

# The Cultivation of Outstanding Chemistry Teachers: Teaching Strategy Design and the Characterization of Such Design

Cheng-yin Yang, Lin Su

School of Chemistry & Chemical Engineering, Shaanxi Normal University, Xi'an, China

## Email address:

yangcy@snnu.edu.cn (Cheng-yin Yang)

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**Abstract:** The importance of teaching strategy is self-evident among the teaching goals and the teaching activity process in the whole course teaching design elements. On the basis of the "Concept Map and Mind Map", once the teaching strategy design is visualized by the computer software or the hand drawing system, the teaching goal design intention can be converted into a more detailed teaching activities process design in order to achieve the effective integration of teaching goals, teaching process, measurement and evaluation.

**Keywords:** Teaching Process Design, Teaching Strategy, Visualization, Pedagogical

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## 1. Introduction

The research of instructional design of China began in early 1980s, after more than 20 years development, it has made remarkable success both theory and practice. With the development and popularization of information technology, education informatization will become the leading trend of education in twenty-first century, while the integration of information technology and pedagogical through the information-based instructional design. There are some quotations from the *Outline of the National Basic Education Curriculum Reform (Trial)* with The Ministry of Education enacted, such as we should vigorously promote the universal application of information technology in the teaching process, promote the integration of information technology and pedagogical, and gradually realize the changes in the presentation of teaching contents, learning ways, teaching ways and teacher-student interaction ways. We should give full play to the advantages of information technology, to provide rich and colorful education environment and strong learning tool for student's learning and development [1]. Chemistry instructional design must reflect the subject characteristics, such as on the bases of experiment, in the means of scientific inquiry activities, for the purpose of student's development, chemistry language as the tool,

scientific methodology as the guide, scientific epistemology as the principle, closely related to life and social reality. Chemistry teacher must reflect these factors in the instructional design [2], and they usually need to study the curriculum criterions, parse the contents of teaching materials, analyze the learning situation, and then combined with the specific teaching environment to write clear and appropriate teaching goals, meanwhile, the teaching tasks will be completed and the teaching goals will be achieved by carefully designed teaching process. Teaching goals is the beginning and ending of course teaching and its statement from the three dimensions knowledge and skill, process and method, emotional, manner and values. While teaching process is the path and method to realize the course teaching. The instructional design is the planning and thinking for solve the teaching problems, complete the teaching tasks, achieve the teaching goals and determine the composition of teachers and students and their relationship with the organization. And it was accomplished before course teaching [3]. In course teaching design, teaching strategy is always between teaching goals and teaching process, which form a bridge for the coupling of both. Chemistry teaching strategy is often made based on the certain theoretical hypothesis, it is the guiding ideology, action rules and implement basis of chemistry teaching activities, and it is the essence, soul and essential

characteristic of the chemistry teaching methods [4]. However, the biggest problem in the chemistry teachers' instructional design is that teaching goals are not related to teaching process, showing "two pieces of leather" phenomenon.

Surveying finds that the chemistry teachers seldom write teaching strategy in their conventional instructional design, and there is a large deviation between instructional design and actual course teaching activities. This phenomenon has two reasons, one is that the knowledge of concept level is difficult to be explicit with the correct words, another reason is that teachers don't know how to express the knowledge of concept level. In order to improve this phenomenon, this paper illustrates a graphic teaching strategy combined with the knowledge visualization technology, hoping that it can express concise teaching goals and complex teaching process and ideas of implication in the teaching process, through the more intuitive and clearer way in the instructional design.

## 2. Graphic Strategy

### 2.1. Handling the Explicit Knowledge and Tacit Knowledge in Instructional Design

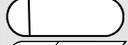
Here are explicit and tacit knowledge points. Explicit knowledge that can be textual, and tacit knowledge is the experience or hidden in the individual mind which has not been demonstrated [5]. Hui-ping Zhang, and Ning Zhou analyzed the relation between knowledge visualization and information visualization, and pointed out that Concept Map, Semantic Sap, Causal Map and Visual Metaphor can effectively represent tacit knowledge [6]. Text of instructional design can be attributed to teachers' explicit knowledge, and the teaching ideas of teachers, such as inherent logic contact and presentation are mostly related to tacit knowledge. Through the bilateral activities between teacher and students will deliver the explicit knowledge in course teaching, while individualized teaching ideas will produce different teaching effects, under the same teaching model, because the activities' teacher, students and the environment are in thousands ways. For this purpose, we recommend using knowledge visualization tools to express the teaching strategy that can change the past teaching process which confined to the text description and does not reflect the ideas of instructional design. We use graphic strategy strive to represent the tacit knowledge contained in the instructional design and achieve the optimization of teaching, which compensate for the textual representation of the vacancy in visual perception.

### 2.2. Knowledge Visualization Tools

Knowledge visualization refers to the representation of knowledge by drawing sketches, knowledge graphs and visual metaphors, then promotes the innovation and dissemination of knowledge [7]. The Concept Map tools of teaching flowchart are widely used to represent tacit knowledge. Mind Map also is a very effective visual cognitive tool. The Concept Map which was proposed by psychologist J.D. Novak of American Cornell University in the 1960s based on Ausubel's

meaningful learning theory, it consisted of four basic elements including concept, proposition, cross connections and hierarchies. Nodes represent concepts, conjunction words and conjunction lines show the relationship of concepts to form proposition, according to the order of core concepts being up(inside) and the general concepts being down(outside)to unfold or cross-connect, it forms a hierarchical structure. It can graphic highlight the concept, the relationship and hierarchy between them, so it is an excellent tool for organization and characterization of knowledge, as shown in Table 1 [8].

Table 1. The meaning of symbol.

Symbol	Meaning
	Teaching contents or teacher activities
	Student Activities
	Media Applications
	To operate and learn with media by students
	Logical judgment by teachers

Mind map was put forward by a British psychologist Tony Buzan in 1970s after he was inspired by Da Vinci notes. It is a divergent thinking visual tool based on "whole brain thinking", which is an invention for noting. It can be synthetically used to transfer information by varieties ways such as symbols, colors, images and text. The most significant purpose is to stimulate and organize thinking by the means of "divergent non-linear notes from the center to the surrounding" like a tree, which is hailed as the Swiss Army Knife tool for quick learning and thinking [8]. It emphasizes using keywords instead of phrases and sentences in the process of painting, so it not only retain the advantages of graphical representation but also possible reduce the burden of left brain that processing phrases and sentences, which better play the ability of right brain that processing graphical information. With the manifestations of Concept Map and Mind Map we can achieve teaching strategy visualization, as shown in Figure 1.

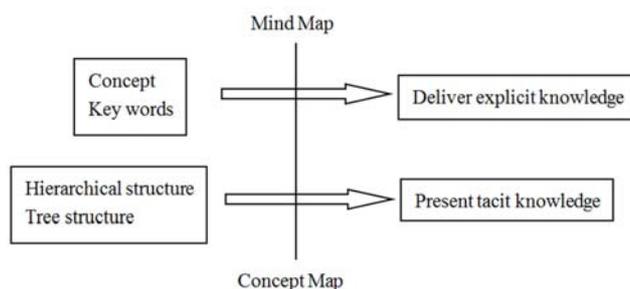


Figure 1. The way of teaching strategy visualization.

## 3. Painting Teaching Strategy Chart

In whole course instructional design, teaching process is generally presented in tables, it includes teaching links, teacher activities, student activities and design ideas. Through the teaching intermediary, such as subject knowledge, teacher

guides the students to complete the teaching contents and achieve the teaching goals. Teaching strategy is the bridge of teaching goals and teaching activities, which can embody the summary teaching goals and simplify the complex teaching process. We recognized the teaching process is the bilateral activities of teacher and students and teaching content is their interactional objects, then teaching strategy is their guiding ideology, action rules and implement basis. Therefore, making appropriate teaching strategy is the vital work of instructional design. With the development of information technology, we can use the diagram to express the elements of teaching process (teachers, students, teaching contents) and design a visual teaching flowchart to display teaching strategy. It can laying foundation for the teaching goals, teaching process, a harmonious point between the measurement and evaluation, making the design ideas of teaching goals convert to more detailed process of teaching activities.

### 3.1. Painting Tools

Inspiration software is generally used to draw Concept map, the operation is simple and it is easy to learn, the higher version can also draw Mind Map. Using MindManager or iMindMap software to draw the Mind Map, there are various types of templates for different professional designers choose, they have beautiful lines and suitable for beginners. Instructional design is based on learning theory, teaching theory and communication theory, using systematic ways to analyze the teaching goals and tasks, to analyze the students' practice, to analyze teaching environment and resources, to determine teaching goals, to choice teaching methods, to design teaching ideas and processes (including arrange the teaching process, a combination of teaching methods, determine the form of teaching organizational, select the teaching media, etc.), as well as a process to solve the generalized and pilot teaching program, to evaluate results and modify program [4]. Therefore, we recommend teachers use computer software to draw the teaching process for open class, observe classes, instructional design contest and other situations that the instructional design presented to students or expert judges by electronic version, as beautiful, structured teaching process to show design ideas. In the daily teaching

for their own class can drawing teaching strategy flowchart by learning the characteristics of Concept Map and Mind Map. Drawing teaching strategy flow chart not only more fit the art of instructional design, but also has the function of conveying the designer's emotion. Therefore, the clearest, easiest and best reflect the individual's thinking pattern can be directly drawn by the hand of the designer on paper [9].

### 3.2. Hand-painted Flowchart Program

For example, PEP Senior middle school compulsory Chemistry 2 Chapter III section II "Na<sub>2</sub>O and Na<sub>2</sub>O<sub>2</sub>" instructional design

#### 3.2.1. Define the Hierarchical Requirements of Teaching Goals at Different Levels

Standardized teaching goals include four elements: Audience, Behavior, Condition and Degree. For the sake of memory, we use the ABCD pattern (shown in Table 2) which is an acronym to stand for the four elements. The design of teaching goals can be shown by the combination form of CABD, or the simplified ways like CBD or BD.

Table 2. Teaching goals elements.

Teaching goals elements	Means
Audience	Clarify teaching objects (students)
Behavior	Students can do sth (behavioral changes)
Condition	The condition of behavior changes
Degree	To expect the degree of behavior

As can be seen from the narrative form, the Behavior can't be arbitrarily chosen. Instead we should follow the principles that they can measurable, evaluation, specific and clear. Teachers must be familiar with and master the meaning of Behavior specified in the curriculum criterions at different learning levels. When design the teaching goals, teacher should according to the content of the teaching materials to find out the corresponding "content standard" items and related knowledge points firstly. Then take the foundation of students into account, and find the appropriate Behavior. Finally, design the corresponding activities, also can add scientific methods carried by the chemical knowledge, as shown in Table 3.

Table 3. Analyzing teaching goals of "Na<sub>2</sub>O and Na<sub>2</sub>O<sub>2</sub>".

Teaching content	Knowledge points	Learning level	Degree	Activities	Scientific methods
Na <sub>2</sub> O	Physical properties	Know	Describe	Observe chemicals	Observe
	Equation of reaction with H <sub>2</sub> O	Understand	Express	Be similar to Cao	Analogy
Na <sub>2</sub> O <sub>2</sub>	Physical properties	Know	Describe	Observe chemicals	Observe
	Reaction with H <sub>2</sub> O	Phenomenon	Comprehend	Experiment 3-5	Experiment, Observe
		Chemical equation	Understand	Inquiry experiment	
	Reaction with CO <sub>2</sub>	Experimental operation	Master	Express	Group cooperation
			Grasp		
	Reaction with CO <sub>2</sub>	Understand	Understand	Be similar to H <sub>2</sub> O	Analogy, Analyze
	Apply	Feeling	Feeling	Group interaction	Abstract

#### 3.2.2. The Method of Hand-painted Flowchart

This paper introduces two visualization flowchart

tools--Concept Map and Mind Map. They put forward the background of the times have their own characteristics, so

they also has their own strengths in knowledge visualization. The informational instructional design provides painting flowchart methods by using Concept Map (Table1). This method can accommodate various elements of course teaching and its development becomes more and more mature. Through the perspective of comparative, we analyzed the performance of visualization tools used in the design of graphic teaching strategy, considered the similarities and differences, and put forward the following hand-painted methods. During the instructional design, teacher can select the most suitable method to drawing teaching strategy flowchart with the specific teaching resources.

Materials of hand-painted Concept Map and Mind Map in teaching are easy to get, such as the lesson plan, red, black and blue pen, pencil, or a variety of color markers and so on. The core node(teaching contents) must be first confirmed before drawing hand-painted Concept Map or Mind Map, the knowledge point express in the concept or keywords of hierarchy nodes so that the connection between node and node can able to indicate the timely relationship or logical relationship that followed by activities. Figure 1 shows the way of knowledge visualization, teaching contents is organized and represented frequently by Concept Map, while

the forms of Mind Map is similar to the nerve cells in the brain structure under an electron microscope. When drawing teaching flowchart with Concept Map, knowledge points can be represented by conjunction, activity subjects (teachers, students, media) will be distinguished by the shape of block diagram as well as the knowledge category will be distinguished by different colors. Activity contents and the scientific methods carried by knowledge can be presented with a concept node. When drawing teaching flowchart with concept map, the color of branch lines which spread from the core node will make knowledge point very clear at a glance, moreover, teaching emphasis points will be distinguished by the degree of the thickness of line. Activity contents or the scientific methods carried by knowledge can be located in the under of branch line which corresponding with knowledge point, also activity subjects can be expressed with a simple image as attachments. Accordingly, the completed hierarchical structures or tree structures will naturally express the internal logical relation between the knowledge, and show a teacher's design ideas. The method of how to hand-painted teaching strategy according to the expression form of Concept Map and Mind Map as shown in Figure 2.

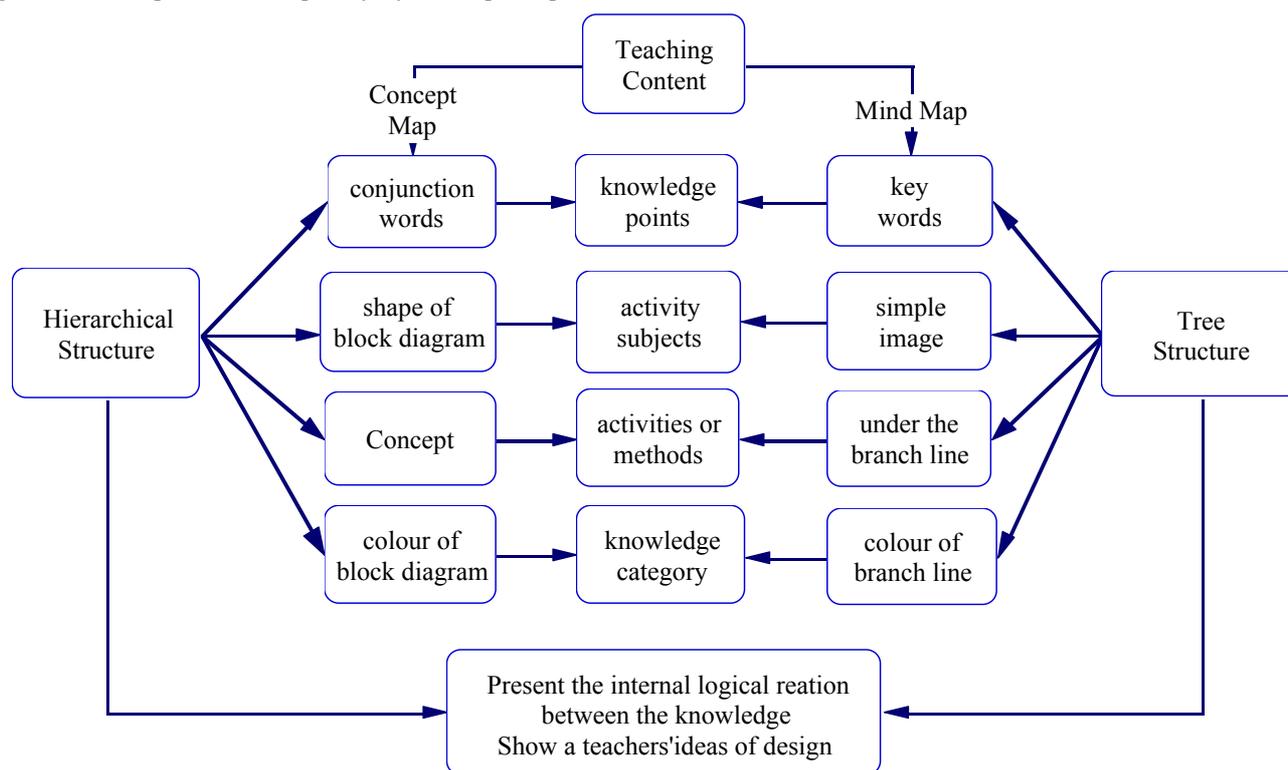


Figure 2. The method of hand-painted teaching strategy by Concept Map.

Taking “ $\text{Na}_2\text{O}$  and  $\text{Na}_2\text{O}_2$ ” instructional design as an example. Figure 3 shows teaching strategy by Mind Map. With linear and font type based on the different colors of branch lines. The words above the branch lines stand for the specific knowledge points on teaching contents. Under the branch lines contain both activity contents and scientific methods behind of knowledge, it can remind teachers should

not only pay attention to science knowledge education should also focus on the education of scientific method in chemistry teaching. In addition, teachers can improve the format of their teaching strategy (such as simple image can distinguish activity subjects) or add annotation (such as experimental phenomenon, chemical formula etc.) according to their own preferences on the hand-painted teaching strategy flowchart.

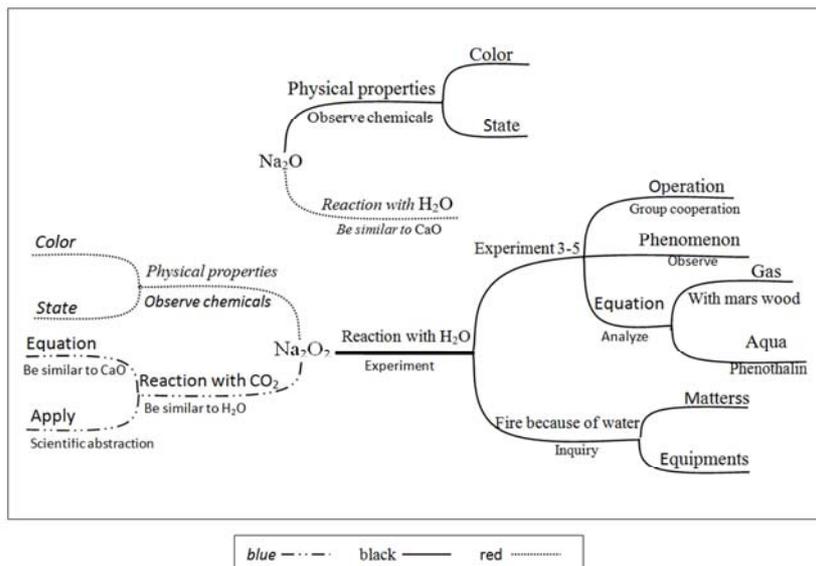


Figure 3. The hand-painted strategy is based on Concept Map's format.

Taking “Na<sub>2</sub>O and Na<sub>2</sub>O<sub>2</sub>” instructional design as an example. Figure 4 shows teaching strategy by Concept Map. Knowledge points can be presented by conjunction words, activity subjects will be distinguished by the shape of block diagram, activity contents will be highlighted by the node

concepts as well as it show the goals that student should achieve after activities. From the figure 3 and figure 4, we find the concept map and mind map each have their own advantages, Concept Map like a divergent tree structure while Mind Map is a hierarchical structure of the program.

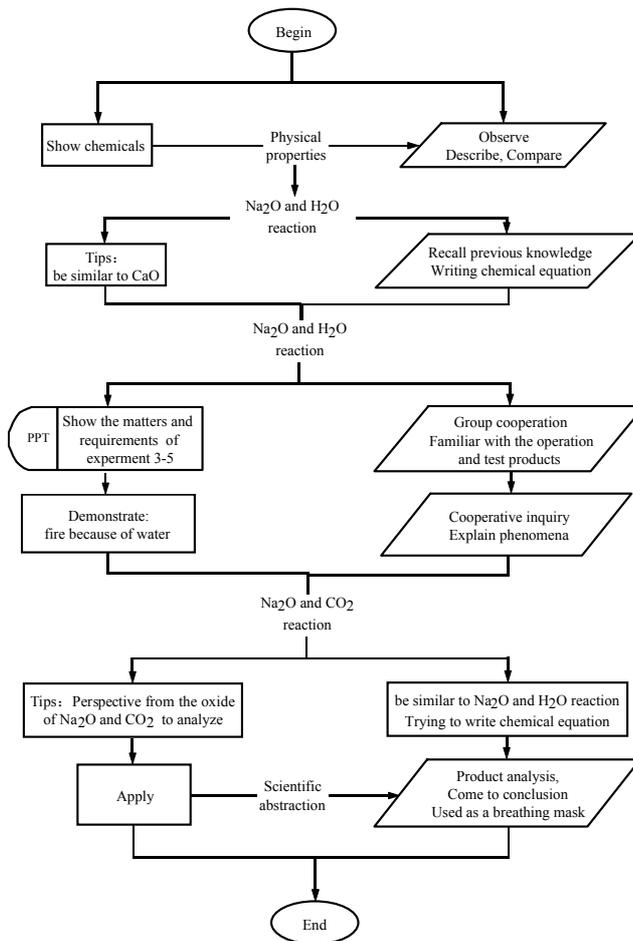


Figure 4. The hand-painted strategy is based on Mind Map's format.

## 4. The Value of Graphic Teaching Strategy Design in Chemistry Teaching

### 4.1. Graphic Teaching Strategy can Optimize the Instructional Design

In the Basic Principles of Curriculum and Instruction, Taylor pointed out the formulation of any curriculum and instruction programs must be answered: what educational purposes should the seek to attain, what educational experiences should be provided and how to organize, how to determine whether these educational purposes are being attained [10]. In terms of specific instructional design, which is to solve the following problems: “where students should go”, “how to go”, “whether it is arrive or not”, these three problems with the corresponding elements of teaching goals, teaching process, and teaching evaluation. When teacher conducts their instructional design, they completed the design of goals, process and evaluation in longitudinal ways one by one. But they lacks of a transverse comparison test, in other words, we can't exactly know whether the process can toward the goals or not and whether the evaluation can meet the goal or not, so it causing the "seemingly harmonious" phenomenon between these elements. The teaching strategy design of flowchart is a behavior way to solve problem, that the designer based on certain teaching ideas and teaching experience to make an arrangement of the teaching actives, in order to achieve teaching goals effectively.

Before painting the teaching strategy flowchart, we formed a transverse one to one relationship between the related knowledge points, Behavior and activity contents. And we made a clear hierarchical requirement for different levels of teaching goals. Behavior is the standards for examining "whether it is arrive or not", activity contents create the conditions of "how to go". When painting flowchart we should make three elements (goals, process, evaluation) interrelate between each other, and learn from the forms of Concept Map and Mind Map for reference depend on the logical relationship of knowledge points. Thus, we can realize the probability of these three transverse comparison examine and optimize the instructional design.

### 4.2. Graphic Teaching Strategy Can Optimize the Knowledge Structure

Chemistry knowledge includes factual knowledge and theoretical knowledge. The former are the knowledge of elements, chemistry between society, production and actual life, which reflect the properties, existence, use and various aspects of materials, the latter are chemical basic concepts and basic principles, which reflect the nature of matter and its changing and intrinsic laws [3].

Learning any knowledge is a gradual development, from easy to digest, and the design of teaching process is a gradual, step by step. When teaching process which following an order, teacher and students are difficult to grasp the overall situation of the teaching contents. We use a flowchart form design

teaching strategy, the teaching contents will be similar to a full sheet of paper, knowledge points distribution on any location of paper with the different design ideas of the teachers, while, teaching important and difficult points will be demonstrated by the thickness of flowchart lines. In this way, both the used by teacher and enjoyed by students are not only can fully see the trees, but also can grasp the "forest" as a whole. For the scattered factual knowledge, we can use the Mind Map design teaching strategy according to the characteristics of divergent thinking. Which can stimulate and reorganize the students thinking and make the knowledge will be structured and rule-based. For the basic theoretical knowledge, we can use the Concept Map show the difference and connection between the old and new concepts scientifically and vividly by using of graphic teaching strategy. Then we can find that our instructional design conducive to concept change and concept formation.

## 5. Conclusions

We studied 462 class instructional design cases for statistical analysis based on *Chinese Journal of Chemical Education, Education In Chemistry, Teaching and Learning Reference for Middle School Chemistry* which have the influence on chemical education journals from 2004 to 2015, and found the teaching strategy is an essential element for the outstanding instructional design. An excellent chemistry teaching strategy are scientific and good artistic, while the graphic strategy not only reflect the logical thinking process of teacher, also describe the creative thinking of teacher. Concept Map and Mind Map both have their own advantages; we can use respectively or combined both to realize teaching strategy visualization. The systematic design of scattered knowledge can be expressed in the form of Mind Map, while knowledge of the concept and its mutual form can use the Concept Map as auxiliary.

There is an old adage “a picture is worth thousand words”, teacher use more graphic methods can not only improve the efficiency of the instructional design, also stimulate the creative thinking of teacher, then form their own teaching style in the course of regular painting.

However, the subject to seek design's visualization is a teacher, the teaching ideas of instructional design will be manifested to teaching, and it is the demand of convenient by instructional design, so you can't put the cart before the horse devotion to the visualization design results.

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curriculum system aiming at cultivating outstanding teachers of science. No. JSJY2015J009.

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