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Teaching intervention in cultivating students' Scientific reasoning ability based on Inquiry Teaching

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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

Scientific reasoning, model construction, induction and deduction and critical questioning are important connotations of scientific thinking. as a kind of high-level thinking ability, scientific reasoning plays an important role in the process of individual acquiring new knowledge and understanding the world. it is not only one of the necessary qualities for students, but also one of the important goals of science teaching. Teaching strategy is a very important aspect to realize the cultivation of scientific thinking in physics education. therefore, this study first introduces the teaching mode of cultivating students' scientific reasoning, and then shows the teaching cases based on inquiry learning.

1.Introduction

Education in the new era needs innovative talents, who not only need complex technical skills, but also need scientific thinking ability to solve increasingly complex problems. "Scientific thinking" is clearly regarded as one of the scientific core literacy for the first time in the Science Curriculum Standard for compulsory Education (2022 Edition). As the core component of scientific thinking, scientific reasoning is an indispensable ability basis for scientific inquiry. Because front-line teachers do not find practical teaching methods in the teaching process and lack of research on scientific reasoning ability, it hinders the pace of cultivating students' scientific thinking to a great extent. therefore, an in-depth study of scientific reasoning ability is of great significance to improve the quality of education and implement the reform of basic education, as well as to develop students' scientific thinking ability.

2.The Teaching Mode of promoting the Development of Scientific reasoning ability

In the teaching environment, the level of scientific reasoning ability is tested mainly through the students' ability to design experiments and carry out control experiments. The development of this ability can be promoted in the short term through various teaching methods. Many scholars have studied the teaching model to promote the development of scientific reasoning. For example, Kuhnand Dean suggested that the investigation hints should be focused on a single variable (Kuhnand Dean,2005). Lazonder and Wiskerke-Drost divided the research problem into univariant quantum problems(2015). Heijnes and Joolingen studied drawing-based modeling to promote students' scientific reasoning(2018). In this study, a model of the evolutionary process is constructed by modifying the graphical modeling tool simsketch, and the complexity of reasoning is analyzed in the student dialogue as a measure of the effectiveness of modeling tools and teaching. The results show that the scientific reasoning that motivates students and drawing-based modeling tools and domain teaching guidance should be integrated; when creating a model, there must be scaffolding, and without a suitable scaffolding, students will not be able to create a model. Because the scaffolding is too high, students' reasoning may show that external causes are mistakenly attributed to behavior during modeling. Xu Jianliang cultivated students' scientific reasoning ability through scientific inquiry teaching, and put forward three teaching strategies of scientific inquiry experiment: preview of basic knowledge before class; coexistence of guidance and opening in class; assign experimental tasks and ask for feedback after class(2018). Chen Xi shows that teaching tasks should be arranged reasonably according to the differences of cognitive levels of different ages, and that students with poor foundation should pay attention to knowledge cohesion and help them establish a framework of thinking (2019).Students with good foundation should pay attention to the creation of problem situations.

In a word, the cited research illustrates that the design of problems and the arrangement of activities in teaching should be able to reflect a variety of learning methods, such as inquiry, cooperation, dialogue and so on. At the same time, scaffolding is given to students in the process of inquiry, and the inquiry problems are decomposed. Transition from simple to complex, so that students' thinking can be better cultivated.

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3.An Inquiry Teaching case for cultivating students' Scientific reasoning ability

Exploratory teaching is a kind of inquiry-based teaching. Exploratory teaching not only integrates the traditional teaching methods, but also contains the teaching concept of "people-oriented", which teaches the learning of science as a process of exploration. Students, under the guidance of teachers, combine autonomous learning, cooperative learning and inquiry learning according to life experience, encourage students to observe experimental phenomena carefully, and then ask questions and make hypotheses. Design the experiment and get the experimental data, let the students draw the conclusion according to their own experimental data. Inquiry teaching is a process of guiding students to learn actively, finding and solving problems, and developing students' cognitive ability and scientific reasoning ability on the basis of the coexistence of openness and guidance.

Case one is to cultivate students' scientific thinking through inquiry teaching methods. in the first week, all students take pre-tests, and in weeks 2-6, students participate in five science classes with different themes. Each class revolves around a specific topic (Figure 1), and students learn through exploratory

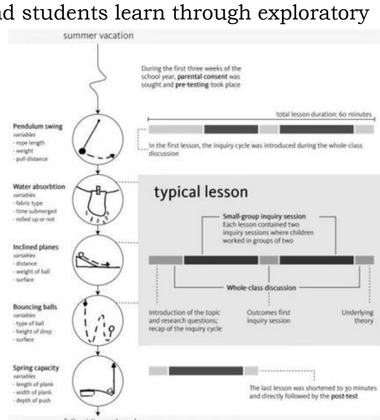

Figure 1: Based on the introduction of the topic of inquiry physics unit

Taking the teaching content of "simple Pendulum" in the first volume of the fifth grade of the textbook as an example, this case mainly focuses on raising questions and making hypotheses, designing experiments and generating evidence, explaining evidence and drawing conclusions to establish teaching design to cultivate students' scientific reasoning ability.

First of all, in the first link, students are required to observe the phenomenon and find problems from it. Different pendulum s swing differently in the same time, and the same pendulum s wings the same number of times in a certain period of time. Stu dents will naturally think of a question: what factors are related to the speed of the pendulum? Secondly, in the second link, the teacher guides the students to analyze the causes of this pheno menon, the students understand the factors that affect the swin g speed of the simple pendulum through group communication, and the students mobilize their original cognition. will put forwa rd different assumptions: the weight of the pendulum, the shorte r the rope, the faster the pendulum, the larger the swing, the fa ster the pendulum. In order to ensure the progress of the follow -up experiment, the influence of swing is excluded. Whether the hypothesis is correct or not needs to be verified by experiments, and the appropriateness of the experimental scheme will directly affect the acquisition of experimental data. if we want to study t he relationship between the quality of the pendulum and the sp eed of swing, how to design the experimental scheme? one group fixed the string on the hook, hung a pendulum at the top, let t he pendulum swing freely in a small range, and observed the nu mber of pendulum swinging for 30 seconds. Keep the length of t he pendulum rope unchanged, increase the mass of the pendulu m in turn, measure the times of 30 seconds swing of the pendu lum with different mass, and analyze the effect of the pendulum quality on the speed of the pendulum according to the investigat ion results. In this link, students should be guided to reason st ep by step, make it clear that the length of the pendulum rope remains unchanged in the course of the experiment, change the quality of the pendulum in turn, gradually form the experimenta l plan, and promote the development of students' thinking. Stud ents can complete the hypothesis and experimental scheme desig n through the worksheet, including the trial method, my hypoth esis, different conditions and the control of the same conditions. In the course of the experiment, teachers should observe the sta ndardization of students' operation and correct the mistakes in t ime. Finally, in the third link, the students collect experimental data, analyze the influencing factors and compare them in the g roup to summarize the rules. After the end of the first survey, t he students experienced a complete experimental process and di scussed in the whole class. The questions discussed roughly incl ude: a brief description of the experimental scheme. What are th e factors related to the speed of the pendulum? How do you kno w that? Following the same steps, the group designed an inquiry experiment for another hypothesis. after all, the students analyz ed the experimental phenomena and explained the problems the y found, and described the experimental data to get what they t hought were the basic scientific principles. in the course of the discussion, if the students' answers are limited (for example, "We find this important"), students are encouraged to provide more details (for example, "can you explain your findings more accurat ely?" If the students' description is wrong, appropriate guidance should be given to help students draw correct conclusions and d eepen their impression of scientific conclusions. Finally, let the s tudents make a complete description of the whole process from t he phenomenon to the conclusion, and strengthen the understan ding of the experimental conclusion.

The inquiry teaching method with the coexistence of opennes s and guidance should fully reflect the students' subjectivity, cre ate an open atmosphere, give students the opportunity to think i ndependently and communicate with each other, and make stud ents' thinking actively participate in the inquiry process through independent reasoning. At the same time, teachers should also g rasp the inquiry process as a whole, provide appropriate guidanc e, let students explore independently, fully exercise students' abil ity of analysis and comparison, and improve students' ability of scientific reasoning. The students' four kinds of scientific reasoni ng skills reached a higher level in the process of exploring the fi ve topics.

The second case is to explore the factors affecting the reverb eration time of gongs and drums. First of all, the classroom intr oduces the operation steps of the computer simulation page, dra wing lessons from the computer simulation used by Lazonder an d Egberink (2014). The lower half of the simulation interface con tains four independent variables that students can control to det ermine what affects the response time of the musical gongs displ ayed at the top of the screen. The teacher explains that the ele ments in the simulation familiarize the students with the simula tion interface, and they can choose any value of each variable to experiment (such as choosing a high, medium or low tone). The influence of each variable is determined by comparing the resul ts of two or more simulation tests. When the "start" button was clicked, the partner sounded the gong, the sound began to fade, and a timer was embedded in the interface to calculate how lon g the echo lasted. Students write down the echo time on paper and use these data to draw conclusions about the four simulate d variables. These inferences must be entered into a simple text editor, which can be opened by clicking the continue button. T he learning environment stores each student's mouse clicks and keystrokes in a separate log file.

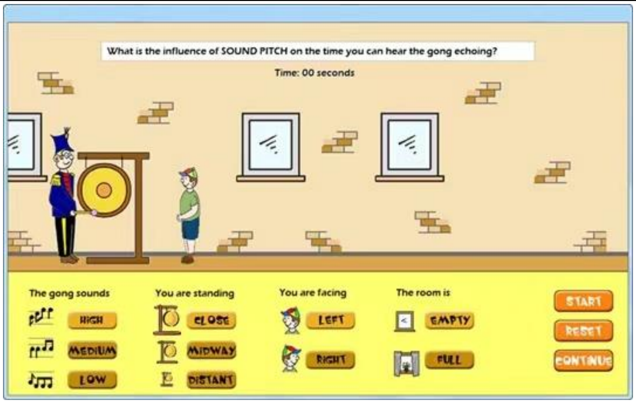

Figure 2: Analog interface

Secondly, teachers test students' inquiry achievements through two formative evaluations. The first time was a pen-and-paper test on the field of echo in a regular science class: students began to answer after understanding the concept of echo (for example, does it matter whether the room is empty or full? Not only do you answer these questions by checking "yes" or "no", but you must also accurately describe the effect on the response time. For example, "if the room is empty, you can hear a longer / shorter gong than when it is full"). The second time is to examine the students' mastery of controlling a single experimental variable: in order to avoid the effect, the test focuses on projects in other fields, including cover stories, research questions and key variables. students not only have to judge whether the experimental setting is correct or not, but also need to correct pictures, teachers and give feedback.

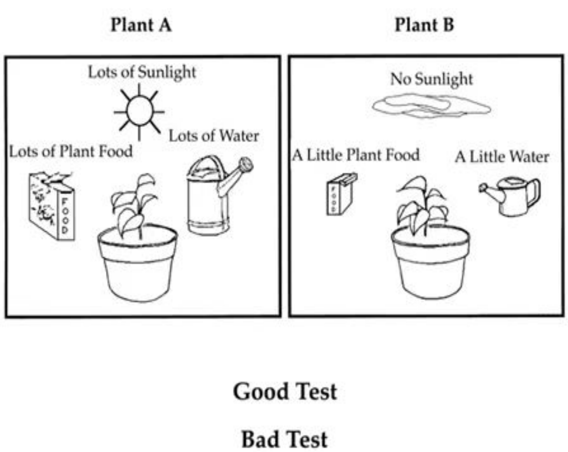

Figure 3: CVS test example-plant growth

Finally, teachers give personalized guidance to each student according to the results of the formative test, and understand the level of students' scientific reasoning ability through three non-instructive questions. The first question leads to the goal of the experiment ("what are you going to investigate in this experiment?" The second question asks students to predict the results ("what do you think the results of this experiment will be?" The third question asks them to prove their predictions ("Why do you think so?"). Teachers write down their answers on the electronic scoring form, and students can continue to investigate until they think they can answer all the questions. In the differential guidance, teachers can know the students with low level of scientific reasoning ability, give different support according to the level of students' thinking level, promote the development of students' high-level thinking and cultivate scientific reasoning ability steadily.

4.Conclusion

Scientific thinking is the core of the core literacy of scientific disciplines, and scientific reasoning is an important part of scientific thinking. Scientific thinking permeated in the process of exploratory experiments is helpful to cultivate students' scientific reasoning ability. At present, most basic science teachers still give priority to teaching methods and lack the consciousness of experimental teaching, so the development of students' scientific thinking is faced with great obstacles. Therefore, teachers should change their teaching mode, carry out student-oriented inquiry teaching, give full play to students' subjective initiative, attach importance to the inquiry process in scientific experiment teaching, and effectively use inquiry-based methods to let children learn scientific topics and cultivate students' scientific reasoning ability in experimental teaching.

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