Original Research Article

Transformative Teaching Strategy and Design to handle Pre-concepts in "Matter State Changes" in Junior High School Science

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ABSTRACT

Concept is a systematic element in junior high school subject knowledge, and concept learning is not only concept acquisition, but also includes concept transformation. In order to effectively transform students' pre-concepts, this study takes the chapter of "matter state changes" in junior high school science as an example. On the basis of the previous inquiry and analysis of the pre-concepts, a targeted teaching strategy of the pre-concept transformation is proposed.Teaching strategies include exploring learners' pre-conceptions, setting up experimental situations, scientific reasoning, analogizing the pre-concepts and science concepts, and integrating students' knowledge. Meanwhile the relevant teaching design of the state of "white gas", endothermic and exothermic, factors affecting the speed of liquid evaporation, the substances inside the bubble and the condition of bubble motion when water boils, dry ice stage effects, etc., are presented. It is hoped that by making such attempts to effectively transform students' pre-concepts, help students establish science concepts. and realize the adjustment and change of the original cognitive structure.

Keywords: pre-concept transformation; junior high school science; teaching design; matter state changes.

1. INTRODUCTION

Concepts are systematic elements in junior high school subject knowledge. The establishment of science concepts is a prerequisite for solving teaching problems, and in order to draw correct conclusions in the process of reasoning and judging using science concepts, students must first master the concepts correctly and understand them [1-5]. Concept learning is not only concept acquisition, but also includes concept transformation, therefore, when teaching science concepts, students should not be treated as a "blank sheet of paper", but should take into account the pre-concepts that existed before students received education.

Pre-concepts generally refer to students' views and ideas about things and phenomena formed by long-term daily experience before learning a science concept. Junior high school students, on the other hand, are prone to consider problems superficially, and are often confused by superficial phenomena without seeing the essence of things. Therefore, it is easy to form some false pre-concepts. In the teaching of science in junior high school, we cannot ignore the pre-concepts formed in the brains of students. The correct concepts should be used, and the wrong ones should be carefully guided and eliminated. Only by effectively applying students' pre-concepts can students actively construct their own knowledge networks [6-10].

Method

We previously conducted a questionnaire survey on students to investigate the pre-concepts of the seventh grade of junior high school students in Hangzhou in the chapter of "matter state changes", and found the wrong concepts held by the students [11]. In this paper, we hope that based on the previous analysis of the causes of pre-concepts, put forward targeted teaching strategies and carry out teaching designs combined with relevant teaching theories to help students construct scientific concepts while transforming erroneous pre-concepts.

2. TEACHING STRATEGIES FOR TRANSFORMING PRE-CONCEPTS

The pre-concepts possessed by students are a resource that teachers cannot ignore in their teaching, and the following strategies can effectively transform pre-concepts into science concepts in actual teaching:

(1) Fully exploring learners' pre-conceptions. Teachers should complete the excavation of pre-concept details through the process of interaction with learners, and improve and clarify the details of pre-concepts that are incorrect or uncertain to learners.

(2) Setting up experimental situations to trigger cognitive conflicts. Learners believe that the pre-concepts stored in their brains are correct, and these concepts exist in a much rather hidden way. Teachers should expose these wrong pre-concepts, and setting up experimental situations should be the most appropriate way. The experimental method has a rock-solid and unshakable position in the teaching process because of its intuition, vividness and image. Teachers can convince students by adopting the experimental method to present the phenomena directly in front of them. Through experimental teaching, the learners' original knowledge system is affirmed, and the perceptual cognition is deepened. Learners will also intentionally accumulate life experiences in such a reinforcement process, and form science concepts after passing the assessment that is in line with their level of thinking.

(3) Through scientific reasoning, helping students analyze new science concepts in terms of their essence. Let students complete the analysis of the deficiencies of the pre-concepts in two steps, namely, intuitive scientific experiments and logical and rigorous scientific reasoning, so as to help students break down the erroneous pre-concepts and lay the foundation for the construction of science concepts.

(4) Analogizing between pre-concepts and science concepts. Analyze the similarities and differences between these two in depth, and explain the nature of erroneous pre-concepts that have previously produced. Connect some of the similarities and categorize the similar concepts for application. Distinguish the differences among them, grasp the key, explain these details thoroughly, and constantly reinforce them through exercises and other means to help students understand science concepts.

(5) Aiming at integrating students' knowledge, the knowledge integration model is used to build a system of concepts. In science learning, students reorganize to form an integrated understanding of a particular scientific viewpoint by integrating their newly learned knowledge with their existing old knowledge. In the teaching process, teachers should not rely on their own experience to directly judge what erroneous pre-concepts students may have, but should take a teacher-student interaction to expose them and let students consciously realize their shortcomings - this process is also the process of extracting viewpoints. Then teachers add new science concepts to the students in a variety of ways - this process is the process of adding viewpoints. Teachers set up specific situations to trigger students' cognitive conflicts, weaken the influence of erroneous pre-concepts on students' learning of science concepts, analyze the relationship between erroneous pre-concepts and science concepts, and distinguish between true and wrong two concepts - this process is the process of identifying viewpoints. For those causes for the formation of wrong pre-concepts formed by students, analyzing and reflecting on the reasons for the formation and how to prevent students from forming similar erroneous pre-concepts in future learning, which will bring great trouble to teaching and students' own understanding - this process is the process of rethinking viewpoints.

Taking knowledge integration as a criterion and taking the state change as an example, we design the following pre-concepts transformation teaching designs.

3.TEACHING DESIGN OF THE STATE OF "WHITE GAS"

Teacher: Students, this picture is the picture taken by me when the kettle boils water, does anyone know what the white substance next to it is?

Student: It is "white gas".

Teacher: This student is very good, it seems that he should usually love life and observe things very carefully. In life, we can often see this substance next to the boiling kettle, we call it "white gas". Then students, think carefully, what is the state of this substance called "white gas"?

Student: Teacher, because it is called "white gas", I think it is in the gaseous state.

Teacher: This student put forward his own opinion, and he gave his own reasons, do you agree?

Student: It's not gaseous, the water boils and turns into water vapor, in fact, there is water vapor in the air, but it is invisible to our naked eyes, so I deduce that it is not a gaseous substance.

Teacher: Then, combined with the vaporization and liquefaction we learned before, what state is it in?

Student: It should be liquid, these "white gas" is actually white droplets.

Teacher: This student is also very good, he combined with our previous learning to come up with new ideas, so where do these little white droplets come from? Does it pop out of a kettle?

Students: It certainly doesn't pop out of a kettle, it is formed by liquefying water vapor.

Teacher: you are very good and have your own ideas, so can any students tell me where these water vapors come from?

Student 1: It should be the water vapor in the air.

Student 2: There is water vapor in the air, but you can't see small white droplets all the time, they only appear in specific situations. In my opinion, it should be the water vapor formed by the vaporization of the liquid water in the kettle first, and the small white droplets formed by the liquefaction of the water vapor again.

Teacher: This student's thinking is very clear, he gave his own opinion, do other students have other ideas?

Student: No, agree with his point of view.

Teacher: Can any student summarize the specific formation process of "white gas"?

Student: The water in the kettle is violently vaporized by heating, forming a large amount of water vapor, the temperature next to the mouth of the kettle is low, and the water vapor liquefies into small water droplets when cold. Therefore, the "white gas" is formed by the vaporization of liquid water and then liquefaction.

Teacher: Well, some students have a more thorough understanding of this process, do any students have any doubts? It doesn't matter, you can raise your hand.

Teacher: Next, I will reproduce this small experiment that you are accustomed to in life, the substance heated here is alcohol, the student who just raised his hand please come up and feel it.

Demonstration experiment: pour an appropriate amount of alcohol that has been heated in a hot water bath at 75 °C into the beaker, continue to heat until boiling, and form a large amount of "white gas" at the mouth of the beaker, so that students can observe and reach out to feel the state of "white gas".

Teacher: After what you just felt, do you understand what state "white gas" is?

Student: Yes, teacher, "white gas" is liquid.

4. TEACHING DESIGN OF ENDOTHERMIC AND EXOTHERMIC

Teacher: How many states of matter exist?

Student: Three.

Teacher: How many changes of state are there between the three states?

Student: Six.

Teacher: During the melting process, we continuously heat the rosin through an alcohol lamp, what is the change for solid rosin?

Student: The solid rosin continues to melt, gradually becoming softer and thinner. The number of thermometers is also rising.

Teacher: The number of thermometers is constantly rising, does it mean that rosin is constantly absorbing heat?

Student: There is no causal relationship between the two. Because the alcohol lamp is constantly heating, the rosin is constantly melting. But for hypo, the alcohol lamp is still heating up, but the thermometer does not change, which can only indicate that the properties of hypo and rosin are different.

Teacher: These two sets of concepts must not be confused. Because the melting process needs to absorb heat, the alcohol lamp needs to be continuously heated to supply heat. If the alcohol lamp stops heating, the heat supply is interrupted and the melting process does not continue.

Teacher: We know that the melting process needs to absorb heat and the melting is changed from solid to liquid, then what about solidification? Say your own ideas.

Students: exothermic, solid state becomes liquid absorbs heat, then in turn from liquid to solid, must release heat.

Teacher: This student's analysis is reasonable and correct, please combine with examples in life to prove your own point of view.

Student: Teacher, I also agree that the solidification process releases heat. I used to go to the northeast during the winter vacation, and I found that the cellars in the north would put a few buckets of water next to them in winter.

Teacher: This student has observed very carefully and is very studious, and this spirit is worthy of our praise. Come on, class, and let's give him a round of applause.

Teacher: Is vaporization endothermic or exothermic?

Student: It should be endothermic, taking the boiling of water as an example, water boiling needs to be heated for a long period of time, and this process needs to continuously provide heat to make it boil, so vaporization is endothermic.

Teacher: So is liquefaction endothermic or exothermic?

Student: Liquid changing to gaseous state is endothermic, then gaseous state becoming liquid must be exothermic.

Teacher: This student is very smart, the transfer and application of knowledge is very fast, please give examples to prove your point.

Student: Water vapor at the same temperature burns more severely than liquid water.

Teacher: This student's knowledge is very broad, which is great. Is sublimation endothermic or exothermic?

Student: Sublimation should be endothermic, in the process of iodine heating, iodine will be heated on the alcohol lamp from solid iodine to gaseous iodine, and so it is endothermic.

Teacher: Are there any other opinions?

Student: Because sublimation is a process of changing from a solid state to a gaseous state, it can be split into a solid to liquid state, and the melting process needs to absorb heat; then change from liquid to gaseous state is a vaporization process that also needs to absorb heat. Therefore, changing from a solid state to a gaseous state also requires endothermic attention.

Teacher: This student has integrated all the knowledge, which is very good, but this student has disassembled the sublimation process into two matter state change processes, which has a certain deviation from the actual situation. In the process of iodine sublimation, there is no intermediate state liquid that as the student just now said. Science is a very rigorous subject, and students must be rigorous when expressing it.

Teacher: Does condensation endothermic or exothermic?

Student: Exothermic.

5. TEACHING DESIGN OF FACTORS AFFECTING THE SPEED OF LIQUID EVAPORATION

Teacher: What are some of the tips you have in your life to make your clothes dry faster?

Student: Before drying clothes, I will wring out the residual moisture on the clothes by hand, and then dry the clothes in a place with a relatively high temperature, sun, and better ventilation.

Teacher: Drying clothes is actually the process of water evaporation on clothes, combined with the experience of drying clothes in life, what are the factors that affect the speed of liquid evaporation?

Student 1: Liquid type.

Student 2: Liquid temperature.

Student 3: The wind speed on the surface of the liquid.

Student 4: Liquid amount.

Student 5: The surface area of the liquid.

Teacher: You are great and have come up with so many ideas based on your own life experience. Then, let's design some experiments to test your ideas based on these assumptions you put forward.

Students: (happy and active)

Teacher: Based on the scientific group divided earlier, I prepared some experimental equipment for you, including glass slides, rubber-tipped burette, alcohol, alcohol lamp, matches, fan, measuring cylinder, etc. Please design an experimental plan according to these experimental equipment.

Teacher: Okay, the time is almost up, please raise your hand if you have already envisioned the experimental plan. I saw that you had almost completed it, and then took the first conjecture as an example - the liquid type may affect the evaporation speed of the liquid, which group has a more complete experimental plan for this idea, you can raise your hand to share.

Student: Our group selected two different types of liquids, alcohol and water, used a rubber-tipped burette to drop the same amount of liquid on the sheet, controlled the same surface area of the liquid, and placed them in the same temperature and the same wind speed to judge the time it takes for the liquid to evaporate completely, so as to judge the speed of liquid evaporation.

Teacher: This student's experiment is very rigorous, according to his own ideas, the two liquids selected are alcohol and water, and other conditions are strictly controlled, so what are the results of your experiment? Can you share it?

Student: Through experiments, we have found that the speed of liquid evaporation is related to the liquid type when the liquid temperature, the wind speed on the liquid surface, the liquid amount and the surface area of the liquid are equal. For both alcohol and water, alcohol evaporates much faster than water.

Teacher: Very good, this student conducted the experiment according to his own ideas, and the conclusions reached are completely consistent with the experimental conclusions of the scientists, let us applaud for this student.

Teacher: Can the liquid amount affect the speed of liquid evaporation? Please say your basis.

Student: When I dry clothes, I will first wring out the water on the clothes, so that there is less water remaining on the clothes, and the drying time of clothes will be relatively short, I will reduce the drying time of clothes through such measures, so we think that the liquid amount is the influencing factor.

Teacher: It makes sense, but let's analyze it. The more liquid amount, the amount that needs to evaporate will be a little more, so the time it needs to evaporate will be longer. The liquid has less amount, and it takes less time to evaporate. In the case of the same liquid type, we can use the evaporation time to judge the speed of liquid evaporation. If the type of liquid is different, the evaporation time cannot be used to indicate the speed of liquid evaporation. So is liquid amount an influencing factor?

Student: (shaking head)

Teacher: I see that many students shake their heads, and they may think that I has just analyzed it reasonably. But there are still some students who have a very puzzled expression. So next, let's ask the group who studied this conjecture to answer.

Student: We add 2 mL and 4 mL of alcohol to the 10 mL graduated cylinder, the height of the liquid to the naked eye is a certain difference. We put them on the environment with the same wind speed of the liquid surface and the same temperature. We finally found that the liquid with more amount does take a longer time to completely evaporate the alcohol, and the group with less amount, it makes the alcohol completely evaporate consuming a shorter time. Through the recording of experimental data, it is found that the liquid amount and the time it takes for the liquid to completely evaporate are in a ratio relationship, and the ratio is a fixed value.

Teacher: We can conclude that the liquid amount is not a factor that affects the speed of liquid evaporation.

6. TEACHING DESIGN OF THE SUBSTANCES INSIDE THE BUBBLES AND THE MOVEMENT STATE OF THE BUBBLES WHEN THE WATER BOILS

Teacher: Students, evaporation is a vaporization phenomenon, meanwhile boiling is another vaporization phenomenon. Compared to evaporation, boiling is more violent. When boiling water, have you ever carefully observed the internal changes in the liquid before and after the water boils?

Student: Teacher, I helped my mom boil water. Before the water boiled, I saw a lot of small bubbles attached to the inner wall of the kettle, and those small bubbles would keep gathering together and getting bigger and rising.

Teacher: Do other students have other views? What different phenomena do you see?

Student: Teacher, I don't agree with him. I found that when the water boiled, the bubbles rose but became smaller.

Teacher: This student is also very good, but his expression is quite different from the classmate just now. Although we all have the experience of boiling water in our daily lives, few of us will observe the specific changes inside the water.

Demonstration video: Using an alcohol lamp to heat the water in the beaker, we can intuitively see the internal changes of the water in the heating process. Please be sure to observe carefully, find out whether the process described by the two students just now exists, and in addition to these two processes, are there other states existing?

Student: (watch the video carefully)

Teacher: The video is over, I see that you are watching very carefully. Then I wants to ask everyone, is the state just described by those two students a real existence?

Students: (nodding)

Teacher: Please carefully analyze these two situations, the bubble is indeed rising, we have no doubt about this conclusion. Then what's inside the bubble? Why do bubbles keep rising?

Student: Because inside the bubble is a gas, and gases are less dense than water, so the bubble will keep rising.

Teacher: This student thinks that the inside of the bubble is gas, then what is the composition of the gas?

Student: Water vapor formed by the vaporization of water.

Teacher: Is it just water vapor? Is it possible that it is mixed with other substances?

Student: Teacher, I think there should be a lot of air inside the bubble.

Teacher: Very good, very comprehensive consideration. The fish in the pond will not die of lack of oxygen, why?

Student: Because some of the air is dissolved in the water, and the oxygen in the air can be supplied for breathing.

Teacher: Does the bubble get bigger or smaller?

Student: Teacher, through the observation just now, I found that the bubbles will keep rising before the water is fully boiled, and will keep getting smaller in the process of rising. After the water boils, the bubbles will continue to rise, and in the process of rising, they will continue to get bigger and bigger.

Teacher: Very good, I give two pictures of the inside of the liquid before and after boiling. The phenomenon has been clearly observed, but what is the truth behind the phenomenon? Please continue to think about for a science group as a unit, why there are two diametrically opposed states of bubble rise and bubble size before and after boiling?

Student: I think that before the liquid boils, the water below is closer to the heat source, the temperature is higher than the temperature of the water above, and the bubbles shrink when cold as they rise, and continue to become smaller to rupture.

Teacher: You grasped the tips given by me, combined your own knowledge as well as thinking, and overcame this difficult problem, which was very good.

7. TEACHING DESIGN OF DRY ICE STAGE EFFECTS

Teacher: We will see the smoke-filled, fairyland-like stage effect at the school's New Year's Day party, do you know what the substance that creates this phenomenon is?

Students: dry ice, solid carbon dioxide.

Teacher: Very good, this student has a very wide range of knowledge. Why dry ice can create such a smoky situation like a fairyland?

Student: dry ice sublimes into carbon dioxide gas, so these stage effects are actually made of carbon dioxide gas.

Teacher: This student has a very good grasp of the knowledge of sublimation and condensation in this lesson, he knows that dry ice is solid, and then this smoky situation created is gaseous, so he thinks that it is a process of sublimation solid into gaseous state. So please think about what the state of the substance that creates this smoky sceneis?

Student: gaseous state.

Teacher: I heard most of you say that it is gaseous and carbon dioxide gas exists in the air, but can you see carbon dioxide gas directly with the naked eye?

Student: No.

Teacher: Yes, because carbon dioxide gas is colorless and odorless, just like we are in the air in this environment, but it is difficult to perceive its existence with the naked eye, so we can rule it out. This kind of stage effect visible to the naked eye is not made of carbon dioxide gas.

Student: (Nod).

Teacher: I brought you some dry ice today, next I will demonstrate this experiment, please observe this process carefully, what is the state of the final formed substance?

Student: Teacher, I saw that there seems to be a lot of "white gas" near dry ice, just like those "white gas" on the mouth of the kettle when the water boils.

Teacher: I saw that you nodded in agreement with his views one after another, but there are still some students insist on their original views without wavering. Then I would like to ask the students who shook their heads to feel what state of matter it really is.

Student: Teacher, it's wet, it should be water, like the mist on the glass in winter morning.

Teacher: It seems that you are very familiar with the nature of water, the result is also the same as you described. These substances are indeed water, and the smoky scene you see is actually composed of many small droplets like "white gas".

Student: Teacher, can solid dry ice melt into liquid water?

Teacher: Maybe you will have such doubts, we put solid dry ice, and the final formation is liquid water, so liquid water must be converted from solid dry ice. But please pay attention to the nature of these substances, solid dry ice is essentially carbon dioxide molecules, the essence of water is water molecules, does carbon dioxide molecules change to water molecules? Obviously impossible.

Student: So the droplets that eventually form must be made up of water molecules, right?

Teacher: Yes, combined with the environment of this stage where this dry ice is located, guess what substances might turn into small droplets.

Student: Teacher, it should be gaseous water vapor. There is a lot of water vapor in the air, and the water vapor should turn into small droplets, forming a smoky environment.

Teacher: This guess is very reasonable, then where did the initial solid carbon dioxide actually go? Solid carbon dioxide becomes gaseous, and the water vapor in the air turns to small liquid droplets. Why do these two seemingly unrelated processes of matter state change occur one after the other?

Student: Temperature. Because sublimation absorbs heat, so it will lead to the temperature to be reduced, and water vapor will be condensed into small droplets.

Teacher: We can see many phenomena in our daily lives, and we have a relatively simple and crude understanding of these things. But after our systematic study, please carefully analyze the specific process and conditions of matter state change, combine with the several situations just mentioned by me, integrate the whole process, and use refined language to describe why dry ice can create this smoky fairyland-like stage effect.

8.CONCLUSION

The mastery of scientific concepts in junior high school is very important, and if science concepts are not well learned, it will affect subsequent learning. In view of the pre-concepts of students in "matter state changes", we propose a targeted strategy of pre-concept transformation, and design related learning activities to enable students to generate cognitive conflicts, actively participate in the learning process to understand the true meaning of the concepts, then be able to apply the new concepts to solve real problems. In order to transform the vague and erroneous pre-concepts in the students' minds into science concepts, strengthen and consolidate them, and realize the adjustment and change of the original cognitive structure.

CONSENT

All the interviewees consent the use of their views for analysis and publication purpose of the study.

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