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Application of Flipped Classroom in Second Language Teaching from the Perspective of Cognitive Load Theory

Chenxi Li

Department of Public Foreign Language Teaching and Research, Jilin University of Finance and Economics, Changchun, China

International School of Chinese Studies, Northeast Normal University, Changchun, China

110072@jlufe.edu.cn

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Abstract: Economic globalization has put forward new requirements for foreign language teaching, and the development of science and technology has provided a new platform for English education. Cognitive load theory refers to the efforts in working memory and is a set of general learning principles that affect the process of cognitive learning by designing an effective teaching environment. “Flipped classroom”, as an effective teaching method to reduce learners’ cognitive load, is based on the cooperation between teachers and students with the progress of science and technology to realize the reform and innovation of foreign language education. This paper adopts the method of comparative research: comparing the traditional teaching method with the flipped classroom method; 12 English classes in 5 universities are selected by means of interview and questionnaire. Moreover, this paper will explore the relationship between the two teaching methods and students’ cognitive load which will consequently play an indispensable role in understanding teenagers’ cognitive pattern and optimizing teaching design. Effective cognitive regulation can reduce students’ extraneous cognitive load and optimize educational functions, teacher-student relations, curriculum system and educational system.

1. Introduction

In the new situation, every foreign language teacher should face and think about the new demands of economic globalization on foreign language talents, the new development of 5G Internet and the influence of information technology on education. Traditional teaching and independent learning fail to meet the needs of language learners. College students' learning styles are gradually changing to blended learning, classroom flipping, cooperative learning and inquiry learning. The changes in learning styles brought about by Internet-based mobile learning not only have a profound impact on learners’ academic performance, but also require teachers to continuously optimize instructional design in the classroom to accommodate students’ cognitive

processes. Therefore, the impact of flexible teaching environments and methods on students' cognitive load has become a much-needed research topic. This paper firstly describes the cognitive load theory and its impact on flipped classroom design. Second, it compares the cognitive load of students in traditional and flipped classrooms. Finally, this paper will explore how to improve students' learning efficiency and enhance teaching effectiveness by changing the role of teachers and the role of learners.

1.1. Cognitive Load Theory

Cognitive load theory was first proposed by John Sweller, a cognitive psychologist at the University of New South Wales, Australia, in 1988. This theory is based on the early research of John Sweller believing that cognitive load is the level of mental energy required to process the given information (Sweller, 1988). Since then, other scholars began to study cognitive load and interpreted it from different angles. Yang define cognitive load as all mental energy required for mental activities in working memory to complete a task (Yang, 2007) . In addition, Pass and van Merriënboer, the most representative figures, believe that cognitive load consists of multiple dimensions, which is the load imposed on individual cognitive system when performing a specific task (Pass & van Merriënboer, 1994).

Cognitive load can be divided into three types: intrinsic cognitive load, extraneous cognitive load, and germane cognitive load. Intrinsic cognitive load refers to the load formed by the interaction between elements. It depends on the interaction between the essence of the materials to be learned and the learners' professional knowledge. Teaching designers cannot have a direct impact on intrinsic cognitive load. Cognitive psychology shows that learners' cognitive efficiency is largely restricted by the limited processing of information and the selectivity of "attention" in working memory. Specifically, complex learning content will reduce their learning efficiency, and this is also the fundamental reason why effective teaching cannot be realized.

Extrinsic cognitive load is the core of cognitive load theory. It comes from the way of textbook design and presentation or teaching activities. Teachers can reduce students' extrinsic cognitive load by optimizing teaching design. Nowadays, in the form of education, Internet-based teaching method, such as flipped classroom, has become an important means to optimize teaching design. In other words, the flexible and student-oriented teaching method will play an essential role in reducing students' extraneous cognitive load and optimizing educational functions, teacher-student relations, curriculum system and educational system. van Merriënboer of Maastricht University in the Netherlands took the lead in teaching experiments with animation examples. It shows that for students with low pre-cognitive level, fragment animation reduces the high cognitive load caused by animation and improves students' learning effect (Pass & van Merriënboer, 1994). Moreover, Renkl and Schroeder found that in multimedia-based science teaching, presenting teaching content in an integrated way is better than presenting teaching content in a single text, regardless of cognitive burden, learning time or achievement test (Renkl & Scheiter, 2017; Schroeder & Cenkci, 2018). The study also found that charts play a particularly important role in reducing cognitive load for complex teaching contents with greater difficulty.

With the progress of mobile Internet technology, from the first article on cognitive load in information technology environment in 2005 in China, Nine Methods to Reduce Cognitive Load in Multimedia Learning, we gradually began to study the relationship between teaching based on network technology and cognitive load. In 2009, Zhang Jianbo's enlightenment on the application of cognitive load theory in online education classified and analyzed the new research results on

cognitive load in current online education and teaching based on the introduction of cognitive load theory in the past decade, but the types of classification are not detailed and comprehensive enough (Zhang, 2009). In 2014, Fang Zhongyu's research focusing on learners' cognitive load in E-learning environment puts forward relevant inspirational suggestions through combing the existing research results, but there is no quantitative data evidence (Fang, 2014). In addition, from the perspective of cognitive load theory, Zhang Xiaojun analyzed the cognitive process in the learning process from the perspective of cognitive load theory, and combined with a large number of examples, practiced the strategies and methods to reduce the original and irrelevant cognitive load and improve the relevant cognitive load. It realizes the guiding role of cognitive load in the design of micro-curriculum courseware (Zhang, 2014).

1.2. Flipped Classroom

"Flipped classroom" originated in the United States and has gradually become popular in China in recent years. Generally, "flipped classroom" requires students to learn new knowledge after class (at home) through videos recorded by teachers for about ten minutes in advance, and digest and consolidate the knowledge through videos by doing exercises and communicating with classmates and teachers after school. Therefore, "flipped classroom" is also called inverted classroom teaching. In essence, "flipped classroom" is a reconstruction of the traditional learning process. Our traditional teaching mode is that students go to school to attend class, review and do their homework after class. In the flipped classroom teaching mode, students first watch the teaching video produced by teachers for self-study, come to the classroom with questions, communicate and solve with classmates and teachers, and do some targeted exercises. "Flipped classroom" is based on the deep integration of information technology and education, which will reduce students' learning burden and increase learning efficiency.

The implementation of "flipped classroom" can be divided into four steps. First, a teacher puts forward three to five questions to the students. These questions should be selected after careful consideration by the teacher. They should reflect the key and difficult points of a class, be exploratory, and be interesting and open at the same time. If the question is too simple, students can get the answer directly from the network; If the problem is too difficult and the students still have no clue after a long time of exploration, they will lose their interest and enthusiasm to continue their research.

The second step is to let the students watch the video prepared by the teacher after class and look for the answers in the video. The videos prepared by teachers can be either self-recorded or downloaded from the network resource platform. In the process of selecting video, there are three points to pay attention to: initially, the time of video should not be too long. Eight to ten minutes of micro-teaching video can allow students to watch it repeatedly through computers or smart phones in their spare time. There is no denying teenagers can concentrate for no more than 15 minutes generally. If the video is too long, students will lose interest in watching and cannot achieve the expected teaching objectives. Simultaneously, the video must be closely related to the key content of the course. Teachers can't put all the important and difficult points of a class in a short video because certain key points often need repeated explanation and practice to understand, and most students can't fully understand them in ten minutes. Of course, a video cannot be all simple knowledge, so it may fail to stimulate students' thirst for knowledge and exploration. Ultimately, the video should be interesting and show the fixed points to students vividly and flexibly. When selecting and making videos, teachers must fully consider the age characteristics of students.

College students have a strong sense of the times and criticism. Therefore, when selecting videos, teachers can combine the knowledge points in textbooks with current events, campus life and popular trends to enhance the appreciation and interest of videos. To sum up, although the videos selected in the “flipped classroom” are short, it is not easy to take into account the two characteristics of appropriateness and vividness, which need the careful design of teachers.

The third step is to ask questions and detect the knowledge points in class, and conduct in-depth analysis, organize activities and sublimate them appropriately. "Flipped classroom" reverses the way of knowledge transfer and knowledge internalization in the traditional classroom, puts the knowledge transfer outside the classroom, which is completed by students independently, and the knowledge internalization is realized in the classroom (Zhang, 2014). The first and second steps of “flipped classroom” are completed by students outside class, which saves more effective time for teachers’ classroom teaching. In classroom teaching, teachers will pay more attention to the targeted and in-depth explanation of key and difficult knowledge. On the one hand, teachers can test students’ mastery of relevant knowledge points through video by asking questions or pre class quizzes. For problematic knowledge points, teachers can also group students and let them absorb knowledge and improve students' comprehensive ability through mutual cooperation. In the process of group learning, teachers should encourage students to try their best to explore the answers and record the unsolvable problems one by one. Then, the teacher will answer the questions raised by each group in detail, explain and practice the difficult points repeatedly, so that the students can have a clear and in-depth understanding of the focal points. When organizing classroom activities, teachers can also refer to the content in the pre-class micro video for in-depth development. The use of micro class teaching to carry out interesting classroom activities can stimulate students’ learning enthusiasm and ensure the interaction between teachers and students in the classroom. At the same time, it can also use groups to complete classroom activities and increase students’ participation. After discussing the key points in class, teachers should sublimate and extend the classroom content to meet the needs of students at different levels. In recent years, most of the basic English teaching in colleges and universities is large class teaching, with uneven levels of students and diverse needs. By watching videos and preview before class, some students with good foundation can fully grasp the knowledge content before class. Therefore, before class, teachers must conduct in-depth research on the knowledge points in the syllabus, master the cutting-edge research results and trends, share them with students in class to realize the combination of knowledge teaching and research in classroom.

Finally, teachers need to establish a diversified teaching feedback system to test the content of students’ learning in class to make them gain, use, and reflect. In traditional teaching, teachers lead the classroom rhythm, and the evaluation method of students is relatively single, which leads to some students’ lack of in-depth understanding of the knowledge and cannot be skillfully used in real life. In the process of “flipped classroom”, students are the main body of the classroom, so teachers should also evaluate students in a flexible way in the process of feedback. In the teaching process, teachers should carefully observe students’ learning attitude, learning passion, autonomous learning, cooperative exploration, and mastery of grammar knowledge. In this way, teachers can timely make a reasonable evaluation of students, then deeply reflect on students' classroom performance, arrange corresponding after-school homework, and timely adjust teaching methods, teaching forms and teaching contents, so as to realize the mutual growth of teaching and learning in the real sense. The arrangement of homework after class should have two characteristics: consolidation and deepening. As far as its consolidation is concerned, English teaching is inseparable from the accumulation of corresponding vocabulary, text and grammar. In order to

make students master related knowledge, teachers need to arrange corresponding basic exercises to consolidate the knowledge points. Besides, teachers should assign open, cooperative and exploratory tasks to meet the needs of students with different learning abilities.

2. Materials and Methods

In the new era, traditional teaching and completely autonomous E-learning can hardly meet the requirements of students. By analyzing many factors affecting teaching and learning in the information technology environment, the influence of learners' intrinsic cognitive load on teaching cannot be ignored. Cognitive load is common in the learning process and learning environment is one of the important factors affecting cognitive load. The impact of Internet-based teaching environment on students' cognitive load has become a new topic to be studied urgently.

Cognitive load theory claims that the primary function of instruction is to store information in long term memory and that instructional design can be used to reduce the cognitive load theory of the learner (Atharina & Peter, 2007). Cognitive load theory focuses on the role of working memory in the learning process. Its basic principles are reflected in the following aspects: (1) the capacity of working memory is extremely limited; (2) the capacity of long-term memory is infinite in nature; (3) the learning process requires continuously use of working memory to comprehend and process material and to encode the acquired information for storage in long-term memory; (4) if working memory resources are exceeded, there is an overload of cognitive situation, learning is ineffective.

There are three types of cognitive load: intrinsic cognitive load, extraneous cognitive load, and germane cognitive load. Intrinsic cognitive load depends primarily on the difficulty of the learning material and the learner's prior knowledge. The amount, type and complexity of the learning material is fixed and cannot be changed by external factors (Renkl & Atkinson & Sweller, 2018). However, learners can reduce the internal cognitive load by using external factors to create schematic connections between the brain and the learning material. Extraneous cognitive load is a type of mental activity that is detrimental to learning, mainly when instructional designers use inappropriate ways of presenting information or arrange inappropriate instructional activities during the learning process. Learners do not experience direct working memory effects when constructing knowledge information schemas, nor do they experience interference effects when building relevant information schemas, which result in additional cognitive load. Germane cognitive load is the load associated with facilitating the process of schema construction and schema automation (Sepp, 2019). It motivates learners to better allocate cognitive resources to effective activities by comparing, reasoning, packaging, and reorganizing dispersed information resources, whereas external cognitive load acts as a cognitive barrier.

2.1. Comparison of Traditional and Flipped Classrooms

Cognitive load theory can help teachers create an effective flipped classroom learning environment and reduce the drawbacks of traditional classroom teaching. By observing 12 classes in five universities, two of them are in Northeast China and three are located in coastal areas of China. The five universities are among the top 100 in QS, and all offer college-level English courses. The class size of English courses is between 50 and 60 students. The English teachers at each school will present the last half of the course of this semester, about 9 classes, in the form of flipped classroom. At the end of the semester, students compare the two teaching forms of traditional English classroom and flipped classroom through online questionnaire. A total of 322 questionnaires were received, of which 264 were valid.

Based on valid questionnaires, the flipped classroom is a typical Internet-based hybrid teaching method, which includes three advantages: (1) the lively and flexible teaching method can effectively reduce the extraneous cognitive load and motivate students accordingly; (2) the videos of the flipped classroom can be repeatedly observed according to students' learning ability, which can reduce the extraneous cognitive load of students; (3) when learning difficult, learners' self-confidence may increase due to the associated increased cognitive load. However, the flipped classroom still has the following two disadvantages: (1) the instructional design is complex and inappropriate, which can increase the extraneous cognitive load of students and hinder the learning process. For example, a flipped classroom requires young people to be able to operate a computer or smartphone proficiently, but some may lack knowledge about smart devices. This can increase learning difficulties and cognitive load for students. (2) Lack of prior knowledge and experience makes it difficult for learners to engage in micro-courses. That is, the flipped classroom places a higher demand on students' prior knowledge.

The traditional teaching and learning process usually consists of two stages: knowledge transfer and knowledge internalization. The transfer of knowledge is done by the teacher in the classroom, while the internalization of knowledge requires students to complete it through homework or by completing operations or exercises after class (Sweller, 1998). In a flipped classroom, the processes of knowledge transfer and knowledge internalization are reversed: knowledge transfer is accomplished primarily through student independent learning and inquiry after class, while knowledge internalization is accomplished by the instructor and students in class through collaborative research. As the focus of teaching in class changes from knowledge transfer to exploration and research, the corresponding teaching sessions designed by teachers will also change. Table 1 shows the differences between traditional and flipped classroom instruction.

Table 1: Comparison of traditional and flipped classroom delivery methods

	Traditional Classroom	Flipped Classroom
Teacher	Transferring knowledge and managing the classroom	Promoting learning
Student	Passive acceptance	Proactive research
Teaching Format	Teaching knowledge and assignments	Pre-course study, classroom workshop
Course Content	Knowledge sharing	Research questions
Technology Applications	Demonstration of teaching content	Self-directed learning, communication and reflection, collaborative discussion
Evaluation Methodology	Traditional test papers	Diversified testing pathways

Although traditional and flipped classrooms create the same internal cognitive load for students due to the fixed nature of the material, flipped classrooms can reduce the external cognitive load of learners and increase the relevant cognitive load. The reduction of external cognitive load is primarily accomplished through the instructor's course design. In addition, flipped classrooms can increase the relevant cognitive load of learners to a great extent. Relevant cognitive load, also known as effective cognitive load, is generated when learners do not use all their cognitive resources when learning a task. At this point, the learner can use the remaining cognitive resources to increase more advanced conscious cognitive processing, such as restructuring and schema construction. Such processing also increases cognitive load, but this cognitive load does not hinder learning, but rather facilitates it (Seufea & Brfinken, 2007). Furthermore, the level of closely related

cognitive load depends on the total cognitive load and the intrinsic and extrinsic cognitive load. When both intrinsic and extrinsic cognitive load are high, there is no germane cognitive load resource. In addition, learners' cognitive, metacognitive, and motivational factors also influence the relevant cognitive load (Van & Sweller, 2005).

2.2. Teachers' Role Transformation

The flipped classroom transforms the teacher from a knowledge transferor to a learning facilitator and guide (Yi, 2018). This means that the teacher is no longer the center of knowledge interaction and application, but a facilitator of student learning (Korbach, 2017). When students need guidance, the teacher provides them with the necessary support. From then on, the teacher becomes the scaffold for students to access resources, use them, process information, and apply knowledge to practical situations. Some mistakenly believe that the importance of the teacher is diminished when learners absorb information and knowledge from video resources. In fact, teachers play a greater role in knowledge integration, course design, video production, exercise scheduling, and student feedback. First, teachers need to segment course content appropriately. Although course content is immutable as an intrinsic cognitive load, teachers can reduce the extraneous cognitive load by arranging the knowledge they need to teach from shallow to deep. In addition, it is the teacher's responsibility to design relevant exercises at moderate difficulty. Answering the questions correctly will boost students' self-confidence, which will increase the germane cognitive load. Conversely, when students fail to complete the questions, they become aware of their shortcomings and put in more effort. Finally, teachers can reflect on themselves and adjust the pace and difficulty of instruction based on student feedback.

The main factors that influence cognitive load include the organization and presentation of the learning material, the complexity of the learning material, and the level of personal expertise such as prior knowledge and experience (Wouter, 2007). Extraneous cognitive load, also known as ineffective cognitive load, is related to the organization and presentation of learning material. It is caused by mental activities that do not contribute directly to learning. Learners are not directly involved in activities related to cognitive automation when new learners are involved in cognitively automated learning activities that are not relevant to us. For example, when content is designed in such a way that the teacher includes both text and graphics, which are not directly related to each other, the extraneous load on the student increases. This is because students need to spend more time and effort to understand the words and images separately and to establish relationships between them; less computer-savvy learners also incur extraneous cognitive load when using the computer. They should use additional cognitive resources to operate the computer. Having students search for problems or find information during instructional activities also increases extraneous cognitive load.

In order to achieve the goal of reducing students' extraneous cognition, teachers should pay attention to two points when designing the inversion of classroom content: first, the curriculum should not be designed with overly complex software wich would cost students additional cognitive resources. Teachers should not change their instructional software too often after selecting it. When students start using a certain software, they need to spend extra time and effort. This process inevitably increases the extraneous cognitive load on students. When students become familiar with the operation of the software, they will concentrate on the content of the course itself. In addition, teachers should avoid choosing complex instructional software that increases the extraneous cognitive load and impairs learning. In the flipped classroom, teachers should reduce the learning

difficulty of students by refining knowledge points, increasing interest, and arranging exams appropriately. The difficulty of the teaching content itself cannot be changed, but teachers can restructure the knowledge to reduce the learning difficulty of students. For example, teachers can adjust the order of textbooks or add pictures, sounds, and videos to help students understand. In addition, textbook content is often abstract, but teachers can make the content lively, interesting, and easy to understand through hands-on approaches. After the lesson, teachers need to design graded test questions to test students' learning.

As the center of instruction changes, teachers are challenged to develop new teaching skills. In a flipped classroom, students dominate the entire learning process, and they must engage in post-class learning and research to build a body of knowledge and knowledge base sufficient to support in-class discussions, and to identify and record their questions and doubts in the process of independent learning for in-class discussions and research. This requires teachers to use different teaching methods and classroom activities to efficiently achieve the teaching objectives and to facilitate students' growth and development. In addition, after learners have completed a certain amount of learning tasks, instructors should check whether students have fully mastered the content and give timely and effective feedback so that students understand their learning. Timely assessment also facilitates teachers to adjust the design of classroom activities in time to better facilitate students' learning.

Learning is one of the most valuable human activities and time is the most essential element in all learning activities. Reducing extraneous cognitive load and while increasing germane cognitive load is the main purpose of flipped classroom. Adequate time and effective learning are key factors in improving academic performance. By maximizing the pre-reading time in the flipped classroom, the instructional time in the class can be appropriately shortened and the cognitive load of the students can be reduced. In this process, teachers need to carefully consider how to design classroom activities to enhance teaching and learning and reduce students' extraneous cognitive load. The core feature of flipped classroom is to reduce the teaching time in class and leave more time for students to learn after class. After-class activities should be based on real-life situations and at the same time closely follow the teaching theme, so that students can complete learning tasks and achieve teaching objectives in an interactive way. Teachers should transfer traditional classroom content to after-school student pre-reading and enhance student interaction in the classroom to check student learning without reducing the amount of basic knowledge presented. Ultimately, this change will improve students' understanding of knowledge. In addition, classroom interaction will become more important when teachers conduct assessments. Through teacher assessment and feedback, students will have a more objective view of their learning and better control over their pace of learning.

2.3. Students' Role Transformation

The "flipped classroom" is a way for individuals to fully demonstrate their research questions through cooperative learning methods such as dialogue, negotiation and debate, in order to achieve their learning objectives. The collaborative approach to learning is conducive to the development of critical and creative thinking skills, the enhancement of communication skills among learners, and the ability to accommodate each other. Small group learning is a typical implementation of the inverted classroom. The advantages of group work are: each has the opportunity to participate in activities; students are allowed and encouraged to participate meaningfully in a low-risk, non-threatening manner; participants are provided with opportunities to interact with peers and to

check the validity of their ideas at all times; and a variety of problem-solving strategies and brainstorming interactive activities are provided (Sweller & Pass, 2017). In other words, in this free and easy learning environment, the creativity and enthusiasm for learning of young people will be fully developed. In other words, the relevant cognitive load of students can be increased for better learning outcomes.

3. Result and Discussion

This paper studies the four steps of "flipping classroom" in college English classroom. Specific implementation requirements and matters needing attention are put forward for each step. The new teaching model – flipped classroom based on network, centered on autonomous learning and dominated by teacher-student cooperation puts forward new requirements for English teachers. With the rapid development of Internet and wireless communication technology, it is possible for students to learn with the help of network equipment at any time and place. "Flipped classroom" enables students to study in fragmented time by means of micro video before class, which is concise, efficient and focused. In class, "flipped classroom" realizes the teaching concept of "teacher led, student-centered". Teachers enable students to realize in-depth learning and cognitive upgrading by mobilizing students' subjective initiative. After class, teachers adopt diversified hierarchical system evaluation system to achieve the best teaching effect. The realization of "flipped classroom" is a multi-step, cooperative and systematic process, which needs teachers to constantly adjust and improve in the process of teaching.

Most of the studies under the background of Internet aim to promote the sharing and reconstruction of educational resources through the Internet. This study has proved that the Internet-based teaching method really reduces students' cognitive load and improves learning efficiency, and how to explore and implement intelligent precision education on the premise of conforming to students' cognitive rules, so as to promote the "track change and overtaking" of higher education quality.

4. Conclusion

This paper focuses on flipped classroom curriculum design based on cognitive load theory. Effective classroom design refers to reducing students' extraneous cognitive load and increasing students' relevant cognitive load under a fixed intrinsic cognitive load in order to achieve optimal teaching and learning outcomes. A flipped classroom can only promote learning if it is used properly. Teachers should be flexible in their use of instructional feedback and learner control, taking full account of students' cognitive characteristics. The ultimate goal is to transform learners' behavior into knowledge-relevant cognition while reducing unnecessary extraneous cognitive load.

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