

Design and Application of Organic Chemistry Experiment Teaching Based on Cognitive Load Theory

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Keywords: Cognitive Load, Chemical Experiments, Teaching Design, Application Research

Abstract: Since Its Birth, Cognitive Load Has Had a Profound Impact on Education. Due to the “Experimental” Nature of Chemistry Education Itself, It is Easy for Learners to Have a Higher Cognitive Load Level during Learning, Thus Affecting Our Teaching Effect. in the Process of Organizing Chemistry Experiment Teaching, We Should First Fully Consider Each Learner's Pre-Knowledge Level and Structure Related to the Experiment. This Will Help Us to Fully Understand and Control the Cognitive Load Generated by Students in the Process of Chemical Experiment Teaching from a Macro Perspective to a Great Extent, So as Not to Affect the Effect of Experiment Teaching Due to Excessive Load. Secondly, Students Should Be Familiar with the Environment That Will Participate in Experimental Learning Before the Experiment through Pre-Study and Field Visits, So as to Minimize the Excessive External Load Cognition Brought to Them by the Complex Experimental Environment. That is to Say, At the Beginning of the Experiment, the Students Should Pay Attention to the Experimental Content Itself, Not Other Things. through the Design of the Integrated Experimental Manual and the Computer Simulation of the Pre-Experiment, We Can Help Students to Minimize the Internal Cognitive Load Related to Theoretical Knowledge during the Experiment, and Truly Realize the Purpose of Testing and Developing Theoretical Knowledge through Experiments.

1. Introduction

With the Process of World Economic Integration, Internationally Renowned Chemical Enterprises Have Set Up Production and Research Institutions Closely Related to Organic Chemistry in China, Such as Chemical Industry, Medicine, Biochemistry, Agrochemistry, Quality Inspection, Etc [1]. Organic Chemistry Experiment is an Important Part of Organic Chemistry Course, and It is an Extremely Important Experimental Course for Chemistry and Chemical Engineering, Biotechnology, Pharmaceutical Chemistry, Pesticide Chemistry, Material Chemistry and Other Majors [2]. Mastering the Experimental Technology of Organic Chemistry, Especially the Synthetic Technology, is Especially Important for Scientific Research in the Above Fields [3].the Synthesis and Melting Point Determination of Organic Compounds Are the Most Important Components in Organic Chemistry Experiments. They Are the Basic Principles of Organic Chemical Reactions, Basic Theories and the Comprehensive Application of Scientific Methods for the Basic Operational Skills of Organic Experiments. They Are Dominant and Recessive [4]. the Micro-Integrated Organic Chemistry Experiment Can Cultivate Students' Complete Research Thinking and Practical Operation Ability, Which is Conducive to Students' Integration of Knowledge, and Thus Promotes the Improvement of Students' Experimental Skills and the Cultivation of Synthetic Thinking Ability [5].

Cognitive Load Theory Has Received Extensive Attention Since It Was Put Forward by Australian Sweller and Other Scholars in the 1980s [6]. in Recent Years, Scholars Have Tried to Study the Teaching Process and Guide the Teaching Design from the Perspective of Cognitive Psychology. Cognitive Load Theory Based on Information Processing Psychology is Based on the

Limitation of Human Information Processing Capacity [7]. the Generation of Cognitive Load is Related to Specific Tasks and Requires the Participation of Limited Cognitive Resources in Working Memory. the Magnitude of Cognitive Load Becomes an Important Influencing Factor for Effectively Solving Problems and Obtaining Schemata [8]. under the Guidance of Cognitive Load Theory, the Optimization Design of Organic Chemistry Experiment Teaching Should Not Only Pay Attention to the Diversity of Modern Courseware Information Transmission, But Also Pay Attention to the Advantages of Inheriting Traditional Teaching Methods [9]. the Knowledge System is Displayed in Front of the Students in a Three-Dimensional Manner, So That the Learner's Internal Cognitive Load Can Be Reduced. At the Same Time, It Reduces the External Cognitive Load and Promotes the Deep Cognitive Processing of Learners to Realize the Integration of Cognitive Load and Information Technology Teaching [10].

2. The Concept of Cognitive Load Theory

2.1 The Main Content of Cognitive Load Theory

The so-called cognitive load refers to the sum of intellectual activities applied to the learner's working memory in a certain learning situation. Cognitive load theory was proposed by Australian psychologist John Sweller in 1988, based on summing up and learning from previous researches on "attention" and "working memory." According to cognitive load theory, cognitive load can be divided into three categories: internal cognitive load, external cognitive load and associated cognitive load. The cognitive load due to the interaction between the nature of the learning material and the learner's expertise is called the internal cognitive load. External cognitive load is an extra load beyond internal cognitive load, mainly caused by improper teaching design. Relevance cognitive load refers to cognitive load related to promoting schema construction and automation process. The three types of cognitive load are superimposed on each other. In order to promote effective learning, the external cognitive load should be reduced as much as possible in the teaching process, the associated cognitive load should be increased, and the total cognitive load should not exceed the cognitive load that individual learners can bear.

2.2 The Basic Viewpoint of Cognitive Load Theory

Cognitive process is a process of interaction between external information structure and cognitive structure. Cognitive structure consists of a limited amount of working memory system and an unlimited amount of long-term memory system. On the one hand, for a particular cognition, the limited capacity working memory system is the bottleneck of cognition and cannot be changed. Therefore, the limited working memory system should effectively process complex information structures. Teaching design must optimize the external information structure, reduce the external or internal load, so that the working memory system can be processed, or even effectively processed. On the other hand, the long-term memory system can store unlimited patterns, and the schema can not only facilitate working memory extraction and help work memory to process new information, but also directly drive behavior. Therefore, the teaching design must fully utilize and utilize the patterns in long-term memory. However, the formation and development of schemas comes from the conscious decomposition and re-encoding of information elements of complex tasks, and integration into chunks or rich information units. Therefore, the teaching design will increase the effective load.

3. Relationship between Chemical Experiment and Cognitive Load

3.1 The Idea of Chemistry Experiment Teaching

It is a new thing to set up a separate course in a chemistry experiment. It lacks a blueprint that can be used for reference, and it is difficult to find a suitable reference system. Coupled with the current insufficient teaching resources and material resources, there must be more uncertain factors in the organization and process of the curriculum. The proper resolution of these issues should

allow for a longer period of exploration and gradual improvement. However, it is still promising to improve our experimental teaching with the requirements and methods of inquiry learning. Demonstrations or classroom experiments included in compulsory and elective textbooks, as well as some experimental inquiry activities that students have participated in, have a variety of topics that students can explore again. Or to explore the improvement or optimization of some separation technology, or to explore the improvement of the yield and product purity of a synthesis experiment, or to explore the dependence of some experimental conclusions on reaction conditions, etc. Learning chemistry through experiments is a perceptual knowledge of experimental science, which has the nature of a reader and functions as an experimental instruction book and a reference manual. It is helpful for students to learn chemistry, thus better reflecting the original intention of setting up experimental chemistry elective module.

3.2 The Significance of Cognitive Load Theory to Chemical Experiments

In a sense, the teaching purpose of chemical experiment is mainly divided into two parts: one is to consolidate the knowledge learned, the other is to train the experimental skills. Due to such dual teaching objectives, the environment for chemical experiment teaching is more complicated than the conventional classroom teaching. The content of chemical experiment teaching is very practical. From the cognitive load theory, it can be seen that both the internal cognitive load and the external cognitive load are large in the process of chemical experiment. At the same time, students' interest and enthusiasm in chemical experiments will also increase the related cognitive load. It is easy to make their cognitive load exceed the standard, thus reducing the effect of chemical experiment teaching. Therefore, in order to improve the effect of chemical experiment teaching, it is particularly important to control and adjust the total cognitive load generated by learners in the process of chemical experiment teaching. Only in this way can the total cognitive load generated by learners during chemical experiments be better regulated, the effect of experimental teaching can be prevented from being affected due to excessive load, and the simultaneous improvement of their experimental skills and theoretical level can be promoted.

4. Application of Cognitive Load Theory in Chemistry Experiment Teaching

4.1 Close Contact with Students' Previous Knowledge

Learners construct concepts from existing knowledge. They use the existing knowledge to select relevant information from various external presentation modes, then combine the selected information with the existing knowledge, and finally form their own knowledge structure. Therefore, it is particularly important to study the differences of learners' existing knowledge to improve the effect of experimental teaching. Due to students' high internal, external and related cognitive load in the process of chemical experiments, the total cognitive load is easy to exceed the standard. However, students generally have a strong enthusiasm for chemical experiments. It is difficult for us to reduce their cognitive load in the process of experiments. Therefore, the best way to make the total cognitive load not exceed the standard is to reduce internal and external cognitive load. Strengthening the pre-school pre-study is to help students reduce their internal and external cognitive load during the experiment by strengthening existing knowledge and improving the knowledge structure. For example, studies have found that pre-experimental pre-study, including theoretical review and skill cues, can significantly reduce the proportion of students who raise low-level questions during the course of the experiment, while helping to improve their performance in subsequent experiments.

4.2 Timely Experiment with Pre-Simulation

Due to the chemistry experiment, students have a variety of cognitive loads. External cognitive loads are often difficult to operate under complex laboratory conditions. Therefore, reducing the internal cognitive load in the theoretical aspects of the experiment can improve the learning effect. This is because the internal cognitive load mainly depends on the structure of the learner schema.

Many times, due to heavy teaching tasks, we rarely have time to train relevant experimental skills before the experiment, and simulation is a good way to change this situation. T. Mikael Winberg et al. have studied the auxiliary effects of pre-computer simulation experiments on chemical experiments. The results show that the experimental group before simulation is better than the control group in the quantity and quality of questions related to experiments and the improvement of experimental skills. It can be seen that the pre-simulation experiment can help group students integrate knowledge schema. This will help them have more cognitive space to think, and at the same time find the direction of learning and thinking during the experiment. To reduce their cognitive load in the experimental process, thus improving the practical and theoretical effects of chemical experiment teaching.

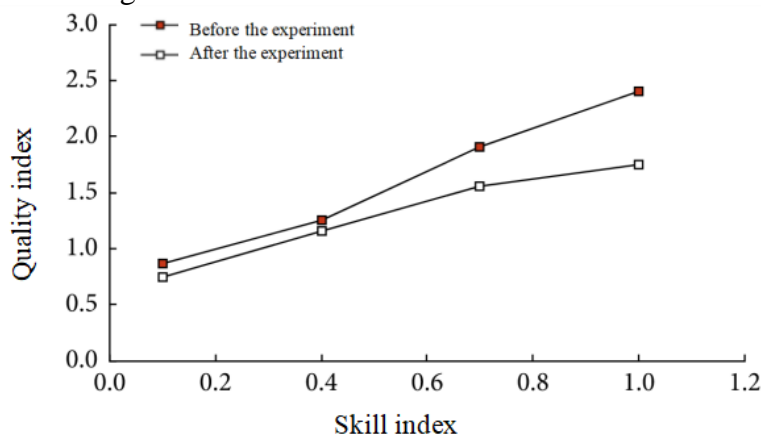


Fig.1 Comparison Table of Chemical Experiment Quality and Skills Before and after Simulation Experiment

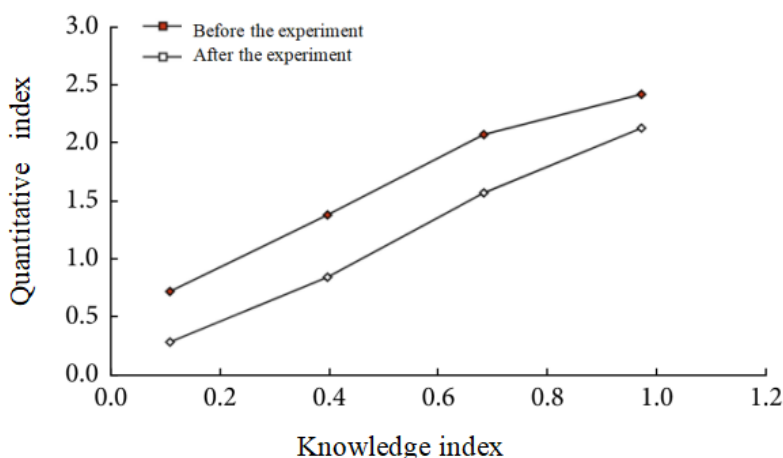


Fig.2 Comparison Table of Chemical Experiment Quantity and Knowledge Before and after Simulation Experiment

4.3 Reasonable Design of Experimental Manual

In chemical experiments, students should not only learn concepts and their applications in a short period of time, but also learn new skills and equipment and carry out experimental operations. For ordinary learners, it is almost impossible to achieve the teaching goal of understanding the theoretical significance of chemical experiment activities and mastering various skills in chemical experiment operation. In order to achieve such teaching objectives, we have designed some experimental manuals to help learners improve their learning efficiency in chemical experiments. However, the conventional textbook-based chemistry experiment manual has presented students with too much new information without integration, which makes the student's cognitive load overloaded, which reduces its guidance and help for student experiments. In order to minimize the cognitive load that the manual puts on students, we can use visual representations such as charts to integrate information. The study found that an integrated graphical lab manual that integrates text

and graphics helps students achieve high scores in academic performance tests and operational skills tests. At the same time, it can also activate students' positive attitude towards chemical experiments.

5. Conclusion

Cognitive load theory can be used to guide the design of organic chemistry experiment teaching, and can also verify the effectiveness of instructional design. Based on cognitive load theory, based on teaching needs and learner characteristics and acceptability. Fully consider the matching degree of learners, teaching content and teaching media, and divide different types of knowledge into modules. By adding a title bar to the courseware, the courseware emphasizes the relationship between the knowledge points and the position of the knowledge points in the whole classroom teaching. Its design concept can also be used for the construction of courseware in other branches of the chemical discipline. The related cognitive load of learners is conducive to promoting learning, and the related cognitive load of micro-lesson videos should be appropriately increased to improve learning effect. The information carrying capacity of micro-lesson videos should be appropriate to improve the cognitive load of relevance and optimize the learning process to achieve better learning results. We should continuously reform the experimental teaching mode and strengthen the training of basic practical skills and innovative thinking. To cultivate and stimulate the innovative ability of graduate students, and to play the dual role of training practical ability and innovative ability.

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