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An analysis on the application of flipped classroom under cognitive load theory

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Abstract: *With the continuous development of The Times, the combination of online and offline education model has become more and more important in practical teaching. Among them, flipped classroom can enable students to prepare lessons beforehand efficiently after class and discuss independently in class, which can enrich students' way of learning mathematics and can also enhance students' interest in mathematics learning. However, students in junior middle school are facing the problem of excessive cognitive load due to the difficulty of the subject, the lack of time and the low willingness to learn mathematics actively. The flipped classroom teaching mode under the guidance of cognitive load theory can reduce the internal and external cognitive load of students to a certain extent, improve the associated cognitive load of students, and improve the mathematics learning efficiency of junior middle school students within a limited time, which has a good role in promoting the educational effect of flipped classroom.*

Keywords: *cognitive load theory; Flipped classroom; teach*

1. Introduction

Flipped classroom is an improvement on the traditional teaching model, which requires students to independently learn new knowledge through online videos, courseware and other teaching resources before class, while the time in class is mainly used to answer questions, deepen understanding and carry out practical activities. This model redefines the roles of teachers and students and seeks to increase student initiative and engagement. In traditional face-to-face teaching, teachers can control students' cognitive load through classroom interaction, teaching rhythm and task assignment. However, in flipped classroom, students preview independently before class and lack real-time guidance from teachers, which may lead to delayed understanding of knowledge and increased cognitive load, which affects learning effect.

According to cognitive load theory, when cognitive load exceeds an individual's cognitive resources, it leads to decreased cognitive effectiveness, increased errors, and difficulties in learning and problem solving. Therefore, when designing educational and work tasks, unnecessary acquisition loads should be minimized and appropriate support loads should be provided to help individuals effectively deal with cognitive tasks. Sweller divides cognitive load into three categories from the perspective of instructional design, namely internal cognitive load, external cognitive load and related cognitive load[1]. The internal cognitive load is related to the characteristics of the learning content and the learner's existing knowledge and experience. The fewer the constituent elements of the learning content, the smaller the interaction between the elements, and the lower the internal cognitive load. From the perspective of learners' internal knowledge structure, the richer, more systematic and more stable the knowledge experience or schema stored in learners' long-term memory and related to the current learning content, the lower the internal cognitive load. External cognitive load is related to the presentation of learning materials. The more reasonable the presentation form is, the more in line with learners' cognitive level, the less the interference factors in learners' information processing, the lower the external cognitive load, and the more conducive to learning. Associated cognitive load refers to the degree of mental effort of learners during the processing of working memory information. The stronger the psychological effort, the higher the associative cognitive load, accompanied by the improvement of emotional arousal level, is conducive to promoting learners' active learning, and psychological effort can only be measured during learners' learning.[2]

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2. Cognitive characteristics of junior high school students

Students' cognitive load mainly comes from the presentation and imparting of knowledge, the shallow internalization and deep internalization of knowledge, the process externalization and the result externalization of knowledge[3]. For junior middle school students, with the gradual deepening of their contact with knowledge, the difficulty of knowledge is constantly increasing, which increases their internal cognitive load to a certain extent. The process of their internalization of knowledge is relatively slow and requires a lot of time to digest and absorb. However, the pressure of junior middle school courses is gradually increasing, the types of courses are increasing, and the time allocated to each subject is very little, so the internalization process of knowledge is not perfect, which again increases their cognitive load. Taking the scores of the Grade one of junior high school students of a middle school in Zibo, Shandong Province as the data for analysis, the results are shown in Figure 1 below.

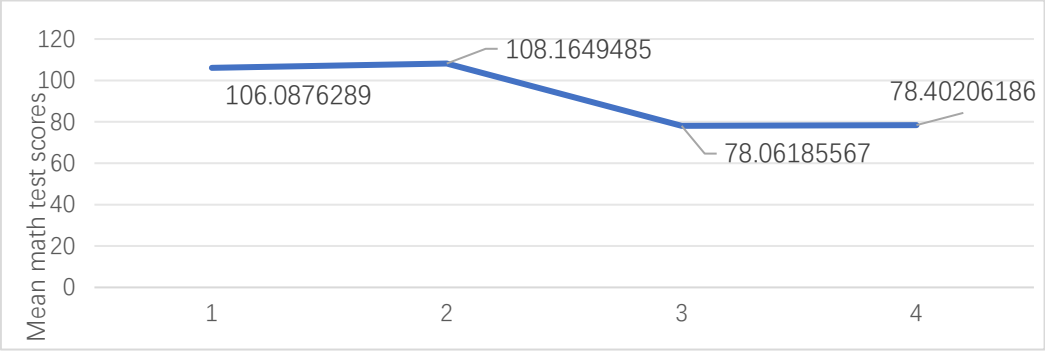

Figure 1: Mean change of math scores of students in Grade One

As can be seen from Figure 1, the average score of the students was above 100 points at the beginning, and most of them could achieve good results. However, with the gradual increase of learning content and the increasing difficulty of learning, their average score dropped to below 80 points. This shows that during this period of mathematics learning, students have difficulty in understanding and digesting what they have learned, which reflects that knowledge far exceeds the cognitive load of students and increases the intrinsic cognitive load of students to a certain extent. Moreover, through the questionnaire survey, the author found that teachers are generally more willing to use the teaching mode of blackboard teaching, and pay less attention to the use of multimedia in the teaching process (see Figure 2).

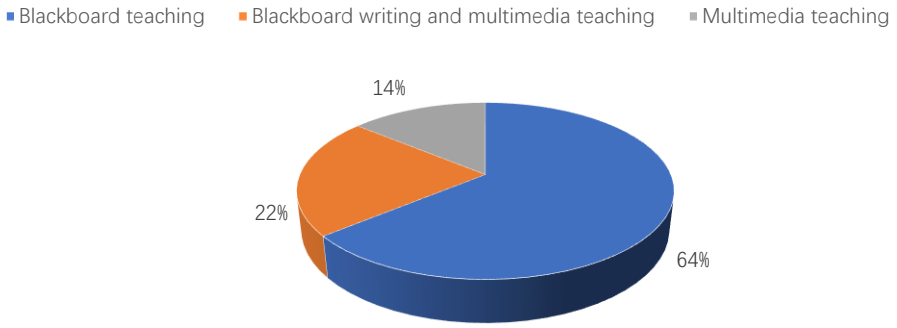

Figure 2: Schematic diagram of mathematics teachers' willingness ro teach mode

This makes students only rely on listening and watching to learn new knowledge, and have a slight lack of intuitive thinking, which increase the external cognitive load of students to a certain extent. Therefore, in the case of excessive cognitive load of students, how to efficiently study mathematics and then reduce the cognitive load of students has become a new research direction.

3. The application strategy of flipped classroom model in junior middle school mathematics under the cognitive load theory

Cognitive load is considered to consist of internal cognitive load, external cognitive load and associated cognitive load. Among them, external cognitive load is mainly related to the way students

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present new knowledge when they receive it, especially for mathematics learning. When understanding the content, the more intuitive the way of receiving, the lower the external cognitive load of students, and vice versa. The intrinsic cognitive load is mainly related to the difficulty of the new knowledge received by the students and the existing experience when building the new knowledge. In general, the simpler the new knowledge received, the lower the intrinsic cognitive load; When learning new knowledge from more existing knowledge, the lower the intrinsic cognitive load of students. Associative cognitive load is mainly related to students' willingness to learn. The more willing students are to learn this subject psychologically, the higher their associative cognitive load will be. Compared with internal cognitive load and external cognitive load, the higher the associated cognitive load is, the more helpful it is to students' learning. Based on the above and combined with the cognitive characteristics of junior middle school students, this paper proposes several strategies to reduce the cognitive load of students in the flipped classroom teaching mode.

3.1. Reduce the external cognitive load of students

In the actual teaching process, teachers pursue simple teaching to reflect the concise beauty of mathematics [4], which can reduce the external cognitive load of students to a certain extent. In the process of classroom implementation, the teacher's language should be as simple as possible, the process of imparts knowledge should be as easy to understand as possible, and the blackboard writing reflects the simplicity and rigor of mathematics. In this way, students can extract the mathematical knowledge that can be digested and absorbed from the refined text, reducing the difficulty of students' understanding, allowing students not to do work unrelated to schema construction, and greatly reducing the external cognitive load of students. Yang Binhu pointed out that the effective combination of information technology and cognitive load theory can significantly improve the teaching effect and improve students' learning experience[5]. The use of information technology can make abstract and complex mathematical contents appear in front of students in a flexible form, and the way for students to acquire knowledge is not limited to teachers' blackboard writing or drawing. In this way, students can have a more intuitive understanding of mathematical contents and greatly reduce their external cognitive load. At the same time, teachers should also pay attention to the arrangement of classroom links, the organization of materials and the design of courseware production in the process of lesson preparation, so as to make the process of seeing and finishing simple and clear as much as possible, and reduce the external cognitive load of students.

3.2. Reduce the intrinsic cognitive load of students

The process of students learning new knowledge is the process of their brain establishing new schema, which need to be connected with existing knowledge. Therefore, in the teaching process, teachers should guide students to independently recall the learned knowledge and review it frequently, so that students can form a good cognitive structure. According to the different types of lessons, the old knowledge is reviewed from different angles, and the new knowledge structure is established on this basis. Not only should the review process reduce the intrinsic cognitive load of students, but also teachers should consciously reduce the intrinsic cognitive load of students when teaching new lessons. For example, for the more difficult to understand the formula or theorem, it is divided into a few simple sentences, respectively understand its meaning, and finally on the basis of students' understanding of the comprehensive application. In addition, students can judge independently when they can use the squared variance formula to complete the solution of the problem. In the teaching process of this class, although the theorem is very simple, it is difficult for students to understand whose square is reduced by whose square. Therefore, teachers should set up more variable training in such class to strengthen students' sensitivity to the topic, split the difficulty of the topic and overcome it separately. The use of flipped classroom mode can also greatly reduce the internal cognitive load of students. Before class, students can preliminary study new lessons in the form of micro-lessons, so that students have a longer time to accept new knowledge. In this way, when learning new lessons in class, they can overcome difficult and important problems in a more targeted way, which improves the learning efficiency of mathematics.

3.3. Improve students' associated cognitive load

Psychological effort refers to how to allocate cognitive resources. Psychological effort is reflected in three aspects: psychological input, emotional input and time input[6]. When teachers often give students positive encouragement, students' enthusiasm for the subject will become more and more high, and students' psychological efforts will gradually improve, which improves students' associated cognitive

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load to a certain extent. Secondly, when students have more performance opportunities in class, they will actively participate in class activities and improve their Psychological engagement. Moreover, the inclusion of ideological and political thinking in the curriculum can cultivate students' correct values, realize that there is mathematics everywhere in life and life cannot be separated from the guiding concept of mathematics, further enhance students' associated cognitive load, and let students clearly and accurately realize the importance of learning mathematics well. Applying the principles of cognitive load theory to interpret teaching materials has important guiding significance in reducing students' learning difficulties, improving their learning efficiency and stimulating their interest, and can help teachers make more effective use of teaching materials[7]. In short, in the process of implementation and teaching, teachers should consciously see the excellent side of students and give positive praise to students, so that they are more willing to learn this subject, thus enhancing their associated cognitive load.

4. Taking "Cutting a Geometry" as an example, the teaching design is carried out

The teaching design is carried out by taking the third section of the first chapter of the first volume of Lu Educational Edition as an example.

4.1. Teaching Objectives

4.1.1. Cognitive goal

Through the process of cutting a cube with a plane, master the relationship between spatial graphics and cross sections, and develop students' spatial imagination ability.

4.1.2. Ability goal

Through the process of students participating in the limited cutting activities of the physical object and the infinite cutting activities conducted by the operational exploration courseware, students can experience the mathematical activities such as observation, conjecture, practical operation verification and reasoning, and develop students' hands-on operation, independent exploration, cooperation and communication, and analysis and induction abilities.

4.1.3. Emotional goal

Guided by teachers, students are guided by observation, bold conjecture, hands-on operation, independent exploration, cooperation and communication, so that students can have a successful experience and enhance their interest in learning mathematics[8].

4.2. Teaching Focus

Guide students to use a plane to cut a cube, experience the relationship between section and geometry, and fully allow students to operate, explore independently, cooperate and communicate.

From the cutting activity to find the law, can apply the law to solve the problem.

4.3. Teaching process

4.3.1. Watch the micro-lesson independently before class to have a general understanding of the content of this lesson

The teacher made a micro lesson about this lesson in advance, which reflected the main content. It mainly includes the definition of the section, the forming process of the section, and the shape of the cross-section of different geometries at different angles. And send micro-lessons to Dingding group (or other platforms) to facilitate students to watch, and guide students in the form of a string of questions, so that students can explore independently and inspire thinking.

[Design intention]: The flipped classroom is used to allow students to preview the content of this lesson in advance, which extends the time of math learning to a certain extent and facilitates students to digest knowledge in sufficient time. Micro-lessons take the form of video, which is convenient for students to pause or watch repeatedly where they have not followed until they fully understand the content and complete the personalized requirements of teaching.

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4.3.2. Create situations and introduce new knowledge

In class, teachers show students some pictures of cross sections of objects, such as cutting a winter melon, cutting a pencil, cutting tofu, etc., and can also actually operate the formation process of the section, mainly to let students intuitively understand the cross section of the prism, so that students understand the meaning of "cut". And use these processes to introduce new definitions, so that students can associate with some basic geometry in mathematics, such as cuboid, cube, cylinder, etc.

[Design intention]: The intuitive image of the scene can attract students' interest in learning, so that students can quickly enter the class. By connecting mathematics with objects, students' core literacy in mathematics can be improved, and the presentation of learning materials in the form of ppt (pictures) can effectively reduce the external cognitive load, so that mathematical knowledge can be transformed from abstract to concrete, and the internal cognitive load can be effectively reduced.

4.3.3. Hands-on operation, explore new knowledge

The teacher asked the question: If the basic geometry in mathematics is also "cut", what will their cross section look like? Give each group a different task and a corresponding model. Let the students discuss in groups.

[Design intention]: By allowing students to explore new knowledge through independent inquiry, students can experience the fun of learning mathematics, improve their associated cognitive load, make students work hard to complete the task, and improve their sense of achievement. Moreover, by giving students models and allowing students to practice, students can reduce their external cognitive load and make abstract mathematical knowledge vivid and interesting.

4.3.4. Summarize new knowledge and comprehensive experience

The teacher organized the students to show and report the results of the research, and summarized the results of each group and taught them as the existing conclusions. To a certain extent, it strengthens the cognitive structure of students.

[Design intention]: Allowing students to report their own results can improve students' interest in math learning to a certain extent, and let students use the narrative language that they can understand each other to describe, can reduce students' internal cognitive load of new knowledge cognition, and in the process of reporting, the use of model demonstration can effectively reduce students' external cognitive load.

4.3.5. Assignment and knowledge absorption

Teachers assign part of homework in Dingding group, and part of written homework. Electronic homework is completed on the platform, including the process evaluation of the completion degree of flipped classroom and the detection of knowledge results. The written work mainly strengthens the standardization of the mathematical process.

[Design intention] This can increase the form of work and complete the policy requirements of "double reduction". Homework in Dingding Group can comprehensively evaluate students' learning results through intelligent education, providing a new way for students' evaluation diversification, and the form of electronic homework can effectively reduce students' external cognitive load and improve students' interest in math learning.

5. Summary

In summary, flipped classroom teaching mode based on cognitive load theory has significant advantages in improving learning effect, promoting independent learning, enhancing classroom interaction, optimizing time allocation, and reducing cognitive load. This teaching mode can not only improve students' learning efficiency and effect, but also promote teachers' professional development and improve teaching quality. The use of flipped classroom not only allows cognitive load theory to play a greater role in teaching. It can not only reduce the internal and external cognitive load of students, but also improve the associated cognitive load of students, and reduce the difficulty of students' math learning to a certain extent. In the future, we expect to see more educators in the practice of flipped classroom teaching model is not limited to a single teaching model, towards the diversification of the start.

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