

Research on the Optimal Control Strategy of Cognitive Load in Flipped Classroom Teaching of College English

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Abstract: This study aims to explore how to optimize and control the learning cognitive load of students in the flipped classroom model of college English. By analyzing the influencing factors of cognitive load, conducting surveys, and summarizing the situation of students' cognitive load in flipped classroom teaching of college English, a series of optimization control strategies were proposed to reduce cognitive stress in the learning process, increase students' interest and sense of achievement in learning English, and promote the occurrence of effective learning.

Keywords: College English; Flipped classroom; Cognitive load; Optimal control; Effective learning

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1. Introduction

In the context of intelligent education, the abundance of learning resources and the diversity of teaching methods impose a considerable cognitive load on learners to some extent. Under the flipped classroom model, students need to handle a large amount of information independently, which may lead to an increase in learning cognitive load ^[1]. Excessive cognitive load can lead to cognitive fatigue, affecting students' learning outcomes and mental health. Therefore, how to optimize the control of students' learning cognitive load and improve learning efficiency has become an urgent problem to be solved in flipped classroom teaching.

2. An overview of cognitive load theory

The cognitive load theory was proposed by Australian psychologist John Sweller in the late 1980s. Cognitive load refers to the total amount of cognitive resources that learners consume when processing information ^[2]. The theory divides cognitive load into three categories: intrinsic, extrinsic, and related. When the sum of the

three exceeds the working memory capacity, it triggers a high-load state that hinders the learning process. Therefore, the core concern of the cognitive load theory is how to ensure that the cognitive load does not exceed what learners can bear, so that effective learning can occur smoothly^[3]. Paas and Van Merriënboer put forward the initial structural model of cognitive load^[4]. The intrinsic load depends on the complexity of the learning content and the learner's original knowledge level; the External load is induced by the presentation of materials and redundant information. Although related loads consume working memory resources, they can promote knowledge construction by stimulating learning motivation and effort, and thus are also called effective cognitive loads^[5].

The theory of cognitive load, based on the theory of diagrams, the theory of limited resources, and the theory of cognitive structure, examines problem-solving and learning processes from the perspective of resource allocation, providing a psychological basis for instructional design^[6]. The theory of cognitive load has important implications for optimizing flipped classroom instructional design.

3. Analysis of students' cognitive load in college English flipped classroom teaching

To understand the cognitive load of students in flipped classroom teaching of college English, the author selected four undergraduate institutions and distributed questionnaires to 2,134 first-year and second-year non-English major students who had participated in flipped classroom teaching of college English. The results show that students have the following characteristics in terms of learning cognitive load.

3.1. Overall cognitive load analysis

In terms of adaptability, only 34% of the students thought they had adapted to the flipped classroom teaching, 42% needed time to adapt, and 16% had difficulty adapting. There was no significant gender difference, but sophomores adapted significantly more than freshmen. The data show that the flipped classroom of college English, as an emerging model, still requires continuous guidance and exploration by teachers.

In terms of overall cognitive load, 52% of students have an overload problem, 40% think the load is manageable, and 8% have an ambiguous attitude. There was no significant difference between gender and grade, but a significant difference in English proficiency affected cognitive load: those with a solid foundation were able to manage cognitive resources efficiently, while those with a weak foundation were often overburdened due to difficulty in understanding materials, which hindered subsequent learning. This suggests that a solid foundation in English is directly related to the absorption of flipped classroom content.

3.2. Intrinsic cognitive load analysis

The intrinsic cognitive load mainly stems from the difficulty and complexity of the materials and the limitations of the learners' cognitive abilities. The survey showed that 37% of students thought the materials were difficult, 41% reported difficulty in previewing before class, 43% indicated that the fragmentation of the content led to blurriness of key points, and 78% expected to enhance the attractiveness of classroom activities. The data shows that more than half of the students think that the flipped college English classroom is too difficult and not attractive enough.

In terms of workload, 41% reported an overload of homework after class, 63% thought that running on multiple platforms increased the burden, and 59% noted an excessive amount of self-study content. Taking a certain university as an example, the author conducted a special survey on the use of platforms for college

English courses, and the data are shown in **Table 1**.

Table 1. The use of platforms for college English courses

The platform	Learning tasks	Weighting of assessment
U Campus	MOOC learning, tutorial, self-study	10%
Fif platform	Oral practice, tests	15%
Itest	Comprehensive exercises, unit tests, final exams	35%
Superstar Learning Pass	Sign-in, class interaction, etc.	5%

The data shows that college English courses require students to use apps with four different functional modules. While digital empowerment provides convenience and diversity in teaching, it increases students' cognitive load: information overload leads to difficulty in screening and integration, switching between multiple platforms distracts attention, increases internal load and reduces efficiency; And it takes extra time to get familiar with the platforms. Without a strategy, learners tend to get lost in the ocean of resources and have difficulty effectively building knowledge and allocating cognitive resources.

3.3. External cognitive load analysis

Extrinsic cognitive load mainly stems from the organization of learning materials and interference from redundant information. In the survey, 66% preferred textbooks, 55% chose micro-videos, and 45% preferred supplementary materials such as study guides and courseware. More than 40 percent reported problems such as distraction and difficulty in understanding when previewing videos before class. The data shows that textbooks remain the main channel for systematic knowledge acquisition, and teachers need to guide students to use them efficiently. Video resources lack difficulty control or interactive design, which can increase external load. When external load is combined with insufficient self-discipline and a weak foundation in English, the obstruction of self-study will directly affect classroom participation.

Regarding the allocation of study time, 48% reported that “there is too much teaching and insufficient practice”, 23% said that “there is not enough time for homework after class”, and 25% believed that “there is not enough time for thinking in class.” This reflects the imbalance in the allocation of teaching time in the current flipped classroom of college English.

3.4. Relevant cognitive load analysis

Relevant cognitive load is closely related to existing knowledge and experience, learning motivation, and interest. In terms of interest in learning English, only 6% of the students indicated a strong interest, and 14% indicated a clear lack of interest. In terms of motivation, over 80% aim to pass CET-4 and CET-6 as their primary goal, 45% just want to pass, and only 30% think English is useful for their career development. In terms of strategy, over 70% of freshmen and sophomores attribute their learning disabilities to improper methods, and 80% consider themselves to lack motivation to learn. In terms of class participation, more than 80% of students regarded the attractiveness of the activity content as the primary factor of participation, followed by the form of interaction, teacher feedback, and reward mechanism. The data suggest that students' overall interest in English is weak, their test-taking tendencies are obvious, and they generally lack effective

learning strategies and the willingness to explore and apply knowledge.

4. Strategies for optimizing students' cognitive Load in flipped classroom teaching of college English

In response to the cognitive load of students in the flipped classroom model analyzed above, this paper proposes the following optimization control strategies to promote effective learning.

4.1. Optimization control strategies for intrinsic cognitive load

Teachers should conduct an analysis of students' learning situation before class to understand their English foundation and learning preferences, and then screen, adjust, adapt, and supplement the teaching materials accordingly. University textbooks are mainly based on thematic teaching, with scattered knowledge and skills points, and no textbook can be fully adapted to all institutions. Teaching content design requires control of task volume and difficulty: 1. Streamline preview content, highlight key points, and control the total amount of information. 2. Design hierarchical and progressive tasks to meet the needs of students at different levels. 3. Build an online interactive system for previewing tasks based on digital intelligence tools to achieve real-time review feedback and targeted classroom evaluation to enhance teaching efficiency.

Reducing the difficulty of materials can reduce the intrinsic cognitive load, but it should be noted that the load level is not the lower, the better. The optimal range depends on the teacher's accurate assessment of the student's knowledge base. According to Yerkes-Dodson's law, learning that is too easy can actually hinder learning, because such learning is not sufficient to stimulate students' motivation to learn ^[7]. Teachers can design learning tasks based on students' English foundation to appropriately reflect "two mindsets and one degree" (higher order, innovation, challenge). For beginners, sufficient teaching support should be provided, but as their level of expertise improves, teaching support should be gradually reduced to prevent the familiarization reversal effect ^[8].

4.2. Optimization strategies for external cognitive load

Teachers can reduce students' extrinsic cognitive load by improving instructional design. Specific optimization strategies include the following.

Scientifically design micro-lessons, courseware, preview materials, etc., add effective guiding questions and interactive elements, and eliminate redundant information to reduce external cognitive load optimization. The presentation of learning materials should ensure that the information is conveyed accurately and vividly, while also focusing on matching the students' cognitive level and interest points. It is worth noting, however, that multimedia learning itself is characterized by the richness and interest of materials and channels, and cannot completely eliminate the external cognitive load. When necessary, the presentation should have a bit of redundancy, which is acceptable if it promotes learning without being too high.

Choose the appropriate teaching technology platform, integrate resources, and reduce the number of learning platforms. The flipped classroom relies on the support of technology platforms, but the functions and ease of use of different platforms vary greatly. If there are too many learning platforms, complex technical operations, or frequent malfunctions will seriously affect students' learning experience and efficiency, and increase the external cognitive load. Therefore, choosing the right and appropriate teaching technology platforms and providing adequate technical training and support are key measures to reduce the external

cognitive load.

Allocate teaching time reasonably, increase the frequency of interaction between teachers and students, and increase students' opportunities for language practice and presentation. The English flipped classroom emphasizes teacher-student interaction, but in practice, due to the limited class time and the large number of students, the frequency of teacher-student interaction is often difficult to guarantee. The lack of timely feedback and communication may make it difficult for students to solve their doubts in learning, leading to the accumulation of cognitive load. Therefore, teachers need to use multiple online and offline channels to increase the frequency and depth of interaction between teachers and students, effectively alleviating students' external cognitive load.

4.3. Optimization control strategies for related cognitive load

Since the total amount of the three cognitive loads is constant, when the intrinsic cognitive load is small, teachers can take the opportunity to increase the relevant cognitive load in the class to facilitate effective learning^[9].

Provide situational scaffolding, case demonstrations, etc., to reduce students' sensitivity to the complexity of the learning content, trigger students' recall of existing knowledge and experience, and facilitate schema construction and automation. For example, create real language communication situations, organically integrate textbook knowledge and language skills in the process of completing communication, and let students learn and apply at the same time. Or by providing a case study of a language practice achievement, students can imitate and apply it to similar language practice tasks. Well-designed and effective examples are much more effective in teaching than traditional problem-solving strategies^[10]. In a flipped classroom, teachers can help students gradually grow into autonomous and independent learners by properly setting up and removing scaffolds^[11-13].

Establish a learning achievement reward system, such as displaying excellent homework and exchanging points for learning resources, to encourage students to actively participate. Carry out English language training activities that combine knowledge and fun, and give students plenty of opportunities to showcase and discuss collaboratively. In addition, teachers need to be flexible in using various forms of praise to affirm students' efforts and achievements from different perspectives in order to stimulate their intrinsic motivation for learning^[14-15].

Strengthen guidance on learning strategies. Through classroom teaching and tutoring, guide students to master effective autonomous learning strategies such as time management, attention allocation, repetition, and memorization. These strategies can help students handle self-directed learning materials better and improve learning efficiency.

Of course, several cognitive loads do not exist independently but are closely related, and there is a trade-off among the three cognitive loads in the process of completing the same task. Therefore, there are commonalities in the optimization control strategies for the three cognitive loads rather than a one-to-one correspondence.

5. Conclusion

The cognitive load that students face in the flipped classroom of college English cannot be ignored. The

cognitive load of students can be effectively reduced and the teaching effect of the flipped classroom can be improved through strategies such as carefully selecting learning materials, optimizing presentation methods, rationally designing classroom activities, providing guidance on learning strategies, and establishing effective feedback mechanisms. In the future, more scientific and reasonable teaching models and methods need to be explored to better serve the practice of college English teaching.

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