in multiple contexts. For example, the system can design a wide variety of conversational tasks, including daily life, academic discussions, or business communication scenarios, so that students can practice their language skills in different situations in the simulation.

II. C.Instructional Design for the Integration of AIGC Technology into the Ecology of English Education

The path of integrating AIGC technology into the ecology of English education is to innovate the education model through the reconstruction of teachers' teaching content, students' personalized learning mode, teaching environment and teaching evaluation, integrate generative artificial intelligence with the ecological environment of English classroom, carry out human-computer coupled digital foreign language education through the use of AIGC technology to provide content support, and comprehensively realize the in-depth integration of digital intelligence technology and foreign language education. The pedagogical design of AIGC technology integrated into English education ecology is shown in Figure 1.

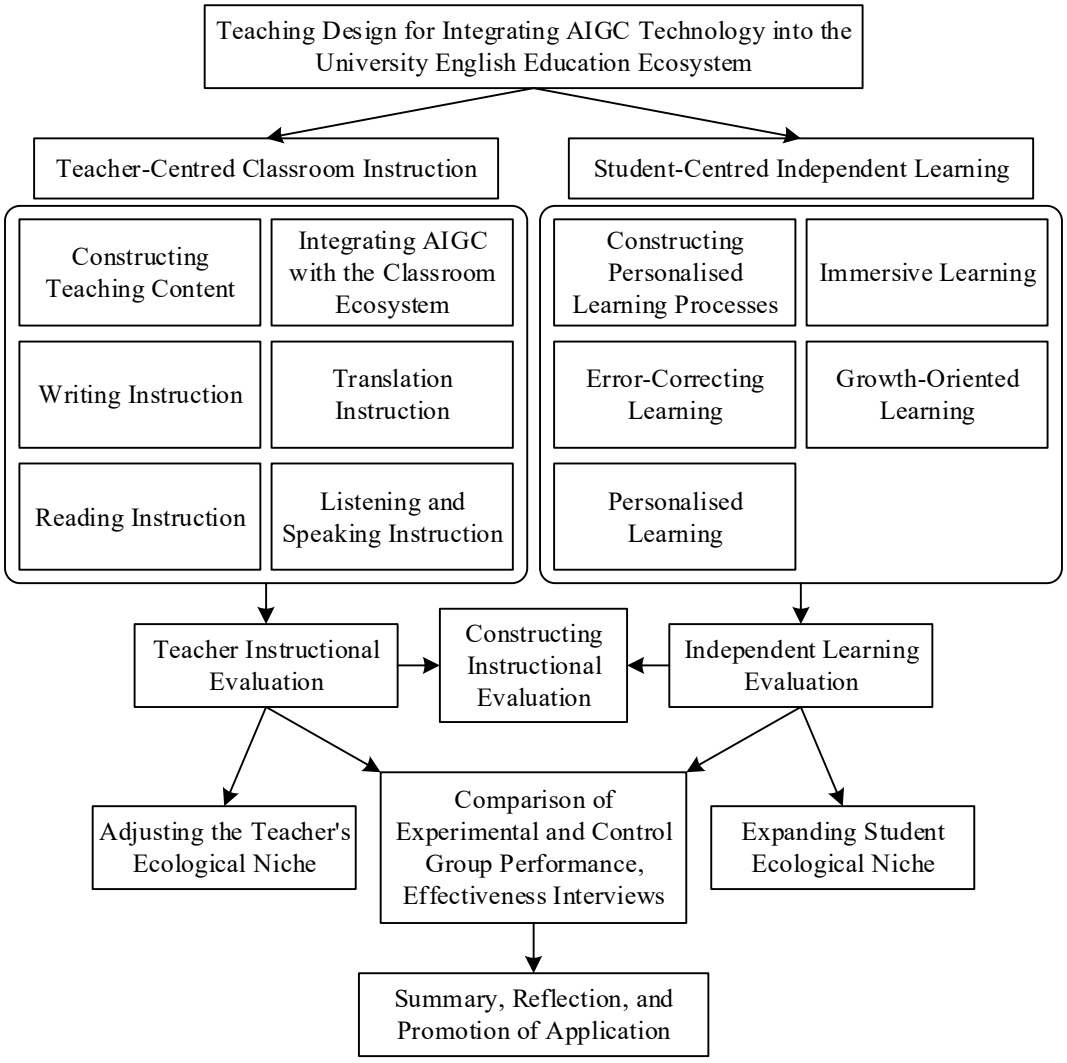

Figure 1: AIGC technology integrated into the teaching design of the English education ecology

II. D.Paths of AIGC-assisted ELT design

The author explores the path of using AIGC to assist English teaching design, and tries to put forward the "ACE three-step design method" under the TPACK framework (A, C, E are the initials of Analysis, Construction, and Evaluation in English, respectively). The method focuses on the integration of subject teaching knowledge to screen, judge, compare and analyze the content provided by AIGC, and optimizes the process of collaborating between teachers and AIGC to complete the instructional design, so as to help teachers make more reasonable instructional decisions, aiming at improving students' comprehensive literacy and implementing the nurturing goals of the English curriculum.

Under the TPACK framework, English teachers need to have the ability to integrate English teaching content, teaching methods and information technology to jointly promote teaching and learning, and under the influence of technology, the choice of English teaching content will inevitably change.

The TPACK framework is a comprehensive model of teacher knowledge proposed by American scholars Kohler and Mishra in 2005, and the TPACK framework is shown in Figure 2. It contains three basic elements, namely, subject knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK). The parts of the three elements that overlap with each other are composite elements, the two-by-two elements include subject matter pedagogical knowledge (PCK), technological pedagogical knowledge (TPK), and technological content knowledge (TCK), and the element that combines the three elements is the subject matter pedagogical knowledge that integrates technology (TPACK).TPACK helps teachers to understand how to integrate technology with instructional content and methodology in order to create more effective learning environments. It helps teachers integrate technology effectively into their teaching practices.

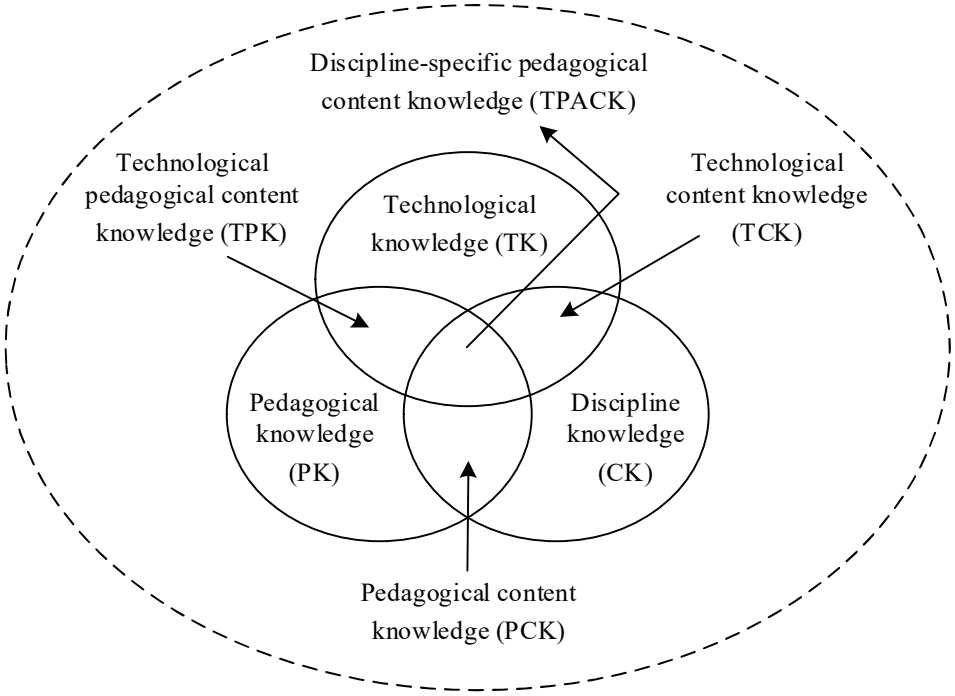

Figure 2: TPACK framework

After the completion of knowledge construction, teachers should focus on the analysis of the interrelationship of the teaching elements, design and implement the teaching of the unity of objectives, activities and evaluation, so that students can become participants and collaborators in the evaluation activities. Based on the teaching knowledge of the above subjects, the author proposes the “ACE three-step design method”, which includes discourse analysis, knowledge construction and classroom evaluation, as shown in Figure 3. Under the TPACK framework, teachers can make full use of the pedagogical knowledge of the subject that integrates the AIGC technology to complete the instructional design process by applying the “ACE three-step design method”.

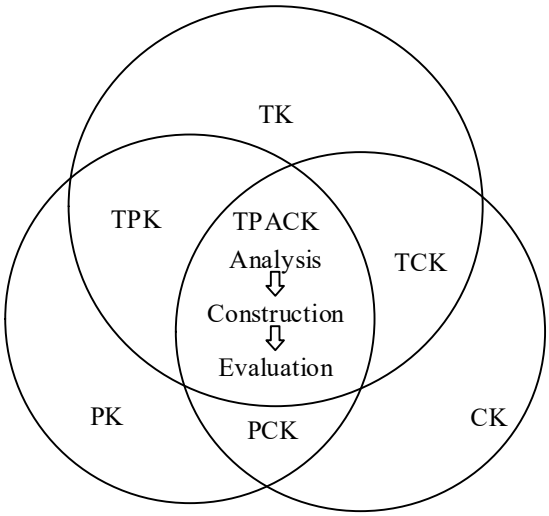

Figure 3: The ACE three-step design under the TPACK framework

III. Tracking the cognitive effects of language acquisition

In this paper, we set up an experimental group and a control group by selecting two classes of students in University S for teaching experiments. The English teaching model based on claimed artificial intelligence proposed in this

paper is adopted in the English teaching of the experimental group, while the control group is not required to follow the traditional teaching method. The cognitive outcomes of language acquisition of the two groups of students were tracked over a period of one semester.

III. A. Language Perceptions of Students in the Experimental and Control Groups Before the Experiment

In order to understand the differences in the receptive vocabulary acquisition effects of the two groups of subjects before taking part in the experiment, the researcher distributed a total of language acquisition cognitive pre-test test papers to the two groups of subjects before the experiment, and the pre-test data were collated and analyzed by using SPSS23.0, and the results were obtained as shown in Table 1.

The mean values of the pre-tests of language thinking, language and culture cognition, language comprehension, and language application of the subjects in the experimental group are 15.26, 16.24, 14.85, 15.63 respectively, and the mean values of the pre-tests of the subjects in the control group are 15.07, 16.39, 15.02, 15.71 respectively.The difference between the mean values of the subjects in the experimental group and the mean values of the subjects in the control group are 0.19, 0.15, 0.17, 0.08 respectively. and 0.08. It can be found that the mean values of the experimental group are all higher than those of the control group, but it does not indicate that the difference between the two groups of subjects' pre-test scores is significant. in order to further determine whether there is a significant difference between the pre-test scores of the two groups of subjects, the researcher used the independent samples t-test for significance measurements in SPSS23.0, and the results are shown in Table 2, in which A~D stand for linguistic thinking, linguistic and cultural cognition, language comprehension and language application.

The probability of significance of Levine's test of equivalence of variances is greater than 0.05, which indicates that the variances of the two groups of subjects in the pre-test of language acquisition and cognition are the same, and therefore the probability of significance is expressed by the data of “assumed equivalence of variances”, which is greater than 0.05 as can be seen from Table 2, which indicates that there is no significant difference in the subjects' performance in the pre-test of language acquisition and cognition, and at the same time, there is no significant difference between the two groups in the pre-test of language acquisition and cognition. At the same time, the 95% confidence intervals of the difference values contain 0, which also indicates that there is no significant difference between the two groups of subjects in the pre-test of language acquisition cognitive performance.

Therefore, a comprehensive analysis of the statistical results of the data in Tables 1 and 2 can prove that the two groups of subjects have the same cognitive effect on language acquisition in the pre-test, and can be used as research subjects without interfering with the subsequent experiments.

Table 1: Pre-test language acquisition cognition of experimental and control group

	Group	Number	Mean	SD	SE
Language thinking	Experimental	44	15.26	3.265	0.426
	Control	45	15.07	3.471	0.415
Language culture cognition	Experimental	44	16.24	2.946	0.387
	Control	45	16.39	3.285	0.452
Language understanding	Experimental	44	14.85	3.475	0.442
	Control	45	15.02	2.698	0.379
Language application	Experimental	44	15.63	2.849	0.348
	Control	45	15.71	3.265	0.405

Table 2: Pre-test independent sample T test results of experimental and control group

		Levine variance equivalence test		Mean equivalence t test						
		F	Sig	t	df	sig(2-tailed)	MD	SED	95% CI	
									Upper	Lower
A	Assumed	0.026	0.826	0.236	87	0.806	0.128	0.523	-1.256	1.632
	Unassumed			0.236	86.485	0.806	0.128	0.523	-1.256	1.632
B	Assumed	0.027	0.815	0.245	87	0.792	0.145	0.436	-1.425	1.487
	Unassumed			0.245	86.748	0.792	0.145	0.436	-1.425	1.487
C	Assumed	0.031	0.795	0.263	87	0.788	0.154	0.536	-1.632	1.389
	Unassumed			0.263	86.745	0.788	0.154	0.536	-1.632	1.389
D	Assumed	0.023	0.853	0.298	87	0.822	0.166	0.478	-1.584	1.749
	Unassumed			0.298	86.593	0.822	0.166	0.478	-1.584	1.749

III. B. Changes in language cognition of students in the experimental group and the control group after the experiment

In order to investigate the effect of the English teaching mode of this paper on the long-term language acquisition effect of the subjects, the researcher distributed post-test test papers to the subjects after the experimental teaching. After that, the researcher used SPSS23.0 to organize and analyze the collected data to obtain the posttest data of the subjects' language acquisition cognition as shown in Table 3, and the results of the independent samples t-test as shown in Table 4.

As far as the values of the posttest scores are concerned, the mean values of the experimental group are 24.26, 23.41, 22.84, and 23.48, while the mean values of the control group are 16.03, 16.85, 15.67, and 16.11, and the numerical differences between the two mean values are 8.23, 6.56, 7.17, and 7.37, respectively.

The probability of significance and significance (two-tailed) under the “Levine's test of variance equivalence” are both smaller than 0.05, indicating that there is a significant difference in the cognitive posttest scores of language acquisition between the two groups. In addition, the 95% confidence intervals of the differences between the two groups do not contain zero, again indicating that the difference in the values of the cognitive posttest scores of language acquisition between the two groups is significant.

Table 3: Post-test language acquisition cognition of experimental and control group

	Group	Number	Mean	SD	SE
Language thinking	Experimental	44	24.26	5.042	0.628
	Control	45	16.03	3.856	0.462
Language culture cognition	Experimental	44	23.41	4.975	0.574
	Control	45	16.85	3.645	0.447
Language understanding	Experimental	44	22.84	4.725	0.462
	Control	45	15.67	3.247	0.398
Language application	Experimental	44	23.48	4.685	0.478
	Control	45	16.11	3.584	0.416

Table 4: Post-test independent sample T test results of experimental and control group

		Levine variance equivalence test		Mean equivalence t test						
		F	Sig	t	df	sig(2-tailed)	MD	SED	95% CI	
									Upper	Lower
A	Assumed	4.845	0.004	5.626	87	0.001	2.915	0.596	0.926	3.515
	Unassumed			5.626	83.425	0.001	2.915	0.596	0.926	3.515
B	Assumed	3.695	0.008	4.215	87	0.001	2.845	0.574	0.968	3.745
	Unassumed			4.215	84.256	0.001	2.845	0.574	0.968	3.745
C	Assumed	3.748	0.013	3.748	87	0.001	2.045	0.589	1.054	3.942
	Unassumed			3.748	83.458	0.001	2.045	0.589	1.054	3.942
D	Assumed	4.827	0.007	5.237	87	0.001	2.341	0.568	0.905	3.415
	Unassumed			5.237	84.052	0.001	2.341	0.568	0.905	3.415

III. C. Changes in language perception within the experimental group before and after the experiment

In order to comprehensively assess the impact of this experiment on students' cognitive effects on language acquisition, the researchers analyzed the pre-test and post-test data of the experimental group's cognition of language acquisition using the paired samples t-test method. By comparing and examining the changes in the experimental group's language acquisition cognition before and after the experiment, this study was able to gain a deeper understanding of the extent of the experiment's impact on students' language acquisition cognition. The language acquisition cognition within the experimental group before and after the experiment is shown in Table 5.

The results show that the p-value is 0.000, which is less than 0.05, in the language thinking, language and culture cognition, language comprehension and language application tests, indicating that there is a significant difference in the performance of the experimental group before and after the experiment.

To sum up, based on the analysis of paired samples t-test, the following conclusion can be drawn: in this experiment, there are significant differences in the results of the experimental group in language thinking, language and culture cognition, language comprehension and language application tests.

Table 5: Inner-group comparison in language acquisition cognition of experimental group

	Pre-test	Post-test	T	P
Language thinking	15.26±3.265	24.26±5.042	-7.452	0.000
Language culture cognition	16.24±2.946	23.41±4.975	-5.374	0.000
Language understanding	14.85±3.475	22.84±4.725	-6.484	0.000
Language application	15.63±2.849	23.48±4.685	-5.674	0.000

III. D. Changes in language perception within the control group group before and after the experiment

The results of comparing the cognitive changes in language acquisition in the control group before and after the experiment based on the paired samples t-test are shown in Table 6. From the data in Table 6, it was found that this study found no significant difference in the performance of language acquisition cognition before and after the experiment in the four tests of language thinking (P=0.845>0.05), language and culture cognition (P=0.726>0.05), language comprehension (P=0.516>0.05), and language application (P=0.736>0.05). Accordingly, it can be inferred that this traditional teaching method has no significant effect on the enhancement of students' language acquisition cognition.

Table 6: Inner-group comparison in language acquisition cognition of control group

	Pre-test	Post-test	T	P
Language thinking	15.07±3.471	16.03±3.856	-0.915	0.845
Language culture cognition	16.39±3.285	16.85±3.645	-0.826	0.726
Language understanding	15.02±2.698	15.67±3.247	-0.748	0.516
Language application	15.71±3.265	16.11±3.584	-0.856	0.736

IV. Conclusion

Through a semester-long teaching experiment, the study found that the English teaching model supported by generative artificial intelligence significantly improved students' cognitive effects on language acquisition. Data analysis showed that the average score of students in the experimental group using the innovative teaching mode in the language thinking dimension increased from 15.26 to 24.26, an increase of 58.9%; language and culture cognitive ability increased from 16.24 to 23.41, an increase of 44.1%; language comprehension ability increased from 14.85 to 22.84, an increase of 53.8%; and language application ability increased from 15.63 to 23.48 points, an increase of 50.2%. In contrast, the control group using traditional teaching methods showed no significant change in any of the indicators, with the average scores of the four dimensions increasing by only 0.96, 0.46, 0.65 and 0.40 points respectively.

Generative AI technology shows significant advantages in English teaching, mainly in personalized learning path design, real-time language feedback, intelligent resource recommendation and interactive dialogue practice. The technology can provide customized teaching content according to students' learning characteristics and cognitive levels, effectively solving the problem of “one size fits all” in traditional teaching. At the same time, the instant feedback mechanism of the AI system helps students find and correct language errors in a timely manner, which improves learning efficiency. The experimental results confirm that the in-depth integration of generative AI technology and English teaching can significantly improve the cognitive effect of students' language acquisition, and provide a new path and method for the modernization and development of English education, which has important theoretical value and practical significance.

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