Application of Inquiry Teaching Mode in Instrumental Analysis Experiment Teaching

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Abstract. Changing the traditional teaching mode of instrumental analysis experiment, and the inquiry teaching mode is applied to the experimental course of instrumental analysis. The cognitive objectives of each experimental project are determined, and the content discussed by students is determined according to the cognitive objectives of each experimental project, and this overcomes the randomness of the content discussed, and a set of scientific and operable experimental teaching mode is established. And this is of great significance to cultivate the practical ability, innovative ability and scientific literacy of college students.

Introduction

Instrumental analysis is an important professional basic course for many majors, such as chemistry, chemical industry, food, pharmacy, etc. The instrumental analysis method introduced in this course is a test method to solve many scientific research problems in life, chemistry, environment and related fields\cite{1,2} and also a tool course with strong theoretical and practical significance\cite{3-5}. Instrumental analysis experiment is an important practical link of instrumental analysis course, which complements each other with the content of theoretical course. It is not only the application of theoretical knowledge of instrumental analysis method, but also the continuation and improvement of the content of theoretical course\cite{6}. Instrument analysis experiments generally include chromatographic analysis, spectral analysis, electrochemical analysis and other methods of analysis. No matter what kind of experimental analysis methods, students are required to achieve at least two cognitive objectives after the completion of the experimental course, that is, to master each instrument operation skills and the instrument analysis methods.

Because the instrument analysis experiment is usually affected by the factors such as the size of the experimental site, the number of instruments, the price of instruments, and the limited hours of the experiment course\cite{7}, the traditional teaching mode of instrumental analysis experiment is that the experiment teacher explains the experiment content and demonstrates the operation method of the instrument first, and then the students carry out the experiment according to the existing experimental scheme. The disadvantage of this teaching method is the lack of interaction between teachers and students. At the same time, the students lack independent thinking about the experimental content and method. They just "follow the prescription and grasp the medicine", and verify the experimental results according to the standard experimental steps\cite{8}. After finishing the instrument analysis experiment, most of the students only know the operation rules of the instrument, but have no deep memory of the experiment principle, experiment content, and instrument analysis method. The experimental cognitive goal is not achieved well, and the experimental course cannot complement and promote each other with the teaching content of the instrumental analysis theory course, nor can it improve the students' practical ability and exploration ability.

How to change the traditional teaching mode and introduce a more effective experimental teaching mode in the instrument analysis experiment teaching under the condition that the size of the experimental site, the number of instruments and the experimental hours are limited? How to carry
out high-quality instrument analysis experiment teaching, improve students' practical ability, innovation ability and scientific literacy, and cultivate high-quality talents in the new era?

Inquiry teaching mode refers to a method that students, under the guidance of teachers, study independently, explore deeply and communicate with each other in groups on the main knowledge points in the current teaching content through the learning mode characterized by "autonomy, exploration and cooperation", and find and master the corresponding principles and conclusions by themselves. The inquiry teaching mode has been tried and applied in the theoretical teaching of many subjects[9], but few people use it in experimental teaching.

Our teaching and research group of instrument analysis experiment, according to the content of the instrument analysis experiment project, has made clear the content and method of the students to explore in each experiment project in the instrument analysis experiment, applied the inquiry teaching mode to the course of instrument analysis experiment, and established a set of scientific and operable experimental teaching mode.

Determining the Content of Inquiry according to the Cognitive Objectives of the Experimental Project

In the course of instrumental analysis experiment, "what is the experiment content explored by students" directly determines whether the inquiry teaching mode can be successfully applied to instrumental analysis experiment, so the randomness of the inquiry content should be avoided. This needs to determine the cognitive objectives of each experimental project, which determine the content of students' exploration. It is required that the cognitive objectives of each experimental project should be explorable and appropriate in difficulty; it cannot be simply equivalent to the experimental purpose in the traditional experimental handout. It should be put forward according to the content of the experiment project and the goal of the experiment course. At the same time, it should be combined with the content of the instrument analysis theory course, and as much as possible to complement the content of the theory course.

For example, an experimental item in instrumental analysis experiment is "Determination of caffeine content in tea by HPLC". This experimental project usually uses the standard curve method for quantitative analysis. The standard curve method is a commonly used method for content determination in instrumental analysis methods. Therefore, the first cognitive goal of the experimental project is to master the method for caffeine content determination by the standard curve method. In addition, according to the course of instrumental analysis theory, there is an obvious difference between high performance liquid chromatography and gas chromatography, that is, the separation result can be improved by changing the mobile phase ratio, so how to change the mobile phase ratio to improve the separation result of liquid chromatography? If this knowledge point is only explained by the teacher in the theory class, it is undoubtedly abstract for the students, difficult to understand deeply, and unable to use flexibly. Therefore, this knowledge point can be introduced into the experimental inquiry content, so that the students can draw their own conclusions from the experiment, deepen their understanding of this knowledge point, and make the theoretical teaching content concrete through the experiment, so it is determined that the second cognitive goals: to master the method of improving separation by changing the proportion of mobile phase.

Application of Inquiry Teaching Mode in Instrument Analysis Experiment Course

After confirming the cognitive goal of the experimental project, how to apply the inquiry teaching mode to the instrumental analysis experiment? The following steps should be included.

Step 1: Before the experimental class, the experimental teacher puts forward the questions to be explored according to the cognitive objectives of each experimental project. The students are divided into groups of 2-4 people in each group. Based on the inquiry content put forward by the teacher, they consult the literature, design the experiment plan and submit it to the teacher for review. The teacher points out the feasibility of the experiment plan and whether it needs to be modified. The students modify the plan according to the teacher's suggestions until the experiment plan is feasible.
Step 2: In the experimental class, the teacher first demonstrates the operation method of the instrument. After the students master the operation method of the instrument, students of each group complete the experiment and record the experimental data according to the designed experiment plan before class.

Step 3: After the experimental class, students of each group process data, summarize the conclusion according to their own experimental results, and submit experimental reports or papers to the teacher. The teacher evaluates the experimental results.

For example, the experimental project "Determination of caffeine in the tea by HPLC" mentioned above has two cognitive objectives. Before the experimental class, according to these two cognitive goals, the experiment contents explored by students include two parts: one is to determine caffeine content by standard curve method, the other is to improve the separation effect by changing the composition of the mobile phase. Students are divided into groups. According to the inquiry content put forward by the teacher, they can consult the literature, design the experiment scheme, and submit it to the teacher for review to determine the feasibility of the scheme. In the experimental class, the teacher first demonstrates the operation method of the high performance liquid chromatography instrument. After the students master the operation method of the instrument, they complete the experiment according to the predetermined experiment plan. After the experimental class, according to the experimental results, students can process the data, get the caffeine content in the tea, and summarize how to change the composition of the mobile phase will improve the chromatographic separation effect, then submit the experimental report or paper to the teacher, and the teacher will evaluate the experimental results.

When the experimental teachers evaluate the experimental results, they should pay attention to that under the mode of inquiry teaching, the experimental results can not only be evaluated according to the information provided by the experimental report or the paper, it should be the weighted average of the scores of all the experimental items. And the evaluation of the scores of each experimental item should be the comprehensive embodiment of the design of the experimental scheme, the experimental operation, the experimental report or the paper. Otherwise, students will only pay attention to the results and not to the experimental process [10,11].

After the evaluation of the experimental results, we should calculate the achievement degree of the cognitive goals of each experimental project, find out the weakness to achieve the cognitive goals and the reasons for the weakness, and further improve and perfect the teaching mode.

Summary

The traditional teaching mode of instrumental analysis experiment is changed, and the inquiry teaching mode is applied to the course of instrumental analysis experiment. According to the cognitive objectives of each experimental project, the content to be discussed by students is determined, and the randomness of the content to be discussed is overcome. A set of scientific and operable experimental teaching mode is established, and further improved by the achievement degree of cognitive objectives. The application of inquiry teaching mode in instrumental analysis experiment makes students become the main body of learning, changes the passive acceptance into active inquiry, makes students explore independently, summarize and draw conclusions from the experimental data, which is helpful for students to establish the most intuitive and profound understanding of the instrument and equipment and its analysis methods, and cultivate the practical ability and scientific research ability.

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References


