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Study on Online Linguistics Teaching Courseware Design and Cognitive Load

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Abstract: *With the continuous development of Internet technology, people are gradually deepening their exploration in online education field. Especially in recent years, the rising of massive open online courses (MOOCs) takes online learning to a new level, and online linguistics teaching course are also developing rapidly. But due to the characteristics of linguistics discipline and the presentation factors of online course design, the quality of online linguistics teaching causes people's rethinking. Therein, how to optimize cognitive load in courseware design is a key of linguistics teaching. Based on cognitive load theory, this paper explores how to reduce learners' internal and external cognitive load and appropriately increase cognitive load from optimizing teaching courseware, visual presentation method and knowledge relevance, so as to effectively control learners' cognitive load and allow them to study a language efficiently online.*

Keywords: *cognitive load; Linguistics Teaching; courseware design; CLT*

1. Introduction

Online course is a new way to bring education to the information era. It includes text, picture, audio, video, cartoon and other forms of course materials, aiming to help students by emotional and motivational means and facilitate human-machine interaction in course learning. Since it is not limited by time or space, it has become an important part of modern education.

In second language teaching, listening and reading are basic receptive skills and are also used as conventional teaching and practice forms. From the process of linguistic code reception, decoding and information processing, listening and reading has certain similarity, and some researchers take reading as a secondary processing system overlaid on previously developed listening system in the learning of mother tongue. However, Michael et al. (2001)[1] discovered the different physiological basis of listening and reading during sentence comprehension through fMRI technology. The development situation of second language is quite different from the acquisition of mother tongue. After studying the incidental vocabulary acquisition in listening and reading. Vidal (2011) discovered the learners acquired more vocabularies in reading than in listening, especially for those learners with lower linguistic proficiency. But for learners with higher linguistic proficiency, the requirement for working memory will be smaller during reading. [2]

In recent years, as cognitive science is developing continuously, some researchers try to elucidate the inner reasons for listening and reading differences during second language learning from the perspective of cognitive resources. The premise of cognitive load theory is that the limited cognitive resources of human determines the limitation of working memory capacity. When an individual tries to complete a task, he/she will consume cognitive resources provided by working memory capacity, leading to cognitive load, which then affect the results of learning and task completion. Li Xiaoyuan (2012) investigated Chinese English learners' reading comprehension and found that cognitive load was a key factor of restricting academic comprehensive ability development of second language.[3]

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. Online teaching courseware design plays the role of language input material, language output demonstration and language activity drive during linguistics teaching. But currently, the relationship between linguistics courseware design presentation and learners' cognitive load hasn't been handled well. So, the paper puts emphasis on how to introduce cognitive load theory in the design of online linguistic teaching courseware, trying to provide reference to the optimization of visual presentation and design of

ISSN 2522-6398 Vol. 6, Issue 23: 122-130, DOI: 10.25236/FER.2023.062321

teaching courseware.

2. Related concepts and theories

2.1 Definition of cognitive load

In the 1980s, John Sweller, a famous Educational Psychologist, put forward the cognitive load theory (CLT) based on the limitations of working memory. CLT is a theory of educational psychologies built according to the cognitive structure of human brain, mainly used to interpret the learning effect of different teaching designs. This theory involves the summation of loads added to working memory by various cognitive activities of human (Sweller, 2004, 2008, 2010). The representative views for cognitive load are shown in Table 1.

Table 1. Representative views for cognitive load

Scholars	Time	Views
Sweller	1988	Cognitive load is the "level of mental capacity" required to process given information.
Cooper	1990	Cognitive load is the total mental activity exerted on an individual's working memory during a given working period.
Pass & Van Merrienboer	1994	Cognitive load composed of multiple dimensions is the load exerted on an individual's cognitive system when performing a specific task.
Quiroga et al.	2004	Cognitive load is generally defined as the degree of cognitive resource investment used to facilitate learning activities.

CLT divides human's cognitive structure into two parts: working memory and long-term memory. Working memory also called short-term memory has limited capacity and could only store five to nine pieces of basic information at a time. As the interaction of elements stored in working memory needs to occupy the space of working memory, less information can be processed at the same time, and merely two or three pieces of basic information can be treated at a time. However, the capacity of long-term memory is almost infinite. No matter small and debris information or large, complex, interactive and serialized information can be stored in it. Long-term memory is the center of learning. If the content of long-term memory doesn't change, the learning of lasting significance won't happen. CLT believes the main function of teaching is trying to store information in long-term memory.

In Education Science, cognitive load refers to that the a student shall pay psychological efforts or physical energy to complete his or her learning tasks. Such input can originate from internal spiritual status, external time pressure, teaching design and so on. Among them, internal spiritual status includes interest, motivation and attitude; external time pressure includes working memory capacity, information processing speed, classroom activities organization form and other factors; and teaching design involves course difficulty, presentation form, interaction mode and other factors.

2.2 Classification of cognitive load

In general, cognitive load is divided into three types: internal cognitive load, external cognitive load, and relative cognitive load (Sweller, 2004).[4] Internal cognitive load refers to the energy and time input by a student when learning new knowledge, which is mainly determined by the characteristic of learning material itself; external cognitive load refers to the extra load brought by teachers or others to organize classroom activities, such as maintaining order, asking questions, etc.; relative cognitive load refers to the relationship between the background knowledge and experience mastered by students and their current tasks, which may interrupt students' thinking process or reduce the efficiency of working memory. (As shown in table 2 & figure 1)

Table 2. Classification of cognitive load

Classification of cognitive load		Main influencing factors
1	Internal cognitive load	(1) Learners' cognitive structure (2) Learning tasks' difficulty degree
2	External cognitive load	(1) Teaching content design (2) Teaching activities presentation mode
3	Relative cognitive load	(1) Learning motivation (2) Learning interests

ISSN 2522-6398 Vol. 6, Issue 23: 122-130, DOI: 10.25236/FER.2023.062321

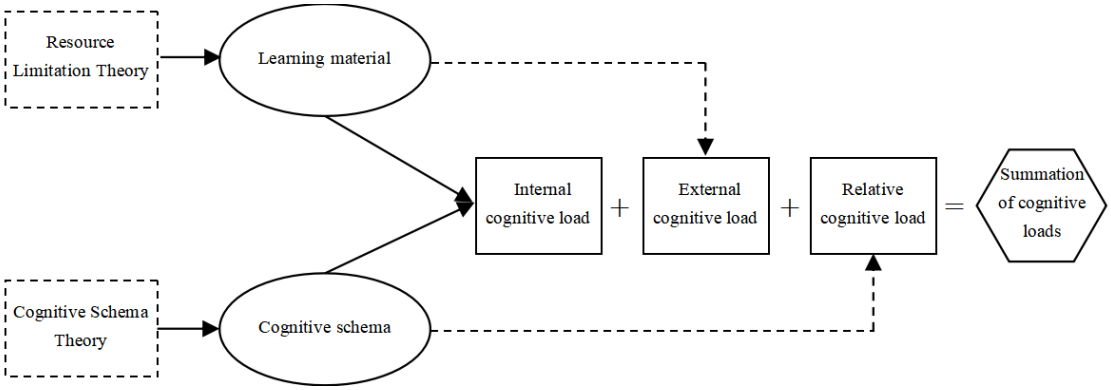

Figure 1. The relationship between CLT and three cognitive loads (Seufert et al. 2007)

2.3 Cognitive theory of multimedia learning

Mayer et al. (1997) proposed the Cognitive Theory of Multimedia Learning (CTML) based on the cognitive load theory and dual coding theory.[5] Dual coding theory believes that humans have two independent but interconnected cognitive systems with different functions and structures used to process and store information, that's verbal representation system and image representation system. Multimedia learning includes three processes: selection, organization and integration. Multimedia teaching information is mainly presented in the form of narration, sound, text and picture. Narration and sound information enters in working memory through auditory channel to generate verbal representation; text and picture information enters in working memory through visual channel to generate image representation. Knowledge construction depends on learners' active cognitive processing during study. Information processing system needs to establish a reference link between these two codes, connecting different representations of the same concept together and connecting them with existing knowledge in long-term memory system. In this process, the total processing capacity of working memory is limited, so the integration of auditory and visual information will be restricted by memory load. Therefore, if too much information is exposed to auditory or visual channel to process, it would cause cognitive overload and impede learners to study. (As shown in figure 2)

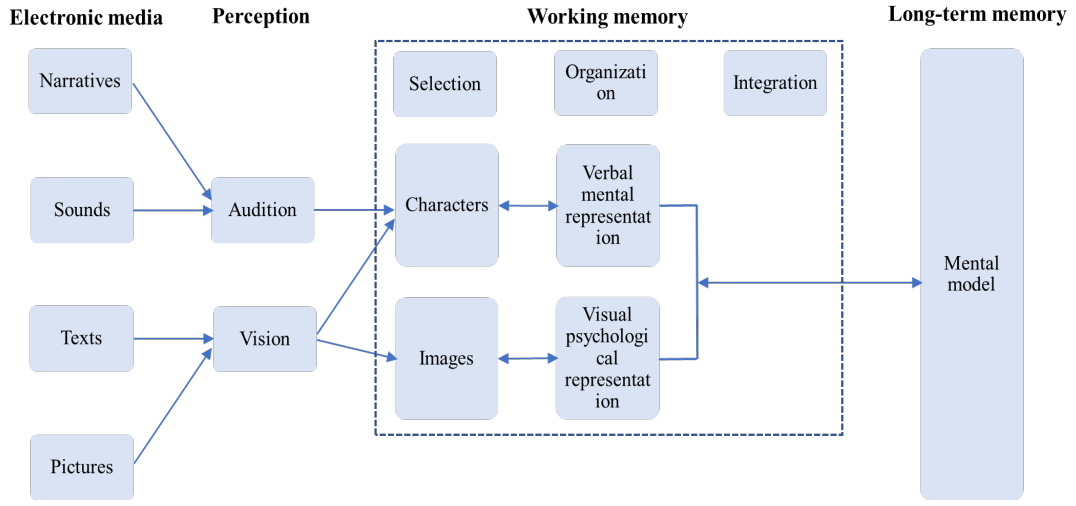

Figure 2. Cognitive Theory of Multimedia Learning (Mayer, 1997)

2.4 Measurements of cognitive load

At present, the common cognitive load measuring tools include questionnaire survey, test, classroom observation and other forms. Therein, questionnaire survey is the most common way. By distributing questionnaires to students and collecting data, the students' cognitive status and related information can be reflected objectively. But this method is subjective to some extent and waste time and energy, so in recent years, more and more scholars have started to use other more efficient and convenient measuring means. For example, the tests based on eye tracking technology can record students' visual information

ISSN 2522-6398 Vol. 6, Issue 23: 122-130, DOI: 10.25236/FER.2023.062321

at real time, thereby more accurately capturing students' allocation of attention; meanwhile, it can be combined with speech analysis software to evaluate the students' oral expression ability and so on (As shown in table 3). [6]

Table 3. Measurements of cognitive load

Causality / Objective reality	Direct	Indirect
Subjective	Difficult degree of material	Mental efforts invested in self-report, and Pressure level borne in self-report
Objective	Brain activity measurements (such as fMRI), and Dual-task analytical method	Performance result test method, Behavior mode or psychological condition and functional analysis method, and Physiological measuring method (heart rate, mydriasis)

2.5 Influencing Factors of Cognitive Load

During the teaching design, the teachers have to consider the impact of multiple factors on students' cognitive load. Two of the most important aspects are: (1)organizing form of learning material; and (2) task type and targeted level. These two aspects will be discussed separately in the following paragraphs.

First, the organizing form of learning material will directly affect students' cognitive load. When learning material is presented linearly, its comprehensibility is high. But accordingly, the students need to process a greater number of information, so cognitive load will be higher. If learning material is presented in non-linear structure or interactive interface, it can better guide students to participate in and think actively, thereby reducing cognitive load. In addition, learning material redundancy is also a very important factor. Too much redundant information could not improve students' working efficiency, but may lead to poor concentration and add cognitive load. Therefore, in selecting learning material, it is necessary to fully consider its quality and difficulty and prevent excessive redundancy.

Second, different task types and targeted levels can produce significant impact on students' cognitive load. For example, it is harder for students to remember a lot of factual knowledge points than to solve practical problems. Because the former needs more time and energy to process information, while the latter involves higher level of thinking activities. At the same time, too high or too low targeted level is not conducive to students to master relative knowledge, while an appropriate targeted level can facilitate a student's learning motivation and effect.

3. Cognitive load based online linguistics teaching courseware design

3.1 Classification of online linguistics teaching courseware design elements

Based on the cognitive load resource allocation theory or limited capacity theory, including mental resources, cognitive resources, attention resources, etc., the author researches and analyzes the online course cases, summarizes the design points affecting the interface layout of online course teaching, and lays the foundation for the subsequent proposal of the interface layout strategy of online course teaching based on cognitive load theory.

3.1.1 Teachers' image

Taking some of the intercepted online course pages as an example. It can be seen that the design of the teachers' image can include the presence or absence of the teachers' image, the change of the position of the teachers' image, the shape and size of the teachers' background, the distance of the teachers' image and other design points. Among them, when there is a teachers' image in the online course, the change of the teachers' position will cause the learners' attention to change, and the frequent change of the teachers' position will increase the level of learners' mental effort; too large or too colorful teachers' background will interfere with the learners' grasp of the course content and make it difficult for the learners to distinguish the information, which will lead to more mental effort; the distance of the teacher's image should ensure that the teachers' image is basically visible, too far or too close will make it difficult for the learners to distinguish the information, which will lead to more mental effort. However, the presence or absence of the teachers' images affects the learners' impression of the course. For learners who are used to or prefer the presence of teachers' images in online courses, it can stimulate their learning motivation and increase their interest in learning, so the teachers' image interface layout elements are

ISSN 2522-6398 Vol. 6, Issue 23: 122-130, DOI: 10.25236/FER.2023.062321

classified based on cognitive load.(As shown in figure 3 and table 4)

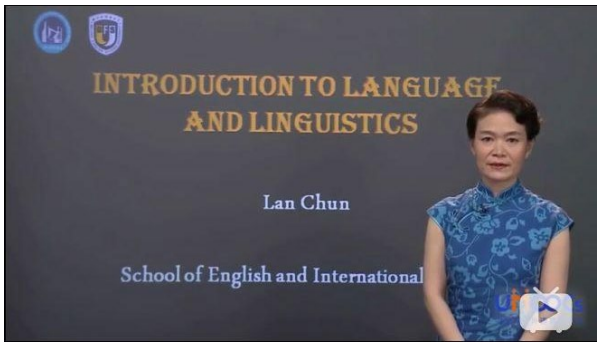

Figure 3. Teachers' image

Table 4. Analysis of the Cognitive Load of Teachers' Image

Serial number	Interface layout elements	Results from cognitive load	Cognitive load classification
1	Presence or absence of teachers' image	Affects learners' motivation and interest and takes up some cognitive resources	Relative cognitive load
2	Positional changes in the teachers' image	Difficulty in distinguishing information, making more mental effort	External cognitive load
3	Teacher background shape and size ratio	Difficulty in distinguishing information, making more mental effort	
4	Distance of the teachers' image	Difficulty in distinguishing information, making more mental effort	
5	Other designs of the teachers' image	Confusion about information, causing interference in learning	

3.1.2 Special effect animation

The animation at the beginning of the course video can arouse learners' interest in the course and increase the relative cognitive load, the special effects animation of pictures and text in the course attracts learners' attention and transforms the static into dynamic effects, which can make learners pay more attention to a certain extent. However, the video itself is dynamic, and adding animation effects based on dynamics will interfere with learning the content of the video itself. Hence, the classification of animation effect interface layout elements based on cognitive load is shown in Table 5.

Table 5. Cognitive load analysis of animation effects

Serial number	Interface layout elements	Results from cognitive load	Cognitive load classification
1	Opening animation	Affects learners' motivation and interest and takes up some cognitive resources	Relative cognitive load
2	Image animation	Affects learners' attention	External cognitive load
3	Video animation	Tends to distract the learner's attention and takes up some cognitive resources	
4	Text animation	Affects learners' attention	

3.1.3 Text interface

The design of the content text in the online course will greatly impact the learning effect of the online course. For example, whether the font of the text is clear and reliable, whether the size and line spacing of the text is appropriate, whether the layout of the text conforms to the browsing habits, and whether the combination of images and text is appropriate, all of these will affect the learners' access to the course content, making it difficult for the learners to distinguish the information and making more mental efforts; the text content of the course is marked with emphasis and modularized, which can reduce the learners'

ISSN 2522-6398 Vol. 6, Issue 23: 122-130, DOI: 10.25236/FER.2023.062321

confusion about the course content itself and improve the learning efficiency. Hence, the classification of textual content interface elements based on cognitive load is shown in Table 6.

Table 6. Cognitive load analysis of text interface

Serial number	Interface layout elements	Results from cognitive load	Cognitive load classification
1	Font of the text	Difficulty in distinguishing information, making more mental effort	External cognitive load
2	Text size and line spacing	Difficulty in distinguishing information, making more mental effort	
3	Typography of the text	Difficulty in distinguishing information, making more mental effort	
4	Combination of images and text	Difficulty in distinguishing information, making more mental effort	
5	Highlight and modularization content	Confusion about information, causing interference in learning	Internal cognitive load

3.1.4 PPT play

The design of the PPT has a certain impact on the learners' cognitive load. Firstly, the switching of PPT should ensure that learners can see the content of the page clearly before switching; otherwise, the switching speed is too fast or too slow, which will affect the mental effort of learners; secondly, the switching effects of PPT are too fancy and will additionally increase the mental burdens of learners; the overall design and page control of PPT will help reduce the impact on the mental effort of learners; finally, PPT play with the teacher is particularly important, the teacher speaks to which course content, which course content is only displayed, can help learners to focus their attention, to prevent too much course content, and learners read faster than the teacher to explain the speed and lead to interference with the learning content. Hence, the classification of PPT design interface layout elements based on cognitive load is shown in Table7.

Table 7. Analysis of the impact of PPT on cognitive load

Serial number	Interface layout elements	Results from cognitive load	Cognitive load classification
1	PPT switching time	Redundant information that takes up some cognitive resources	External cognitive load
2	PPT switching effects	Redundant information with more mental effort	
3	Design sense of PPT	Different levels of mental effort	
4	Number of PPT pages	Redundant information with more mental effort	
5	PPT plays with the teacher	Confusion about information, causing interference in learning	Relative cognitive load

3.2 Design Strategies

3.2.1 Control the internal cognitive load in interface layout of online course teaching

In general, internal cognitive load level of learning tasks should be controlled within a certain range, preventing it to be too high or too low to affect learning effect. Compared to external cognitive load, internal cognitive load is more complex, which can be reflected at the grasping of number and difficult level of knowledge points in online courses. Therefore, learners of different knowledge level should be provided with courses of different difficult level. When internal cognitive load is too low for a learner, it is feasible to properly increase the difficult level of learning material, because excessively low internal cognitive load will make learners feel that current knowledge is too easy, and they will lower or even lose their interest in study. But when internal cognitive load is too high, it is necessary to bring down cognitive load, i.e. reduce the difficult level of course material, even this action may break the integrity of course content. Hence, at the premise of understanding the knowledge level of course learners in advance, the key of controlling internal cognitive load in interface layout of online course teaching could start from controlling the content of teaching courseware.

ISSN 2522-6398 Vol. 6, Issue 23: 122-130, DOI: 10.25236/FER.2023.062321

(1) Modularization and graphing of course content. Display course content in modular, and let each modular to cover one knowledge point. Knowledge points in each course shouldn't be separately arbitrarily, otherwise, it will destroy the systematicness of course. For course content with data and time sequence, they can be processed with charts to visually demonstrate the content.

(2) Presentation of various course samples. Proper course sample could also help learners to understand course materials, spend less cognitive resource in study, and learn in a more systematic way.

3.2.2 Reduce external cognitive load in interface layout of online course teaching

Normally, external cognitive load is caused by inappropriate teaching design and teaching process and it can impede students to study. External cognitive load is easier to handle than internal cognitive load, because it is universe in course teaching and learning, and any course design element can affect it. Though external cognitive load can't be eliminated completely, it can be lowered as possible through course design. Redundant information in video course, such as pictures, cartoons and so on shouldn't be too much, and colors, charts and texts should be controlled within a certain range, to avoid the distraction of excessive redundant information on learners' cognitive study and improve online learners' learning efficiency. In a word, external cognitive load arising from unreasonable teaching design and process is inevitable, but we can reduce its effect through design.

(1) Basic structure of online courseware

Structure refers to the layout of the picture. The main expressive element in the picture should account for 60%-70% of total interface. In an interface, an area with "best view" refers to the most striking position in the picture displayed by computer monitor within a defined distance. By using visual direction and people's visual habits, we can determine the optimal visual area(as shown in the following figure) and effectively design online course content in the optimal visual area, which can effective cut down external cognitive load.

(2) Suitable teacher image

Video content with a teacher giving lessons can attract more attention of learners and increase friendliness of teaching videos. Teacher image at different time periods and positions can stimulate student interest in study, increase learners' attention, and reduce external cognitive load. Teacher pictures can be adjusted according to courseware content. In case of a lot of information like text and pictures in courseware pages, teacher image can be ignored or a small teacher image can be add to the left bottom; but when information is less on the page, a larger teacher picture can be added to the right of pages. Pictures with teacher image and without teacher image can be displayed alternately to relieve course fatigue, while frequent change of teacher image and position should also be avoided.

(3) Add subtitle

Eye movement experiment proves that videos with subtitles has a better learning effect than those without subtitles. Top to bottom layout is preferred in online course with both English and Chinese subtitles. Subtitles are generally displayed in black or white common fonts such as SimSun and Microsoft YaHei, and they should be kept in one line to prevent more cognitive load due to text wrapping.

(4) Reasonable design of interface color

Vision is human's most important and intuitive sensor organ, and human eyes are extremely sensitive to colors. When making online courses, it is essential to pay attention to the contrast and harmony between colors and match colors properly, in order to improve learning comfort, help distinguish course content, and promote course efficiency.

Correct use of color can improve users' ability to obtain visual information and reduce cognitive load caused by visual fatigue. In the color design of teaching video interface, comfortable color combinations should be selected as the front and rear background colors, and key content should be displayed in bright color while non-key content should be dim. The main tone could be cool, warm or neutral color system according to course design style; and the hue should not exceed four in the same page.

3.2.3 Increase relative cognitive load of interface layout in online course teaching

Relative cognitive load, different from internal and external cognitive loads, is a cognitive resource that learners use to handle internal cognitive load effectively. Its level is determined by learners themselves, and it relates to users' learning motivation. The higher the learning motivation is, the more the resources that learners can devote to cognitive resource tasks will be. On the contrary, if learning motivation is insufficient, learners will devote to less relative cognitive load, failing to form a proper

ISSN 2522-6398 Vol. 6, Issue 23: 122-130, DOI: 10.25236/FER.2023.062321

schema construction. Thus, internal cognitive load should be increased in the design of online courses as possible, and activities able to facilitate users' scheme construction should be increased or designed, to help increase their relative cognitive load. A course displayed by multiple channels can stimulate learners' motivation and interest.

Dual channels refers to the fact that learners can achieve better learning results by learning according to the picture and the picture narration than by according to the picture and the textual description of the picture. The channel effect in psychology refers to the fact that during learning, learners can gain better results in processing the information from both visual and auditory channels than in processing the information from one channel alone. As research shows, it can expand the capacity of effective working memory by using both visual and auditory working memories simultaneously more than by using one of them alone. In other words, learning can be facilitated by effectively integrating both types of resources through the use of dual visual and auditory representation techniques. This also means that in multimedia instructional design, the excessive use of single-channel representations should be kept away from and that it is better to make use of the combination of auditory and visual channels, such as "text plus narration" or "image plus narration". Besides, the narration and text or image representation should fit perfectly to avoid increasing the cognitive load of learners.

For example, conceptual courses often have large blocks of text explanation. If there is no pictures to deepen impression, learners are hard to concentrate. Normally, image and picture information is transferred faster than text information, so the design of image and pictures becomes a very important part in the design of online course interface layout. When case explanation matches with some pictures, the obscure concepts can be abstracted to vivid dynamic images and produce good visual impact on learners, allowing teaching content to be transferred effectively. Moderate animation, sound effect and other auditory channel elements can be added in the teaching design of online courses to attract student attention and prevent student fatigue from unchanged picture due to playing static PPT for a long time. However, it should be noted that the purpose of adding animation and sound effect is to stimulate student motivation in study rather than interfering them.

4. Conclusion

Under online teaching scenario, learners' cognitive resource is limited, so language teaching design should start from learners' cognitive rules. If teaching materials are too simple and task design lacks challenge, the learners will stay at a low-load operation state in a long time, making them hard to improve their language competence. On the contrary, if teaching materials are too difficult and teaching design is complicated, the resources required for learning task will exceed the cognitive resource that learners can use, and the "overload" arising from this will make learners to loss interest and confidence in learning. In second language teaching, materials of moderate difficult level and appropriate method should be selected according to learners' language features. Only by controlling internal and external cognitive loads within a reasonable scope can learners acquire a new language form more efficiently, thereby promoting learning effectiveness and realizing a balanced development of language competence.

In the future research, considering that different disciplines have their unique teaching modes and instructional strategies, it is especially significant to analyze the cognitive load of learners according to the characteristics of specific disciplines. In the teaching of specific disciplines, the learners' cognitive load can be measured through different instructional designs, and its sources obtained so as to attain the goal of reducing the learners' cognitive load and get better learning results by optimizing the instructional design.

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