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An Empirical Study on the Influencing Mechanism of AIGC on the Cognitive Load of College Foreign Language Learners

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Abstract: In recent years, with the advent of the artificial intelligence era, AIGC technology has been widely applied in the field of education, and studying the influencing mechanism of cognitive load among college foreign language learners has gradually become an important topic at present. The application of AIGC technology in college foreign language teaching not only affects the cognitive load of foreign language learners but also changes the channels through which they process learning information and acquire foreign language knowledge. Furthermore, it can maximize the quality of college foreign language teaching and continuously improve learners' foreign language proficiency. Therefore, it is necessary to select representative research subjects, adopt scientific and reasonable research tools, comprehensively examine the impact of AIGC on the cognitive load of college foreign language learners, and deeply explore its internal laws. In this regard, this paper first conducts an empirical analysis on the influencing mechanism of AIGC on the cognitive load of college foreign language learners. Then it puts forward corresponding educational implications and suggestions, in order to provide certain references for relevant researchers.

Keywords: AIGC; College foreign language; Learners; Cognitive load; Influencing mechanism

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1. Empirical analysis of the influence mechanism of AIGC on the cognitive load of college foreign language learners

1.1. Research objects and instruments

1.1.1. Research objects

The research targets college English learners. During the group experiment, stratification will be conducted based on learners' majors, grades, or English proficiency to ensure that the ability levels and knowledge backgrounds of learners in each group are roughly equivalent, thereby controlling the differences in intrinsic load caused by prior knowledge.

1.1.2. Research methods

(1) For questionnaire surveys: Design a questionnaire that includes a subjective cognitive load assessment scale (such as the validated Paas Load Scale) and a learning effect questionnaire to evaluate learners' intrinsic load, extraneous load, germane load, as well as learning effectiveness and satisfaction under different teaching scenarios. Quantitative data are collected using a Likert Scale, and reliability and validity tests are conducted.

(2) For interview surveys: Conduct semi-structured interviews with some learners and English teachers to understand their subjective experiences and cognitive perceptions during the learning process using ChatGPT and DeepSeek, providing a qualitative perspective for questionnaire design and data interpretation.

(3) For learning logs: Require participants to record their learning processes and cognitive experiences (such as problems encountered, tool feedback, and thinking processes) during the period of using AI tools for auxiliary learning, so as to supplement the understanding of changes in cognitive load.

(4) For experimental controls: During the empirical research, an experimental group and a control group are set up respectively. The experimental group is allowed to use DeepSeek or ChatGPT when completing specific learning activities, while the control group is only allowed to use traditional resources such as class notes and dictionaries. Both groups complete learning tasks in the same environment, and after the tasks are completed, their learning effectiveness, cognitive load, and other indicators are immediately measured [1].

(5) For Structural Equation Modeling (SEM): This method verifies hypotheses based on the collected quantitative data. SEM can test more complex correlations between multiple variables, verify the relationships among AIGC application, learning effect influence paths, and cognitive load, and reveal the mediating effect generated thereby [2].

1.2. Research data collection and analysis

In order to explore the influence mechanism of AIGC on the cognitive load of college English learners in depth, this study adopted a mixed research method. By integrating quantitative and qualitative data, it conducted a systematic comparison between the experimental group (which used AIGC for auxiliary learning) and the control group (which used traditional learning resources). Data collection included three aspects: the Subjective Cognitive Load Scale, academic performance in learning outcome tests, and learning satisfaction questionnaires. All data were analyzed using SPSS 26.0 for descriptive statistics, t-tests, and correlation analysis. Additionally, AMOS 24.0 was used to construct a structural equation model (SEM) to verify the path relationships between variables.

1.2.1. Descriptive statistics on cognitive load and learning outcomes

A total of 218 valid questionnaires were collected in this study (experimental group, n = 112; control group, n = 106). The Paas Cognitive Load Scale (a 9-point Likert scale) was used to measure learners' intrinsic load, extraneous load, and germane load. Learning outcomes were evaluated based on academic performance in uniformly designed reading comprehension and writing tasks (scored on a 100-point scale). The results are presented in **Table 1**.

Table 1. Comparison of cognitive load and learning outcomes between the two groups (mean ± SD)

Variable	Experimental group (n = 112)	Control group (n = 106)	t-value	p-value
Intrinsic Cognitive Load	5.24 ± 1.32	6.87 ± 1.45	-7.893	0.000
Extraneous Cognitive Load	3.56 ± 1.21	4.89 ± 1.33	-7.211	0.000
Germane Cognitive Load	6.78 ± 1.43	4.32 ± 1.28	11.245	0.000
Total Cognitive Load	5.21 ± 1.12	6.52 ± 1.24	-7.654	0.000
Learning Outcome	82.45 ± 8.76	70.33 ± 9.54	9.876	0.000

Note: *$p < 0.05$ (statistically significant difference), **$p < 0.01$ (highly statistically significant difference), ***$p < 0.001$ (extremely statistically significant difference).

Table 1 shows that the intrinsic cognitive load and extraneous cognitive load of the experimental group during the learning process were significantly lower than those of the control group ($p < 0.001$), while the germane cognitive load was significantly higher than that of the control group ($p < 0.001$). This indicates that AIGC assistance effectively reduces the ineffective cognitive burden and promotes meaningful cognitive processing. Meanwhile, the learning effect of the experimental group was significantly better than that of the control group (t = 9.876, $p < 0.001$), which preliminarily verifies that AIGC has a positive impact on learning effectiveness.

1.2.2. Path analysis of structural equation model (SEM)

To further explore the mechanism underlying the relationship between AIGC use, cognitive load, and learning effect, this study constructed a structural equation model (SEM), which includes four latent variables: "AIGC Usage Frequency," "Intrinsic Cognitive Load," "Germane Cognitive Load," and "Learning Effect." The model exhibits good fit indices (χ^2/df = 2.13, CFI = 0.94, TLI = 0.92, RMSEA = 0.06), and the path coefficients are presented in **Table 2**.

Table 2. Path coefficients and significance test of the structural equation model

Path relationship	Standardized coefficient β	S.E.	C.R.	p-value
AIGC Use → Intrinsic Cognitive Load	-0.38	0.06	-5.212	0.000
AIGC Use → Germane Cognitive Load	0.42	0.07	5.876	0.000
Intrinsic Cognitive Load → Learning Outcome	-0.31	0.05	-4.532	0.000
Germane Cognitive Load → Learning Outcome	0.46	0.06	6.124	0.000
AIGC Use → Learning Outcome	0.28	0.05	3.987	0.000

The model results show that AIGC use has a significant negative impact on intrinsic cognitive load (β = -0.38, $p < 0.001$) and a significant positive impact on germane cognitive load (β = 0.42, $p < 0.001$). Intrinsic cognitive load exerts a negative predictive effect on learning effect (β = -0.31), while germane cognitive load has a significant positive effect on learning effect (β = 0.46). In addition, AIGC use has a direct positive effect on learning effect (β = 0.28) as well as an indirect effect mediated by cognitive load, indicating that cognitive load plays a partial mediating role between AIGC and learning effect.

The above data results indicate that AIGC technology significantly improves the learning effect by

reducing learners' extraneous and intrinsic cognitive load and increasing their germane cognitive load. This finding is consistent with the Cognitive Load Theory proposed by Paas and Sweller, which states that effective instructional design should reduce irrelevant cognitive load and increase germane cognitive load. The personalized explanations, multimodal examples, and real-time feedback provided by AIGC help learners construct clearer mental representations and facilitate in-depth language processing. Furthermore, the SEM results further reveal the dual-path mechanism through which AIGC influences the learning effect via the mediation of cognitive load, providing theoretical support and practical guidance for the educational application of AIGC.

1.3. Research results and discussion

In the experimental group using AIGC technology, the mean score of learners' self-assessment of cognitive load was much lower than that of the control group. This proves that AIGC technology can effectively alleviate the pressure brought by learning complex materials. In addition, regarding germane load, the control group scored significantly lower than the experimental group. This indicates that AIGC can promote learners to enter a state of in-depth thinking, conduct in-depth processing of foreign language knowledge, and organically connect new and existing knowledge points. Furthermore, in the questionnaire survey on satisfaction and learning effects, the scores of the control group were lower than those of the experimental group, which fully shows that learners have a high degree of recognition for AIGC-assisted learning [3].

Learners mentioned that AIGC provides diverse explanations and examples, helping them better understand complex foreign language knowledge, especially in grammar and vocabulary learning. For instance, when encountering an incomprehensible grammatical structure, AIGC can provide easy-to-understand explanations and list multiple example sentences in different contexts, enabling them to draw inferences about other cases from one instance. Teachers, on the other hand, believe that AIGC can serve as an effective supplementary teaching resource, providing more ideas and creativity for teaching activities. However, they also worry that learners may develop over-reliance on AIGC, which would neglect the cultivation of their independent thinking ability [4].

2. Educational implications and suggestions on the mechanism of AIGC's impact on the cognitive load of college foreign language learners

2.1. Teaching content design: Personalized provision and cross-modal integration

In terms of the impact of learning load, it is particularly important to provide personalized foreign language teaching content based on AIGC. Teachers should leverage the advantages of AIGC technology in teaching and combine learners' interests, learning characteristics, and foreign language proficiency to customize personalized teaching content for them. For example, for learners with a weak foundation, teachers can provide basic grammar content and fundamental foreign language vocabulary, and use AIGC technology to automatically generate low-level exercises and explanations. For learners with a solid foundation, teachers can use AIGC technology to provide more in-depth learning materials, such as foreign language news reports and research papers, and guide learners to use AIGC technology to assist themselves in reading and understanding the linguistic structures and language contexts in the learning materials [5].

In addition, teachers can also use AIGC to analyze learners' learning data, understand their usage of learning resources in different modalities and their learning effects, and further adjust the provision and

integration methods of teaching content. By continuously optimizing the personalized provision and cross-modal integration of teaching content, it is possible to better adapt to learners' cognitive needs, give full play to the positive role of AIGC in college foreign language teaching, and promote learners' foreign language learning and cognitive development [6].

2.2. Optimization of teaching process: Human-machine collaboration and real-time feedback

Currently, to improve the effectiveness of college foreign language teaching, it is essential to recognize the importance of human-machine collaboration. AIGC will form a complementary relationship in terms of advantages with teachers, and teachers can leverage AIGC technology to continuously enhance their own capabilities, such as in professional knowledge, teaching experience, and learning guidance. Additionally, teachers can utilize AIGC's functions like rapid content generation, data analysis, and data processing to continuously improve the efficiency of foreign language teaching. For instance, in teaching practice, teachers explain grammatical knowledge systematically and provide example demonstrations. After learners fully understand and master the grammatical knowledge, teachers can use AIGC technology to automatically generate practice questions of varying difficulty levels, analyze learners' answer situations, weak learning areas, and other aspects in real time, and accurately push matching intensive training content [7].

Furthermore, real-time feedback is also a key link in optimizing the teaching process. AIGC can provide timely feedback on learners' learning performance. During oral practice, AIGC can evaluate aspects such as the accuracy of pronunciation, fluency, and intonation, and offer detailed improvement suggestions. For learners' writing assignments, AIGC can conduct quick grading. It not only identifies grammatical errors and spelling mistakes but also evaluates the assignments from multiple dimensions, including content structure, logical coherence, and vocabulary usage. This kind of real-time feedback enables learners to promptly understand their own learning status, adjust their learning strategies, and improve learning efficiency [8].

2.3. Innovation in learning evaluation: data-driven and competence diagnosis

(1) The process-oriented evaluation system can continuously track learners' learning progress and dynamic changes

AIGC can instantly acquire and analyze various information, such as classroom performance, task completion status, and collaborative learning. For example, during oral training, AIGC can record details like pauses in learners' training and speech error rates in real time; during writing training, it can also collect information such as the evolution of learners' writing thinking and traces of writing revisions in real time. Based on this information, personalized learning profiles are established to intuitively present learners' shortcomings and strengths [9].

(2) Regarding cognitive load diagnosis tools

Teachers can develop professional diagnosis tools using AIGC technology to accurately detect the cognitive load of foreign language learners and monitor the distribution of their cognitive resources and their foreign language learning status in real time. For example, during foreign language reading comprehension, the diagnosis tool will collect data such as learners' reading speed, accuracy in reading texts on different topics, and changes in reading attention, so as to accurately evaluate the cognitive load of learners during the reading comprehension process.

2.4. Cultivation of students' competencies: from technology dependence to in-depth learning

(1) Guide learners to develop a correct understanding of the role of AIGC in learning

Even though AIGC technology can provide learners with suggestions for writing, reading, and translation, it remains an auxiliary learning tool that cannot replace learners' independent learning and thinking processes. Therefore, teachers can use case studies, in-class activities, and other methods to clarify the negative effects of excessive reliance on AIGC technology on foreign language learning. For instance, in foreign language writing exercises, if learners fail to think independently or organize language on their own during the writing process and merely copy and paste content generated by AIGC technology, it will be difficult for them to truly improve their writing skills [10].

(2) It is essential to stimulate learners' awareness of independent learning

Teachers can design challenging learning tasks and encourage learners to complete them without the assistance of AIGC technology. For example, organizing foreign language debate activities, thematic speeches, and similar events allows learners to practice and enhance their language expression, logical thinking, and problem-solving abilities in practical scenarios. At the same time, teachers should guide learners to develop personalized study plans: based on their own learning goals and progress, learners can reasonably arrange study time and content, thereby gradually improving their independent learning capabilities.

3. Conclusion

In summary, the emergence of AIGC technology has brought brand-new challenges and opportunities to foreign language teaching. In empirical analyses, the multifaceted impacts of AIGC on the cognitive load of college foreign language learners can be clearly observed, which provides a solid theoretical basis for subsequent teaching practices. By implementing a series of measures, including developing scientific and reasonable teaching content, optimizing teaching processes, innovating learning assessment methods, and cultivating learners' competencies, teachers can effectively guide learners to make proper use of AIGC technology, reduce their dependence on the technology, achieve in-depth learning, and continuously improve their foreign language proficiency and comprehensive competencies.

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