

The Impact of Cognitive Load Theory on Online Learning Outcomes for Adolescent Students

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Abstract. In recent years, the popularity of online learning has reshaped the traditional behavioral model of teaching and learning while making learning more convenient. Cognitive Load Theory (CLT), which characterizes the total amount of attention or mental power used by people in working memory from the perspective of information processing, has become an important theoretical basis for education, psychology, computer science, and other fields. Cognitive load theory provides a practical instructional design theory, which provides a guide for the construction of effective online learning systems. In this paper, under the guidance of cognitive load theory, the optimal online learning path is investigated by studying the factors influencing the effectiveness of online learning for adolescents and combining them with online learning practices.

Keywords: CLT; online learning; adolescent students.

1. Introduction

The appearance and popularization of this new learning method expedites a new evolution of learning resources, and all kinds of course presentation elements become an important content of online teaching resources. In the online learning environment, learners' cognitive resources are limited; therefore, how to use cognitive resources to ensure learning effectiveness has been a hot topic of concern in educational psychology in recent years. Based on resource limitation theory, working memory theory, and schema theory, developing into an intrinsic cognitive load, extrinsic cognitive load, and germane cognitive load, cognitive load theory consists of three aspects: mental load, mental effort, and performance. Mental load refers to the interaction effects between learners and the learning content and its characteristics. Mental effort refers to the cognitive resources required for a learner to cognitive processing of the learning content. Performance refers to a learner's academic performance. As we all know, a large amount of content in online courses needs to be understood, manipulated, and memorized, which means that students need to take multiple cognitive processing tasks. But in fact, students have different cognitive levels. Therefore, teachers need to consider their cognitive differences for designing activities and then select course content suitable for their cognitive development and cognitive levels. As for the presentation of teaching materials, teachers should reasonably deploy their cognitive resources and balance their cognitive processing tasks through comprehensive thinking, thus equalizing their limited cognitive resources and controlling their cognitive load to the maximum extent.

2. Summary of cognitive load theory

Although the term emerged early, scholars took the cognitive load as a theory to conduct a systematic study until the late 1980s. [1] At that time, Sweller developed the theoretical hypothesis that when assuming working memory is also limited under cognitive structure with a certain capacity based on limited cognitive resources as information processing relies primarily on working memory, the composition of the working memory under this cognitive structure is the cognitive load. Moreover, he also assumed that under limited memory, working memory can remain infinitely effective for processing some familiar material because this kind of material is stored in advance in long-term memory which in turn retains many schemas which can be memorized automatically through extensive practice, thus prompting the learner to avoid the limitations of memory capacity. At a

theoretical level, in short, cognitive load primarily refers to the load that people carry during cognitive processing and the cognitive resources they occupy. At the level of educational practice, cognitive load refers to the amount of cognitive processing that students spend on learning within a set learning time, that is, their perceptual experience of the learning task, time pressure, and others during the learning process. Mainly at the classroom teaching level, this paper investigates the factors influencing the cognitive load in IT classrooms, intending to regulate the cognitive load in a targeted manner.

Above all, cognitive load originated from the human cognitive structure and is closely related to the brain and thinking activities, in short, it refers to the cognitive resources consumed in cognitive activities and the load-carrying capacity of working memory in the process of completing a task. Clearly, cognitive load is critical for classroom teaching. If the teacher teaches too much knowledge at once, perhaps the students show no problems in the classroom but may have a poor memory, inaccurate understanding, and ineffective use of all this knowledge after the classroom. In essence, their inconsistent performance compared with classroom effectiveness is inseparable from the teacher's inaccurate prediction of their cognitive load capacity. It follows that teachers' regulation of cognitive load in the classroom will affect students' learning efficiency. The cognitive load in this paper refers mainly to the level of effort when students complete the activity task, their subjective perception of the task load, and the task difficulty.

3. The impact of cognitive load theory on online learning outcomes for adolescent students

3.1. Classification of cognitive load

In the process of teaching, it is important to understand the types and characteristics of cognitive load as the first prerequisite in order to effectively regulate the cognitive load of learners. On this basis, we can make better use of learners' initiative, optimize learning efficiency and improve learning performance. Cognitive load is divided into intrinsic cognitive load, extrinsic cognitive load, and germane cognitive load according to their sources in existing studies, as shown in the table below.

Table 1. Classification of cognitive load[2]

Classification	Meaning	Main influencing factors
Intrinsic cognitive load	The intrinsic cognitive load is the load imposed on the working memory by the intrinsic characteristics of the learning materials.	The complexity of the learning materials, relevant learners' prior knowledge reserve, and others.
Extrinsic cognitive load	The extrinsic cognitive load results from the way the information is presented and the learning activities that learners need, which can reduce the working memory capacity of the learning without learning promotion.	Instructional design, presentation of learning materials, representation of tasks, and others.
Germane cognitive load	The germane cognitive load results from the construction and automation of schema in the learning process, which can promote and motivate learners to allocate cognitive resources to learning activities.	Learning motivation, learning interest, teaching situation, and others.

3.2. Teaching effects of cognitive load theory

3.2.1 Goal-free effect

The goal-free issue generally arises when issues without specific goals replace traditional issues. There are two main theoretical explanations for the emergence of this issue, one is the "method-end

(goal)" analysis strategy blocking theory, which divides the goal into several sub-goals and achieves them one by one to reach the end; the other is the dual problem space statement. Thus, in a certain rule space, the rules of the problem hypothesis and solution can be expressed in formulas, and in the instance space, which contains problem-specific solution strategies.

3.2.2 Sample effect

Sample effect refers to the effect of different cognitive load changes that occur during sample learning as a common way of learning for students. In inquiry learning and problem-solving, learners often need to use samples to increase their understanding of unfamiliar problems. Samples generally provide clear steps in problem-solving, which can purposefully draw students' attention to learning the relevant problem to reduce irrelevant load.[3]

3.2.3 Channel effect

During learning, as the load capacity carried by the learner's nervous system changes with the use of different sensory organs, there are varying degrees of learning effectiveness. Especially in the early stage of learning, when the intrinsic load is high, the integrated use of multiple forms of information presentation can increase working memory use and enhance learning results.[4]

3.2.4 Redundancy effect

Redundancy refers to the resources in the learning materials interfering with learning. In the actual teaching process, knowledge is presented in a variety of ways. Knowledgeable learners should discard some redundant information to reduce redundant information processing and avoid reducing the quality of learning. Meanwhile, in the design of such teaching courseware as micro-lessons and PPT, teachers should be careful not to have redundant resources.[5]

3.3. Factors influencing cognitive load

3.3.1 The effect of the way learning materials are presented on cognitive load

Teaching content design should be premised on adapting to the learner's cognitive processing rules. Consequently, designing learning activities in IT courses is no exception. With different ways to the presentation of learning materials, students occupy different sensory channels and cognitive resources, thus resulting in varying cognitive loads. Considering more such multimedia equipment as computer displays and projections in the IT environment, teachers need to select the equipment reasonably according to the effect of the cognitive load principle to present learning materials. Instilling too much new information will lead to an overload of students. Therefore, it is particularly important to keep information processing within limits that students' cognitive load can carry. With the development of digital tools, more video and animation media are used in teaching practice, which have unique advantages over traditional static pictures. Meanwhile, it also requires teachers to select teaching media more carefully; a single media can be too dependent on a particular sensory channel, which is not conducive to knowledge acquisition and construction; diverse media can generally reduce the cognitive load by spreading it across different sensory channels. However, when teachers use diverse media, it is important to avoid redundancy effects. Although many researchers and teachers believe that diverse media are more effective in transmitting information, it should not be overlooked that they may distract students during the learning process and create a more unnecessary cognitive load.

3.3.2 The effect of the course organization form on cognitive load

Different ways of organizing their learning activities that students rely on can take up varying cognitive resources. Numerous studies show that the specific organization form of the course is also the object that students need to process during their learning. Learners have different meta-cognition due to the different ways of organizing learning, thus resulting in different meta-cognition load. In the organization of the course, all subtleties including the logic of the teacher's language, the pace and rhythm of teaching, the timing of the presentation of knowledge points, and the color and size of the fonts in the multimedia courseware have an impact on the cognitive load of the students.[6] Poor

course organization constrains time commitment and mental effort and increases cognitive load. Conversely, good course organization that spreads out the complex content to the student occupies fewer cognitive resources and reduces cognitive load

User research shows that different recording formats of online courses can affect learners' motivation and interest in learning. The size and availability of subtitles can affect learners' access to the course content. For example, in relatively noisy situations or when the teacher's accent is severe, subtitles can have a greater effect on learners' learning efficiency. Switching the course footage too far away can make it difficult to see the PPT content clearly, so learners can only access the knowledge through the voice while frequent switching of the footage can also lead to distraction. As background music in the course except for the teacher's verbal narration, sound effects must appropriate be for the course after selection, if teachers want to gain the positive impact of adding them.

4. Recommendations

As mentioned above, Sweller divided cognitive load into three categories, intrinsic cognitive load, extrinsic cognitive load, and germane cognitive load. From the perspective of cognitive load theory, all teaching methods and techniques are designed to reduce intrinsic and extrinsic cognitive load and increase relevant cognitive load. As shown in Figure 1. Guided by cognitive load theory, this paper summarizes specific recommendations for optimizing the effectiveness of online learning for adolescents as follows.[7]

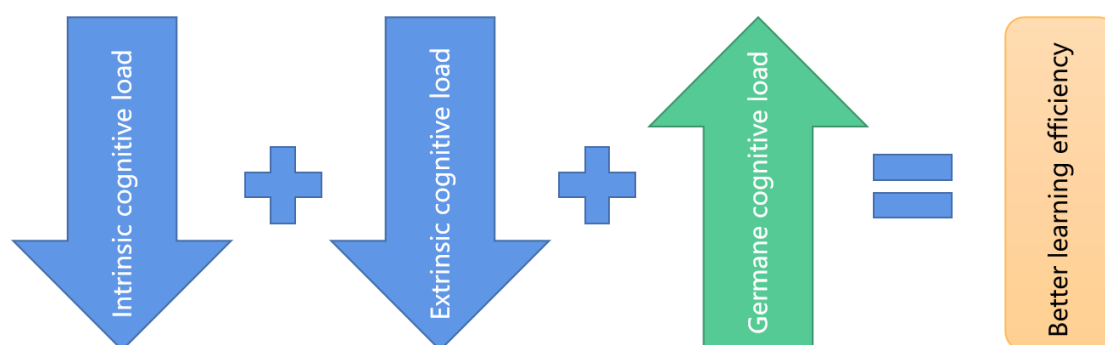


Figure 1. An approach to improve the effectiveness of online teaching based on cognitive load theory

4.1. Clear learning objectives

Teachers shall first make clear the specific objectives of the course and the level which students need to reach, and then determine teaching content, choose suitable teaching method and arrange teaching schedule according to these. For example, for language skill courses like listening, speaking and reading, teachers can take promoting students' listening, speaking, reading and writing skills as the main target; but for cultural cultivation courses, cultivating students' inter-cultural communicative awareness and ability shall be the main objective. In addition, we also have to consider the difference of students at different levels in their demand, and then formulate relevant teaching plan to meet personalized need.[8]

4.2. Reasonable information organization

The organization of information should be paid attention to when making an online linguistic teaching courseware. On one hand, a lot of texts or pictures shall be prevented to show knowledge points, because this easily leads to visual fatigue and increases students' cognitive load. On the other hand, it is unwise to over-rely on multimedia technology and ignore blackboard writing or interpretation, as this will make students hard to understand key and difficult knowledge points. Thus,

it is suggested to combine texts with pictures to explain knowledge, and meanwhile add some cases, video, audio and other supporting materials, helping students to better understand abstract concepts.

Lightweight knowledge output. Splitting complex solutions into smaller units of meaning is conducive to simplifying the cognitive processing of learners; controlling the speed of presentation of teaching materials means that learners have enough time for cognitive processing, thus preventing cognitive overload. Presenting one knowledge point in the group of the training camp every working day in the form of documents, micro-videos, and live broadcasts as the established knowledge framework can reduce the daily learning burden and increase the uptake and conversion rate on the one hand; can help learners gain a positive emotional experience and a sense of learning achievement by unlocking a new skill every day on the other hand.[9]

4.3. Control interaction intensity

Good interaction is a crucial factor to ensure teaching effect. Teaching design should take full consideration of students' cognitive characteristics and habit, and reduce unnecessary interaction as possible, such as pop-up window or close pop-up window. Moreover, interaction process shall be concise, allowing students to get required information quickly and accurately.

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4.4. Immediate responsive feedback

To ensure learning effectiveness, teachers give learners the necessary instructional information, which is conducive to reducing the intrinsic cognitive load during the early stages of learning. After releasing new learning content each day, the head teacher of the training camp assigns a task to urge learners to practice while learning. At the same time, the tutor timely provides feedback with comments for submitted tasks while replies quickly to the questions raised by the learners during practice to strengthen the link between the teacher and the learners.

Timely and effective feedback not only facilitates students to deepen their understanding and memorizing of knowledge, but also stimulate their learning interest and enthusiasm. Hence, courseware design shall attach importance to the establishment of feedback mechanism, including timely giving recognition, correcting errors and providing reference answers, etc.. At the meantime, a flexible adjustment of feedback frequency and method is needful according to students' actual situation, so that every student can obtain suitable guidance and support.

4.5. Creating personalized learning pathways and promoting deeper learning for students

A one-size-fits-all learning approach is not conducive to students' personalized development, limiting the development of their higher-order and critical thinking. Big data has played its role in achieving personalized learning development from different aspects. By mining big data in education to discover the complex rules and patterns of their learning, we can explore learning pathways suitable for individual personalized development, which will help them achieve deep learning, thus cultivating talents to adapt to the development of the digital economy.

Building all-media learning resources

4.6. Building all-media learning resources

The construction and utilization of quality educational resources is a support guarantee for strengthening high-quality educational development while driving the transformation and upgrading

of education with digitization is a strategic action made by China to digitize education. Matching learners with appropriate learning resources by integrating their cognition, motivation, and interests can help them enter immersive learning. The different ways to represent learning resources by diverse media provide the conditions for their immersive learning. The diverse, open, and shared presentation of learning resources help learners acquire iconography, transfer and apply knowledge, and construct a personal knowledge system. In the process of individual and collective knowledge construction, the continuous flow of all-media resources continues to contribute to the digital development of education.

5. Conclusion

In conclusion, under the trend of continuous and in-depth development of intelligent education, online learning has reshaped the teaching and learning environment while making learning more convenient. However, the cognitive load overload of learners caused by the unreasonable design of online course information presentation has become the main challenge that online course learning faces. This paper sorts out the concepts and classifications of CLT and discusses the main factors that affect the effectiveness of online learning for adolescent students. Moreover, based on the CLT proposes online course design strategies and related suggestions, by reducing the intrinsic and extrinsic cognitive load and increasing the germane cognitive load, learners' knowledge absorption is improved, which helps achieve optimal teaching and learning results.

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