

Research and Practice of KM Teaching Theory Based in Data Structure Teaching

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Abstract

Upon teaching experiments and research for over two decades, the author firstly raised an innovative teaching theory - KM teaching theory based on the cognitive mechanism in China in 2010. This teaching theory covers the teaching idea, teaching model and teaching mechanism that are in line with teaching and cognitive rules; optimized teaching structure; completely new teaching method; cultivation of the student's high innovation ability; scientific teaching effect evaluation method; computer aided teaching platform, etc. According to this ideals application in data structure teaching is introduced .K map and M map of data structure are showed.

1. Introduction

Nowadays the contradiction between extremely rich knowledge accumulation and limited human learning time gets increasingly sharp, which induces several common issues of teaching innovation^[1-6]. Therefore, in respect of teaching, it is not allowed to repeat previous cognition mechanically, start from original concept or combine all knowledge details to structure the teaching content of specific discipline; while it is required to use short time and appropriate method to make “a leap” in cognition. The author, based on teaching practice for over two decades^[7], stood on the front edge of international education and teaching field and raised KM teaching theory (also known as Cognitive Structure Teaching Theory) based on innovative teaching concept for the first time in 2010^[8].

2. Connotation and Evaluation of KM Teaching Theory

KM teaching theory is a comprehensive and diversified teaching theory system which integrates teaching idea, teaching mechanism, teaching model, teaching content, teaching method, and the student's capability cultivation, teaching evaluation, modern teaching means and others. Its basic characteristics can be concisely generalized as: the teaching idea

with “knowledge logic structure as core theory”; teaching mechanism of “double chart integration”; teaching model of “teaching loop”; teaching content of “tower structure”; and teaching method of “syllogism”.

KM teaching theory is a teaching methodology, in which knowledge logic structure is integrated with learning in mind form and the macroscopic idea of core theory of knowledge logic structure is implemented; the teacher plays a leading role, the student's learning acts as main body and the students can acquire, remember and utilize knowledge quickly and firmly to improve their innovation ability so as to elevate teaching quality. Eight special subjects included in KM teaching theory are put forward for the first time. According to the novelty search for twice in June 2010 and March 2012, the conclusions are as follows: “there is barely relevant report in the publications and patents at home and abroad”. Compared with American teaching agent teaching method, Finnish substitution teaching method, British graphic symbol teaching method, Chinese thin knowledge system teaching method and other teaching methods, the present teaching method highlights the originality of eight special subjects as well as its difference and elevation based on various schools of teaching at home and abroad.

The said teaching theory passed the high-level appraisal meeting of KM teaching method hosted by China Research Center for Teaching and Learning in Universities and Colleges in 2010, and the results were as follows: “this subject has obtained high-level original achievement in the teaching reform of higher education and had a demonstrative promotion value.”; the teaching theory also passed the appraisal meeting of KM teaching theory in 2012 and the results were as follows: “This teaching theory plays a leading role in similar research achievements at home and abroad, and has demonstration effect on teaching innovation and reform of higher education in China.”; The national patent for invention of “KM teaching theory” has been accepted.

International Science Association, University of California (Santa Cruz), University of Illinois at Urbana-Champaign, Discrete Mathematics Committee of Chinese Association for Artificial

Intelligence, numerous academicians from Chinese Academy of Sciences and CHINESE ACADEMY OF ENGINEERING as well as both teachers and students from lots of universities and colleges at home speak highly of this teaching theory.

3. Theoretical Basis of KM Teaching Theory

If teaching is viewed as a complex system according to the system theory, the system structure and system level should be deeply revealed. Consequently, the teacher should have a profound understanding of teaching content and structure, hold knowledge logic structure as a core and form knowledge logic system so that the teaching is conducted in continuously deepened levels.

Information concept is a broadest, most profound and most generalized philosophical category. According to famous educational psychologist Robert M. Gagne's information processing theory, learning is taken as information processing and storage, which is a viewpoint that is the most emphasized by the cognitive psychologists in modern times. The learning can be classified into: signal learning, stimulus-response learning, chaining, verbal association, multiple discrimination, concept learning, rule learning and others. These forms of learning become the theoretical basis for KM teaching theory to structure knowledge logic structure and learning in mind form.

The teaching process can be regarded as a control process according to the control theory. Based on Weiner's theory, the language system can be taken as a communication network, classified into three grades: voice grade, semantic grade and language behavior (Demonstrated as external visible actions, discourse or written language, etc.) In order to make knowledge information delay for a long time to facilitate information processing and sorting out in compliance with logical thought rule, it is necessary to reveal and clarify internal logic structure of knowledge and form a core to organize teaching language and teaching content.

The basic problem in the visual cognitive theory is as follows: Where is human beings' visual cognition process originated? Is the partial first or the overall first? The cognitive structure teaching theory is an idea of "large scale first", namely, "the overall theory" according to human beings' visual cognition process, that is to say, start from knowledge logic structure, build an overall cognitive base, provide detailed description of learning in mind form and coincide with visual cognition theory.

4. Basic Content of KM Teaching Theory

1) A perfoliate **teaching idea**

Establish "**the teaching view with knowledge logic structure as core theory**", that is to say, the teacher starts from scientific cognition and establishes guiding thought mainly centering on teaching knowledge logic structure, theoretical framework and internal relation and inducing thinking activity according to scientific and rigorous syllabus and internal logic of theoretical development; insists on "erection first, then filling and induction" and "fewer but better" in principle; reforms teaching mechanism, teaching model, teaching content and teaching method according to the foregoing guidance.

2) 4 core issues relating to **teaching mechanism, teaching model, teaching content and teaching method**

(1) **Teaching mechanism:** Seen from macroscopic scale, the knowledge logic structure is mainly expressed as knowledge logic structure chart and characterized by clear structure, integration and others so that we can have a macroscopic cognition of knowledge and clearly know the clues acquired from overall knowledge; one point can thus drive a string to help memory and utilization. Seen from microscopic scale, learning in mind form is mainly expressed as the chart of learning in mind form (e.g. concept type, symbol type, generalized type, proof type, radiation type, forest type, weighted tree type, etc.) and it must be integrated into the concept, inference, proof, solution and other links and represent its specific, detailed, dynamic and developed logic formation and logic deduction. This comprehensive and integrated structure with multilayer hierarchical structure system, in which knowledge logic structure chart serves as a penetrating main body and the chart of learning in mind form is integrated, is just the essence and core of KM teaching theory so as to form the **teaching mechanism of double chart integration** to reflect cognitive mechanism.

(2) **Teaching model:** Structure and reflect teaching model of spiral escalation in design method of "**teaching loop**". As reflected in teaching process, the deduced and unfolded route is as follows: Rough Chart K of the paper (Generalized chart in tree shape) -----rough Chart K of the chapter ----- extension according to the section (core knowledge point; embedded into Chart M; summary in each section) -----exercises generalization of the chapter, solutions, typical key to exercises and so on ----Fine Chart K of the chapter----- Fine Chart K of the paper. The teaching loop model can be embodied in the organization of classroom teaching and in the preparation of teaching materials.

(3) **Teaching content (Main body):** Modern research shows: The multilayer hierarchical structure is the most effective means to reduce the complexity

of system. Hence, any knowledge system should be erected in “solid structure” in nature. That is to say, **extract the points** (extract the concept, theorem, rules, inference, proof and other knowledge points from each part by analysis) → **connect the points into lines** (Two kinds of “factors” should be sought in content: One is internal relation among various concepts, theorems, rules, inference and proofs; the other is a principal line which runs through the concepts, theorems, rules and theories, called “knowledge chain”) → **Form a network** (Highlight the relation of knowledge in horizontal and vertical directions to form a rough framework of “knowledge network”) → **Extension (Develop and extend along various “veins” and add main details of the related parts on the basis of previous rough framework)** → **Embedding** (Embed learning in mind form into the links above) → **Generalize the type** (It is a knowledge generalization of fine framework with high viewpoint and fixed support; the cognition is in spiral escalation) so as to structure “tower multilayer hierarchical structure”(As shown in Fig. 1) to achieve structure optimization of teaching content.

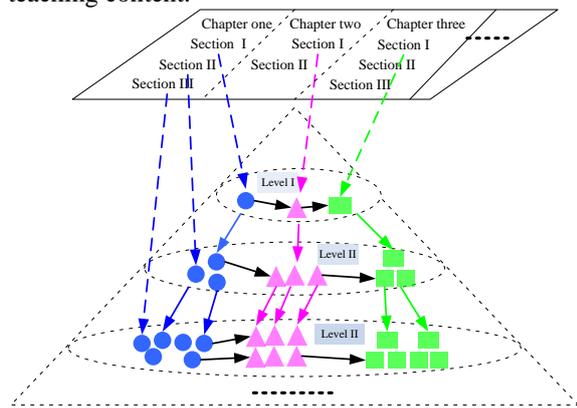


Figure 1. Tower Multilayer Hierarchical Structure Chart of Teaching Content

(4) **Teaching method:** Interactive and structured “**sylogism**” (Thin-thick-thin) teaching method.

The first section is “thin”, which means that main knowledge points of the content are “extracted” and connected into the lines and network so as to form macroscopic “rough” knowledge logic structure chart (Rough Chart K).

The second section is “thick”, which means that Rough Chart K is extended in breadth and depth along the trunk and all branches. For one thing, the breadth is extended by means of “category” to judge “the same category” or “different category”; for another, the “concepts, theorems, rules, inference and proof” of key knowledge points are “interpreted, induced and extended” so as to get extension in depth (Chart M is introduced).

The third section is “thin”, which means that it is required to inspire and guide the students to realize

or structure the overall framework of “thin” from massive carrier on the structure level (Fine Chart K). The teaching method of KM teaching theory is characterized as follows: Emphasize deepening and integration along the levels of “sylogism”, emphasize structuring and interaction and emphasize combination and comprehensive application with elicitation, exploration, history, logic and other unified teaching methods.

5. Application^[9] in data structure teaching of KM theory

1) K map of data structure

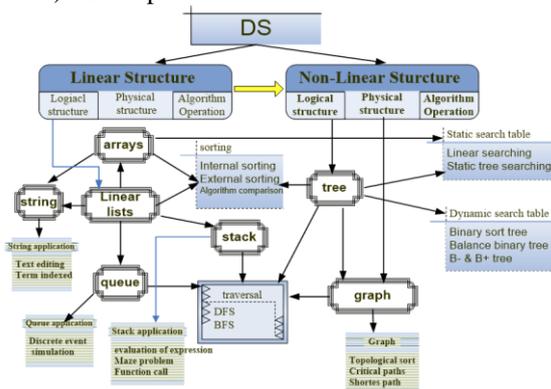


Figure 2. KM map of data structure

K map is divided into two major structure, linear and nonlinear structures, by logical structure of knowledge (K map). In each part, organization of knowledge points can be summarized as: the logical structure, physical representation and related operations and algorithms. Linear structure includes the linear form, stacks, queues, arrays, and string sections, etc., while nonlinear structure is mainly consist of trees and graphs. From the point of view of logic internal relations of knowledge, definition and implementation of nonlinear structure are dependent on the linear structure, and various search and sorting algorithms were established on the basis of linear and nonlinear structures, which leads to time complexity and space differences. When students study this course they feel these knowledge points lack of contact and fragmented, which is a big challenge for teachers. But after using K map, teachers will be able to use this figure to reflect the integrity of knowledge, and realize the knowledge “from thick to thin”.

2) Algorithm multilayer hierarchical structure of KM theory

The data element is the basic unite in data structure algorithm, Most of algorithms are focus on how to operate the data elements of one structure which include initialization or creation or destruction of logical structure and insertion or deletion of data element. Because of importation and complexity of

element inserting and deleting the student study these algorithm is not easy. According to KM theory algorithm multilayer hierarchical structure (see Figure 3) based on “Data Structure” of Tsinghua University press is built which can help students quickly know that.

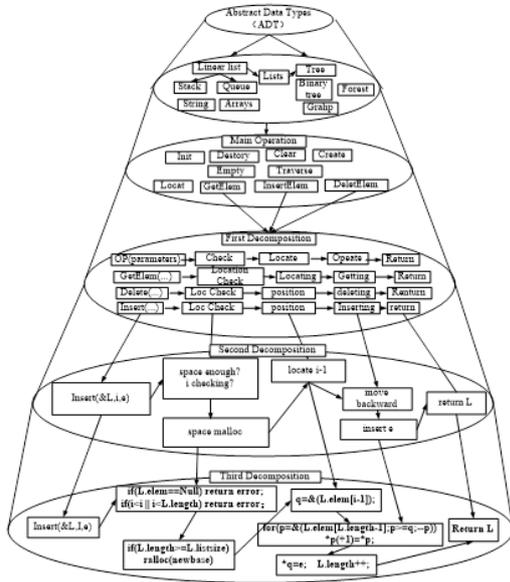


Figure 3. Graph of algorithm hierarchical structure

This algorithm multilayer hierarchical structure show the knowledge of DS is decomposed six layers. The top shows the main knowledge thread: Abstract Data Types (ADT). Next is the two types linear structure and nonlinear structure. Some operations on the two logical structure are listed in the third layer. Then the following layers decompose these operations to multilayer hierarchical structure. In this structure the higher layer is more abstraction and overall knowledge (K map) and the lower is more specific (M map).

In the traditional teaching the definition of logical structure is told firstly. Then operation and the implement of these specific operations under different physical structure are explained. In the teaching materials these logical model have more than forty kinds and relative operation have more than one-hundred fifty. The student difficulty understand these process if all algorithms cannot be generalized and fall into the lots of algorithm operation. So according to the KM teaching theory all operation about ADT induced to five steps: parameter definition and parameters checking and data element locating and operating and returning. Among the four steps include locating to the specific integer i and element inserting and deleting and searching.

3) M map of algorithm on multilayer hierarchical structure

According to the multilayer hierarchical structure the inserting operation can be described that there are two parameters which is the linear L and the inserting location i . Firstly, we need check where the position i is a legal one and whether the existing space is proper to contain new element to be inserted in. Secondly the position $i-1$ must be found before inserting one new element to the linear L . Thirdly the linear L need be adjusted because of the new element inserting. For linear list some existing elements need to be moved backward. For tree structure sub-tree need be adjusted. And for diagram new node and edge need be added. Finally we get new model M (see Figure 4).

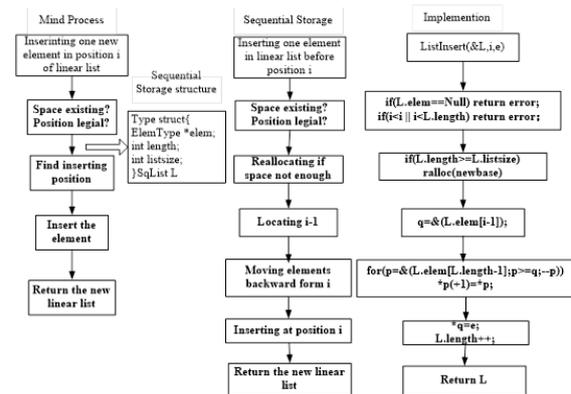


Figure 4. ListInsert (& L, i, e) decomposition based on Sequential Storage

7. Conclusion

The research here breaks the fixed model and geographical limitations, gives the consideration and study of teaching reform in respect of international perspective and international comparison, reflects teaching rules and scientific thought of cognitive mechanism and highlights the difference and elevation in comparison with various schools of teaching at home and abroad in respect of teaching idea, mechanism, model, content, method, auxiliary platform, capability cultivation, evaluation and other aspects.

One application in “Data Structure” teaching is introduced. Because of the specialty and abstraction make the “Data Structure” difficultly in academic teaching. Relative complex logic knowledge makes this course very boring a monotonous to students. In this paper from the perspective of knowledge cognition the KM teaching theory achieved a very good effect through adopting “different category” and hierarchical method to reduce the complexity of logical process, changing flattening teaching into multidimensional and systematic teaching. Remarkably the KM theory requires teachers be quite familiar with all course content.

8. References

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