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An Empirical Study on Chinese Primary School Students' Learning Interest in Science Writing

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A R T I C L E I N F O

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A B S T R A C T

The 20th National Congress of the Communist Party of China pointed out that education, science and technology, and human resources are the basic and strategic support for the comprehensive construction of a modern socialist country. Good scientific thinking is the key to cultivating scientific and technological innovation talents, and scientific reasoning is an important part of scientific thinking, and teachers need to cultivate students' scientific thinking based on scientific reasoning in a targeted way in the teaching process. Therefore, the article firstly explains the connotation of scientific thinking and scientific reasoning, and identifies the relationship between them, then proposes a strategy for teaching thinking based on scientific reasoning, and finally presents concrete cases of teaching junior high school chemistry thinking based on scientific reasoning to help students improve their scientific reasoning ability, develop scientific thinking, and develop into comprehensive and innovative high quality talents.

1.Introduction

In order to further deepen curriculum reform, in April 2022, the Ministry of Education of China issued the Compulsory Education Curriculum Program and Curriculum Standards (2022 Edition), which points out the specific refinement of the Party's education policy into the core literacies that this curriculum should focus on cultivating. Core literacy is the centralized embodiment of the value of discipline education, and is the correct values, necessary character and key abilities that students need to adapt to their lifelong personal development and social development that are gradually formed through curriculum learning. By studying the new standards for compulsory education in 2022, we found that the core literacies of the disciplines to be cultivated in the science curriculum, mainly physics, chemistry and biology, all mention scientific thinking. For junior high school chemistry, scientific thinking is the ability to question and criticize different information, opinions and conclusions based on facts and logic for independent thinking and judgment in chemistry learning, and to put forward creative insights; ideas and methods to study substances and their laws of change from a chemical perspective; and a way of understanding to investigate substances and their laws of change from a combination of macroscopic, microscopic and symbolic perspectives (Chemistry curriculum standards for compulsory education, 2022). This is the first time that China's curriculum standards highlight the importance of scientific thinking. Scientific reasoning ability is one of the main expressions of scientific thinking ability(Zimmerman, 2007). It will not only have an impact on students' academic performance, but also on their decision-making and judgment in life, and is an important and indispensable thinking skill for students.

2. Scientific Thinking and Scientific Reasoning

2.1 The connotation of scientific thinking and scientific reasoning

Many scholars at home and abroad have expounded the connotation of scientific thinking in depth. Downing (1928) described scientific thinking as the process of observation, hypothesis generation, and evidence evaluation using experiments. Kuhn (2008) defined scientific thinking as a conscious process of seeking knowledge, including thinking for the purpose of seeking and enhancing knowledge.

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According to Hu and Lin (2003), scientific thinking is the indirect, generalized and dynamic reflection of the conscious human brain on the essential properties, intrinsic laws of things in nature (including objects, processes, phenomena, facts, etc.) and the connections and interrelationships among things in nature. Zhao (2019) defines scientific thinking as a way of knowing based on factual evidence, using scientific concepts, making judgments and explanations about the nature of objective things, laws and their interrelationships through scientific reasoning and argumentation, and making predictions about the objective development and changes of things. This study is based on the existing literature. Based on the existing literature this study understands scientific thinking as a thinking through scientific reasoning and argumentation, and making predictions about the objective development and changes of things. This study is based on the existing literature. Based on the existing literature this study understands scientific thinking as a thinking process in which the brain consciously uses induction, generalization, deduction, and reasoning to explore the essential properties and laws of things and information processing.

The concept of scientific reasoning was first introduced by Piaget in his theory of cognitive development; for Piaget, scientific reasoning is the type of reasoning that children or adults have after cognitive development proceeds to the formal operational stage(Yan, & Hu, 2009). Morrell and Lederman (1998) defined scientific reasoning as inductive thinking (concept acquisition, concept formation, concept schema) and deductive thinking (based on creativity, observation, model construction, and evaluation based on empirical evidence). Stuessy (1984) considered scientific reasoning as a rational form of intrinsic logical thinking used by individuals in the process of scientific inquiry to propose relationships between observed phenomena, to design experiments to test the proposed relationships, and to decide on all possible alternatives and outcomes; to consider the probability of phenomena occurring and to predict logical inferences, to weigh evidence, and to use a certain amount of evidence to justify a particular conclusion. In Scientific Reasoning: logic and the scientific method of thinking, Zhou (2017) states, "Scientific reasoning is a method of generalizing, abstracting, and reasoning to arrive at laws on the basis of experimentation." Hu (2017) argues that scientific reasoning includes a variety of ways of thinking, such as abstraction and generalization, analysis and synthesis, analogical reasoning, deductive reasoning, and inductive reasoning, which are important manifestations of scientific thinking. Some scholars also consider scientific reasoning as a core component of scientific thinking. Researchers have parsed scientific reasoning at different levels, and the connotation of scientific reasoning as they define it is a higher-order form of thinking that builds on evidence for reasoning. From an integrative perspective, scientific reasoning can be considered to refer to a thinking process that is given indispensable in the learning process, including a series of activities such as asking questions and making hypotheses, designing experiments and generating evidence, interpreting data and drawing conclusions.

2.2 The relationship between scientific reasoning and scientific thinking

Scientific reasoning and scientific thinking, as part of higher-order thinking processes, are concepts closely related to the disciplines of psychology and education. Professor Lin (2013) has described the characteristics of higher-order thinking as profundity, flexibility, originality, criticality, and agility; among them, profundity is the basis of all thinking qualities and is the inevitable trend of logical thinking, while originality is the most delayed, slowest, and most difficult of all qualities to develop. In the study of higher-order thinking, some authors use the concepts of scientific reasoning and scientific thinking as synonyms, so it is possible to find one concept under the name of the other in the literature, for example, Kuhn in 2008 searched for "scientific thinking" using the keyword "scientific reasoning " or find another concept under a keyword alongside the concept(Kuhn, Iordanou, Pease, & Wirkala, 2008), as Zimmerman did with "scientific reasoning" and "scientific thinking as search criteria"(Zimmerman, 1928). Other scholars describe or define it as the same structure, but use different names. For example, Downing (1928) describes scientific thinking as the process of observation, hypothesis generation, and evidence evaluation using experiments. Similarly, Echevarria (2003) describes scientific reasoning as the process of hypothesis generation, evidence evaluation, and experimental design. However, in reality the two involve different processes and should not be confused.

By their very nature, scientific reasoning and scientific thinking are different and they should be distinguishable. Some scholars in psychology, philosophy, and cognitive science have distinguished between thinking and reasoning in different ways. From the perspective of the natural sciences, thinking can refer to different ideas: it can refer to a state of belief, a plan, or a judgment. Holyoak and Morrison (2005) define thinking as "the systematic transformation of mental representations of knowledge to characterize actual or possible states of the world, usually in order to achieve a goal ". At the same time, they define reasoning as a specific process that is more specialized, deeper, and more focused than thinking, but is also part of thinking(Holyoak, &Morrison, 2005). As a specialized process, reasoning can be considered as dependent on its cognitive functions; for example, inductive, deductive and retrospective reasoning. Many scholars have referred to scientific reasoning and scientific thinking in their studies and have distinguished between the two connotations. For example, Crowley et al. (2001) argue that scientific reasoning is the process of formulating hypotheses, collecting evidence, reasoning, and revising theories, whereas scientific thinking is the dialectical logic between theory and practice. Brigandt (2010) argues that scientific thinking, in contrast, is philosophical in nature although it is associated with science, scientific discovery and the content of scientific critical thinking(Kevin, Maureen, Jennifer, Jodi, Karen, & Jeff, 2001). Thus, although scientific reasoning and scientific thinking are often used interchangeably or synonymously in different fields of study, scientific reasoning refers to the set of cognitive skills used to systematically explore and understand phenomena, whereas scientific thinking refers to the integration of scientific knowledge, discovery, and the socio-historical progress of science.

3.Reflections on global competency research

Thinking teaching is an educational activity in which teachers purposefully and systematically guide students to discover problems while imparting factual knowledge to them, and to make appropriate judgments, decisions, and actions from problem situations(Ingo, 2010). In order to develop students' scientific reasoning ability, teachers need to develop thinking teaching strategies for developing students' scientific reasoning ability from various aspects, taking into account students' personality characteristics, teaching contents, subject characteristics and the structure of scientific reasoning ability.

3.1 Strategies to help students structure their knowledge

Students cannot carry out scientific reasoning without their existing knowledge and experience, and knowledge structuring affects the richness of their knowledge and experience; therefore, to improve students' scientific reasoning ability, we must pay attention to students' knowledge structuring. Knowledge structuring means recognizing the correlation and common features among knowledge, putting the new knowledge learned into some larger categories or dividing it into different parts, reorganizing it in the mind, forming knowledge blocks, refining and summarizing the complicated knowledge, and thus forming a good knowledge structure(Liu, 2019). Even subjects such as physics, chemistry and biology, which people usually think of as science subjects, are more or less liberal arts in nature. In addition to the knowledge that needs to be understood, it also includes the knowledge that needs to be memorized. And while the knowledge that needs to be memorized may seem complex, it is also all intrinsically linked to each other. Helping students to structure their knowledge allows them to improve their ability to apply and transfer knowledge based on their knowledge and understanding of concepts or principles, etc. It lays the foundation for their scientific reasoning, which is conducive to better problem identification and problem solving and the integration of theory and practice. To help students structure their knowledge, teachers first need to understand students' original cognitive structure. Students are the main subject of teaching, and only on the premise of mastering students' original cognitive structure can teachers take corresponding teaching measures to help students structure their knowledge. In addition, it is recommended that teachers adopt the teaching mode of large concepts and units, based on the logic of textbook preparation, and combine unit teaching to help students integrate the chemistry knowledge they have learned and better help and guide them to structure the knowledge they have learned.

3.2 Strategies to improve students' information acquisition and processing skills

In the process of acquiring and processing information, students filter and process it to select the appropriate information as an important basis for scientific reasoning. Therefore, students' scientific reasoning ability and information acquisition and processing ability are inseparable. Students' ability to acquire and process information can be cultivated through text reading, experimental investigation, and test practice. Text reading is a basic method of acquiring information, and students usually read textbooks and related materials to obtain the required information. Teachers should consciously strengthen students' reading ability and improve their reading level, so that students can accurately grasp the required information in a large passage of textual information and cultivate their ability to accurately identify and process information. Experiments are an important source of information for students. By directly observing experimental phenomena, organizing and analyzing them, summarizing and forming evidence, reasoning and drawing conclusions, students can not only deepen their understanding of knowledge, but also develop their ability to acquire and process information. Teachers should actively change the traditional indoctrination teaching in the classroom and adopt experimental inquiry-based teaching methods to encourage students to actively participate, actively obtain information, and give appropriate guidance when students carry out experimental inquiry. Meaningful test practice can also exercise students' ability to capture and process information. Teachers should not randomly assign exercises during students' classroom or after-school exercises, but select and refine such questions, guide students to precisely find the key words in the questions, carry out analysis for the problems, find the implied solution information in conjunction with what they have learned, eliminate superfluous and confusing information, and improve students' sensitivity to information and their ability to mine implied information.

4.A case of teaching junior high school chemical thinking based on scientific reasoning

Traditional chemistry experiments are usually taught by first showing students the properties of substances, including physical and chemical properties, and then having them verify them through observation experiments. Although students do experiments, observe and record in class, they simply follow the process described by the teacher and reproduce it step by step. There is a lack of reflection while doing the experiments, not thinking about what hypothesis is proved by the results of the experiments and what causes inconsistencies in the experimental phenomena if they occur. At the same time, students are missing the link of scientific reasoning, neglecting the cultivation of scientific thinking in the core literacy of chemistry. To better develop students' scientific thinking and core literacy in chemistry, scientific reasoning activities need to be applied in the classroom. Teachers should take the classroom as the front, take the problem as the carrier, take students as the center, change students' learning style, and cultivate students' scientific thinking based on scientific reasoning, so as to achieve the purpose of cultivating students' core literacy in chemistry.

“Oxygen” is a very important teaching content in junior high school chemistry, and the author takes the topic 2 “Oxygen” in the first volume of junior high school chemistry of China People's Education Press as an example, and combines the teaching strategy of cultivating scientific thinking based on scientific reasoning to try to carry out teaching design. Fischer et al. (2014) had proposed eight scientific reasoning skills in their study, namely problem identification, problem formulation, making hypothesis, creation and artificial work redesign, evidence generation, evidence evaluation, drawing conclusions, communication, and review. In my attempt to design the instructional design of Oxygen, I designed the teaching activities based on the five major steps of scientific reasoning: problem formulation, making hypotheses, evidence generation, drawing conclusions, and reviewing and communicating (Figure 1), aiming to develop students' scientific reasoning skills in a focused manner. When teaching, a series of progressive learning tasks are designed from life situations to trigger students to transfer old knowledge by analogy, think deeply about making hypotheses, and encourage students to design their own experimental solutions. Experiment first and then investigate, guide students to make scientific reasoning based on experimental phenomena, and summarize the conclusion with existing knowledge. Discussions and exchanges on the questioned points allow students to experience the whole process of scientific reasoning and continuously develop scientific thinking.

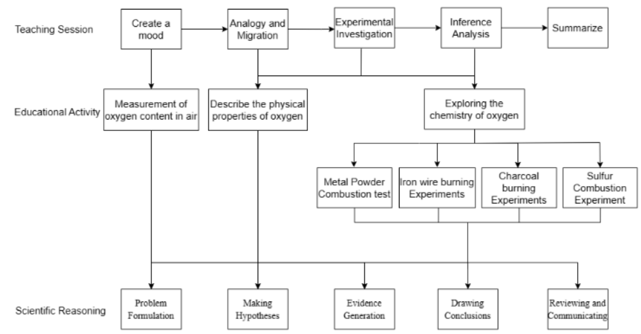

Figure. 1 Framework for designing teaching activities of “Oxygen”

Session 1: Create a situation and discover the problem.

Any problem is found in a certain real situation, and the question is the starting point of thinking. After the teacher throws out the question of what it would feel like to hold your breath for 20 seconds, the importance of oxygen is highlighted by having students try to answer it themselves. When guiding students to answer the physical properties of oxygen, students can be prompted to learn the basic ideas of substances, recall the physical properties of air before, so that students can transfer knowledge. Another example is to guide students to think about what the chemical principles behind the fireworks are after showing the video of the fireworks. Students can also identify problems in their own experiments, for example, after observing the phenomenon of burning iron wire, they can think about whether all iron cannot react with oxygen.

Session 2: Scientific inquiry and reasoning verification.

Scientific reasoning skills are gradually improved by students through observation of experiments, collection of evidence, induction and deduction, and verification of hypotheses in the process of conducting scientific investigations. The teacher guides students to group experiments to investigate the chemical properties of oxygen. After familiarizing themselves with the experimental requirements and contents, students design their own experiments and verify them by observing and recording the phenomena first-hand. The conclusion that oxygen reacts with metal powder, iron wire, charcoal, and sulfur, respectively, is drawn through reasoning. For example, after observing the experiment of burning iron wire, the teacher will guide students to think about “if iron is not in powder form, must it not react with oxygen and burn?” Students will make a hypothesis after thinking about it, use the three bottles of oxygen provided, measure its concentration with an oximeter, and follow the steps and precautions for the wire burning experiment. Observe the phenomena to test their hypothesis and finally draw a conclusion. In the process of the experiment, there may be individual groups that do not see the experimental phenomenon, the teacher needs to guide students to analyze and discuss the reasons for failure, and guide students to think about “what is the purpose of putting some water at the bottom of the bottle?”

Session 3: Discussion and exchange, summary and expansion.

When students work in groups for experimental investigation, the experimental design and results of each group may differ. Teachers need to guide the groups with problems, let students communicate with each other about the experimental plan and the experimental process, and reason through the reflective analysis process so as to reach a consistent conclusion. At the same time, the scope of the discussion can be extended beyond this lesson to other points of knowledge. For example, students try to verify that oxygen supports combustion in a way other than reigniting a strip of wood with a spark.

To sum up, in the teaching process, teachers should not only focus on chemical subject knowledge, but also cultivate students' ability to analyze and solve problems through teaching, so that students' scientific thinking can be further developed. Scientific reasoning is an important part of scientific thinking. The teaching design of “Oxygen” further improves students' core literacy in chemistry by creating realistic teaching situations, asking thoughtful questions, and students actively designing their own experimental solutions, formulating hypotheses scientifically and verifying them through experimental investigations, and exercising their chemical thinking. The classroom is the main site for cultivating core literacy, and teachers should focus on core literacy in teaching implementation, purposefully and systematically carry out teaching design that points to the development of scientific thinking, transform teaching methods, and cultivate students' higher-order thinking with scientific reasoning ability as the grasp, so as to improve their core literacy.

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