



Research on the Hierarchical Interactive Teaching of Middle School Chemistry Based on the Theory of "Mind Map"

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ABSTRACT

The hierarchical interactive teaching model under the guidance of mind map theory advocates problem stratification, intelligence stratification, interactive teaching, cooperative learning, which comprehensively cultivates students' divergent thinking and inquiry ability on the basis of respecting students' differentiated development, so as to implement the core literacy of chemistry. It is a good teaching mode of teaching students in accordance with their aptitude. Based on the actual situation of middle school chemistry teaching in China, this paper analyzes the problems existing in the current teaching, discusses the relationship between this model and China's education policy, as well as the specific methods and strategies of application in middle school teaching design. Taking "The Properties of Chlorine" as an example, the specific teaching design is carried out to explore the specific path of integrating hierarchical interactive teaching mode into chemistry teaching in China, in order to promote the application of this mode in high school chemistry teaching.

Keywords: Hierarchical interactive teaching mode; Mind mapping; Properties of Chlorine

The core literacy of disciplines is the concentrated reflection of the value of discipline education, and the construction of discipline education system oriented to the core literacy of disciplines is the demand for discipline education stemming from the education goal of the new era.^[1] China's "Chemistry Curriculum Standard for Senior High Schools (2017 Edition, 2020 Revision)" published in 2018 includes the following the five core literacy of chemistry: Macroscopic identification and microscopic analysis, changing concepts and balanced thinking, evidence reasoning and model cognition, scientific inquiry and innovative awareness, scientific

attitudes and social responsibilities. Furthermore, teachers are required to focus on students' future in teaching and cultivate students' key abilities.^[2] Under the guidance of mind map theory and taking into account the differences in individual development, the hierarchical interactive teaching mode sets up in-depth questions to inspire students' thinking.^[3] This will help to strengthen students' understanding of chemical knowledge, cultivate students' awareness of scientific inquiry and creative thinking,^[4] so as to promote the development of students' core literacy.^[5]

By now, Chinese young people are under great pressure to go to school. In order to allow students to master more knowledge and skills in a short period of time and successfully pass the single-plank bridge of the "gaokao", many classrooms still adopt the "injection" education for the purpose of rapid memory.^[6] The goal of cultivating students' core literacy has not been well implemented. In addition, the differentiated teaching that promotes the development of all students has not been paid enough attention. Since there are certain differences in knowledge, skills, learning ability, and divergent innovative thinking of each individual, Teaching activities are required in stages according to students' aptitude and the actual level, as well as optimize learning on the basis of existing knowledge, to improve teaching quality.^[7] The relevant concepts put forward by the hierarchical interactive teaching mode are helpful to improve the above problems and cultivate students' innovative spirit of independent thinking, daring to question and criticize as well.^[8]

Furthermore, high school chemistry knowledge is scattered and abstract, which puts forward higher requirements for students,^[9] and the construction of chemical knowledge network has become the key to high school chemistry learning. As an interactive tool for visualization of knowledge structure, mind mapping is integrated into the hierarchical interactive teaching mode. It can not only effectively present the hierarchical relationship between concepts and form an integrated in-depth learning, but also promote students to integrate knowledge in cooperative exploration, and complete the construction of knowledge network, so as to realize the full interaction of teachers as well as students at the thinking level, and cultivate students' ability to learn cooperatively.^[10]

MIND MAP AND HIERARCHY INTERACTION

Mind map is a visual teaching tool invented by the British "father of memory" Tony Buzan in the 1960s ^[11]. It imitates the working mode of the human brain: determining a theme keyword as the center, and using divergent thinking to think from the center word to the periphery, forming a network system.^[12] Mind maps make full use of the characteristics of the left and right brains of human beings, and skillfully establish links between topic keywords and images, colors, etc, so as to make students thinking clearer,^[13] encourage them to carry out deeper learning, and connect knowledge more widely.^[14]

Hierarchical interactive teaching mode is the effective combination of hierarchical teaching and interactive teaching. On the one hand, stratification refers to problem stratification, by setting hierarchical and gradient teaching questions, the learning enthusiasm of outstanding students, middle-class students and underachievers can be fully mobilized and the rate of classroom participation can be improved; on the other hand, it refers to group stratification, on the basis of 'homogeneous class division', which is based on the differences of students' ability, personality and other aspects, in accordance with the way of homogeneous between groups,

heterogeneous within groups' reasonable grouping.^[15] Hierarchical interaction refers to discussing a reasonable teaching design around teaching objectives: (1) through "teacher-teacher interaction" and "student-student interaction", with the advantages and disadvantages, to solve the classroom problems; (2) through "teacher-student interaction" and "teacher-student interaction" to systematize the knowledge learned, so as to build a mental mode for solving the problem. Taking the three-level interaction as a link, it ultimately cultivates students' scientific innovation awareness and the subject ability of discovering as well as solving the problems.^[16]

The hierarchical interactive teaching mode based on the mind map theory takes the hierarchical interactive teaching as the guiding ideology, and runs the mind map throughout the teaching. Students exchange and inspire in group interaction, unite and cooperate, and transform passive learning into active learning. The introduction of mind maps enables students to associate a certain knowledge point with related knowledge points, forming a complete chemical knowledge chain.^[17] It is easier for teachers and students to carry out interactive learning through mind maps to strengthen students' subject status, stimulate students to think in multiple dimensions, and effectively open up the thinking and dialogue between teachers and students.

HIERARCHICAL INTERACTIVE TEACHING DESIGN BASED ON MIND MAP

The "Chemistry Curriculum Standards for Chinese Senior High Schools (2017 Edition)" divides the level of core literacy in chemistry into four levels from shallow to deep, namely, know, comprehension, mastery, and application. This provides a "quality" basis for the development of hierarchical teaching.^[18] Chemistry is the basic natural science that studies the composition, structure, properties, transformation and application of substances at the atomic and molecular levels. Its characteristic is to study substances and create substances at the micro level through macroscopic phenomena.^[19] Hierarchical interactive teaching based on mind maps explores via group cooperation, sets gradient questions, and uses mind maps as an interactive tool throughout the teaching activity, so that students at all levels participate in the classroom, and gradually promote students' understanding from the surface to the inside. It promotes students' comprehension, helps to deeply understand the relationship between the nature of the material and the external performance,^[20] and builds a bridge between students, teachers and the teaching content.

Textbook analysis

The content of 'chlorine and its compounds' is located in the Chinese People's Education Press (2019 edition) high school chemistry compulsory 1, chapter 2, section 2, is the first non-metallic element in high school learning. The content of this section can be divided into three lessons: one is to master the physical and chemical properties of chlorine gas; the second is to explore the reaction between chlorine and alkali and the properties of hypochlorite; the third is to prepare chlorine gas and chloride ion inspection. It undertakes the study of "Substance Category", "Ion Reaction" and "Redox Reaction" in Chapter 1. The existence of these three sections facilitates students' understanding of the nature of inorganic matter. The third chapter is about to enter the study of iron and its compounds. Therefore, it is necessary for students to consolidate the understanding angle and clarify the understanding idea through the study of this chapter, and gradually improve the systematic study of material properties from the

perspective of 'material category', 'ion reaction' and 'redox reaction'. Taking the nature of chlorine gas as an example, this paper discusses and develops specific teaching design.

Teaching purpose

(1) Understand the physical properties of chlorine gas, and master the chemical reaction of chlorine gas with metallic and non-metallic substances. From the perspectives of "substance category", "atomic structure", "element valence", etc, establish a cognitive model for predicting matter and its changes.

(2) Master the reaction between chlorine gas and water, explore the composition of chlorine water, and complete relevant experiments to verify the bleaching property of chlorine gas. Through experimental inquiry, establish a thinking model of putting forward hypothesis-experimental verification-drawing conclusions, and cultivate students' rigorous scientific spirit and innovative consciousness.

(3) Through the study of the properties of chlorine gas, deeply understand the relationship between chemistry and life, society, environment, and establish a materialist dialectical philosophy.

Teaching difficulties

Teaching emphasis: The chemical properties of chlorine and the reaction between chlorine and water.

Teaching difficulties: Composition of chlorine water, disinfection and bleaching principle of chlorine water.

Teaching methods

(1) Teaching methods: Teaching methods, multimedia presentation methods.

(2) Study methods: Experimental inquiry method, cooperative discussion method.

HIERARCHICAL INTERACTIVE CASE DESIGN FOR 'CHLORINE NATURE' BASED ON MIND MAP

Teaching Session 1 - Physical Properties of Chlorine

[Teacher's explanation] Self-report of chlorine: Hello everyone, I am chlorine, and my favorite color is yellow-green, so I often wander around in yellow-green clothes. When I am angry, it is easy to emit a pungent smell. Water is my good friend, and we play a very important role in the protection of COVID-19! Sometimes I see humans and want to say hello to them, but they are far away from me. Sometimes I was sent to the hospital! I like to close to the ground. Anyway, I like water and earth! I can disinfect, bleach, and promote the prosperity of the plastic industry. All right! That's it for today. If you want to know more about me, we will see each other in class later!

[Introduction] According to 'chlorine self-statement', think about how to evacuate people in case of chlorine leakage?

[Task arrangement] The physical properties of chlorine were summarized in the form of group cooperation, and the mind map was drawn according to the physical properties of chlorine.

[Design intent] The personification of chlorine will make knowledge more vivid, stimulate students' interest in learning, and help students understand the new knowledge in this section. Taking into account the differences between students, the problem setting based on the following guideline: backward students can summarize the physical properties of chlorine, so as to improve the learning confidence; secondary students and excellent students can help to improve and supplement them, to consolidate the knowledge base.

Teaching Session 2 - Reaction of Chlorine with Metals and Nonmetals

[Teacher's explanation] Just now we use the physical properties of chlorine to solve the problem of chlorine leakage and evacuation of the population. What are the chemical properties of chlorine? What perspective should we study the chemical properties of chlorine gas?

[Task arrangement] Ask students to think about the following problems by consulting data:

(1) How is chlorine found?

(2) Draw a schematic diagram of the atomic structure of chlorine. 1). Predicting the nature of chlorine from the perspective of gain and loss electrons; 2). Predicting the properties of chlorine from the perspective of material classification; 3). Predicting the properties of chlorine from the perspective of elemental combined valence.

(3) Chlorine has been discovered and identified as a new element for thirty years and has been explored by several scientists. What do you get from this historical fact?

[Panel discussion] (1) Students learn about the development of chlorine by reading historical stories:

(2) 1). By drawing the structure diagram of chlorine atom, it is known that there are seven electrons in the outermost layer of chlorine atom, and it is easy to obtain a stable structure of eight electrons.

2). It is inferred that chlorine belongs to non-metallic elements: It can react with metallic and non-metallic elements.

3). From the point of view of 'chemical valence': Chlorine is zero, and chlorine in nature is usually negative. Therefore, the chemical properties of chlorine are predicted from three perspectives: strong oxidation.

[Design intent] Through stratified questioning, students can think deeply, let students use comparative method to strengthen students' cognitive model of predicting material chemical properties from the perspective of 'atomic structure', 'material category' and 'chemical valence', and lay the foundation for the future study of element knowledge. Through the hierarchical group cooperation and taking into account the differences of students, students are allowed to participate in the classroom to the greatest extent, so as to enhance their learning motivation and form a close relationship of love and mutual trust with each other.

[Teacher's explanation] Through the discussion with students, we know that chlorine belongs to non-metallic elements, and the nature of oxygen in our junior middle school is similar. We have just predicted that chlorine can react with metal and non-metallic elements, and let us verify it together.

[Experimental research] The reaction of chlorine and copper combustion and the reaction of chlorine and hydrogen combustion were displayed by multimedia.

[Question introduction] What is your new understanding of the conditions and nature of combustion through the combustion of H_2 in Cl_2 ?

[Group discussion] The combustion reaction does not necessarily involve oxygen. The essence of combustion is redox reaction, and all the redox reactions with intense luminescence or heat can be called combustion.

[Task arrangement] Students are asked to improve the mind map according to the chemical properties of chlorine involved.

[Design Intention] Based on the combustion knowledge learned in junior high school chemistry, this paper puts forward the thinking problem, which is beneficial to stimulate the development of students' thinking. The use of mind map to sort out knowledge helps students to make the framework clearer.

Teaching Session 3 - Reaction of Chlorine and Water

[Introduction] Bertoli found that the chlorine water formed by chlorine dissolved in water has bleach ability, which will lose the ability to bleach under sunlight and generate hydrochloric acid and hydrogen. Please think about the following questions:

(1) Why is chlorine water bleachable?

(2) Why does chlorine water lose bleaching under sunlight?

[Group discussion] There are three possible reactions of chlorine and water, namely: 1). Complete dissolution (Cl_2 and H_2O); 2). Partial reactions (Cl_2 , $HClO$, H_2O); 3). All reactions ($HClO$, H_2O).

[Experimental study] The chemical reactions of chlorine and water were explored. (From the perspective of hypothesis-experimental verification-conclusion)

(1) Observe the color of chlorine water to determine whether it contains chlorine molecules.

(2) Watch the experimental video: Put the dry and wet paper into the dry chlorine gas respectively to observe whether the colored paper fades and determine what the bleaching substance is.

[Group discussion] The chlorine molecules in chlorine water were determined by observing the color of chlorine water. By observing the experimental video, the dry paper does not fade, and the wet paper fades. It is concluded that hypochlorite is the bleach substance in chlorine water.

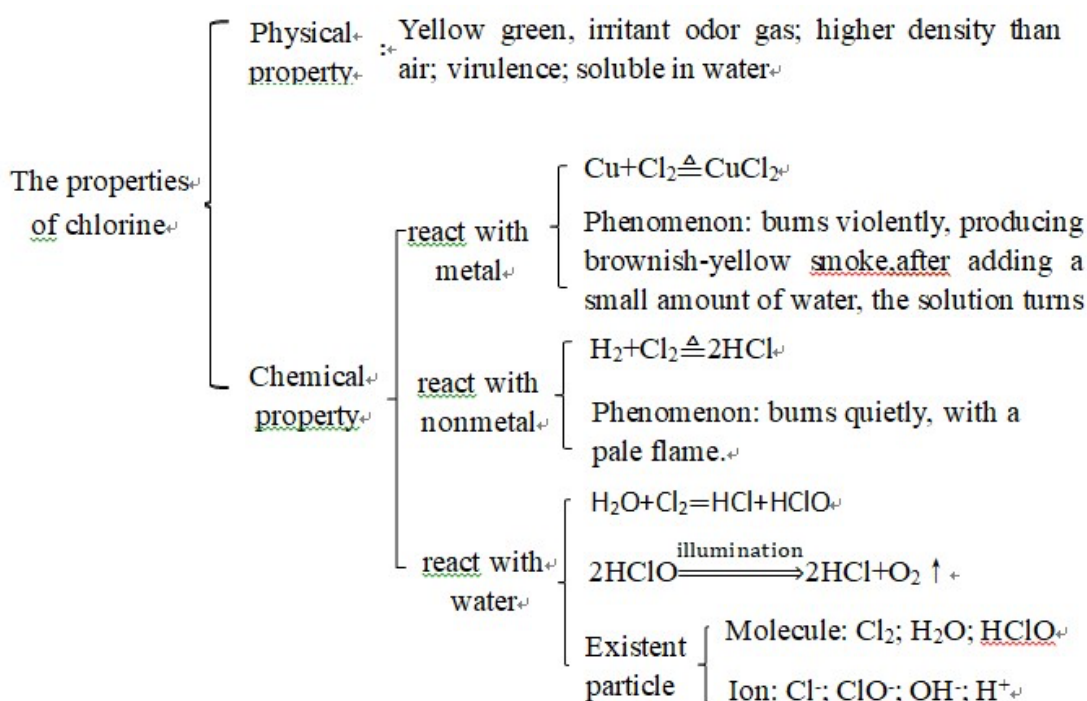
[Task arrangement] Panel discussion, summary the nature of hypochlorite, and supplement the mind map.

[Design intent] Integrating scientific historical facts into teaching adds to the interest of the course, so that students can understand that scientific research is a difficult and long-term road. Scientific research often needs to cultivate rigorous scientific thinking and bold questioning spirit based on a large number of facts. In exploring the reaction of chlorine and water, a thinking model of hypothesis-experimental verification-conclusion was established, which promotes the learning of subsequent elemental compounds.

Teaching Session 4 – Summary

[Result show] The group reports and shows the mind map. Teachers and students comment and appreciate it together, and improve the depth and breadth of the mind map. Each student is required to draw a personal mind map after class.

[Design intention] Perfect the mind map and form a complete thinking system. Strengthen subject knowledge, present clear knowledge context and have a deeper understanding of the knowledge.



CONCLUSION

Starting from the problems existing in chemistry classroom in China and combined with China's relevant education policies, this paper designs a hierarchical interactive teaching mode based on the theory of "mind map". Aiming at teaching students in accordance with their aptitude, this mode can be used for promoting students' individualized development as well as implementing the core literacy of chemistry. Taking "the nature of chlorine gas" as an example, the specific methods and strategies of integrating this model into high school chemistry has been conducted. Moreover, it has the following three characteristics: (1) Guide students to think deeply about what they have learned by setting questions in layers from the shallower to the deeper, based on group cooperation and interactive discussion; (2) Cultivate students' sense of cooperation and inquiry ability as well as mobilize each student's learning to the greatest extent via grouping them according to the differences of students; (3) Stimulate divergent thinking of students at different levels, and improve their understanding and mastery of chemical knowledge by using mind map as an interactive tool throughout the teaching. Through this strategy, physical and chemical properties of chlorine gas had been learned by students, and established a cognitive model for predicting substances and their changes based on the perspectives of "substance category", "atomic structure" and "element valence". In the

experimental inquiry, the general idea of studying the properties of substances (hypothesis-experimental verification-conclusion) was summarized. The core literacy of 'evidence reasoning and model cognition' and 'experimental inquiry and innovation consciousness' was implemented.

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