ISSN:2790-167X DOI: 10.56028/aehssr.4.1.218.2023

Exploration on the Teaching Reform of Instrument Analysis Experiment

Juanjuan Gao [1, a]

[1]College of Chemistry, Jilin University, Changchun 130012, Jilin, China

[a] jjgao@jlu.edu.cn

Abstract. Instrument analysis experiment has an important role in improving students' research awareness and research ability. However, the current instrument analysis experimental teaching is mostly a mere formality and fails to really improve the experimental teaching effect. This paper proposes solutions at the university, teacher, and student levels, respectively. By increasing open experimental projects, adding virtual experiment simulation system, introducing mind maps and other means to stimulate students' interest in learning and operating instrument analysis experiment, cultivating their ability to think independently, practical skills and innovative consciousness.

Keywords: instrument analysis experiment; open experimental projects; virtual experiment simulation system; mind maps.

1. Introduction

Experimental teaching is a very important part of undergraduate chemistry education in higher education. Because only through practical education can we cultivate a group of compound high-quality talents with strong practical ability, good innovation awareness, broad scientific vision and high comprehensive quality for the society. However, in the traditional teaching system, the content of chemistry experiments is old and the students are not exposed to new instruments, new knowledge, new methods and new techniques. This prevents them from improving their experimental innovation and scientific thinking ability, which is contrary to the concept of sustainable development and innovative talent training model of modern chemistry. In addition, the teaching mode lacks innovation. most of them adopt "duck-feeding" teaching . students do not have enough pre-lab study and lack understanding of theoretical knowledge and experimental procedures, which is not conducive to the cultivation of their innovative consciousness and independent thinking ability. In addition, the influence of laboratory facilities, management system and laboratory hours seriously affects students' enthusiasm and initiative in chemical experiment operation[1-5].

Based on the above problems, the reform of experimental system is very important in cultivating high-level talents. Instrument analysis experiment is an important part of university chemistry experiments, generally including the basic skills of experimental operation, the analysis of experimental spectrograms and the processing of detection data, which can effectively cultivate students' motivation and innovation ability[6]. By sharing high quality resources, students are exposed to large instruments such as atomic absorption spectrometer, electrochemical analyzer, UV-Vis spectrophotometer, gas chromatography, etc. This enables students to master the basic knowledge about the usage of instruments and lays a good foundation for future scientific research or completion of thesis. However, due to the lack of funding for higher education institutions, for each type of large instrument, there is usually only one or two units in the laboratory, which leads to students having to perform experiments in groups. In this case, it is inevitable that some group members desert and do not operate by themselves. In addition, due to the limitation of students' credit hours, the teacher needs to prepare the required reagents in advance, and students only need to follow the textbook and the teacher's explanation to operate. Moreover, students usually copy the contents of the guide book when writing the preview reports, and copy other students' experiment summary reports when processing experimental data, lacking independent thinking. Besides, some instrument analysis experiments will involve flammable, explosive, corrosive or toxic chemical

ISSN:2790-167X DOI: 10.56028/aehssr.4.1.218.2023
reagents. For the sake of students' safety, teachers usually choose video teaching, and students only need to operate part of the experimental process [7], which makes the teaching of instrument analysis experiment merely formal and greatly reduces the experimental teaching effect.

To address the problems faced in instrument analysis experiment teaching, reforms can be made at the university, teacher, and student levels.

2. Reform measures

2.1 From the university level

2.1.1 Increase open experimental projects

Increase open experimental projects, expand credit hours, and open chemistry laboratories on all fronts. The experimental content can be selected from subjects related to students' major or closely related to social production and life, such as determination of glucose content in beverages by electrochemical analysis, determination of preservative benzoic acid in soy sauces by gas chromatography, etc. It is also possible to introduce young teachers' research projects, such as the preparation of electrochemical electrode materials, etc., with experimental time chosen by students freely. In addition, Opening chemistry laboratories on all fronts and expanding credit hours requires more time and stamina from teachers. A program of teacher mentoring supervision and student supervision can be used[8]. In the first lesson, the teacher explains the experimental content, demonstrates the operation of the instrument and puts forward precautions, and then students can find time to explore on their own, with the teacher providing assistance at the appropriate time. At the same time, the open experimental projects should be managed with the help of network information technology platform, uploading the names of experimental projects, experimental principles, experimental steps and process arrangements, etc. Students can choose the more interesting experimental projects and make reservations through the network platform[9].

2.1.2 Introduce the virtual simulation experiment system

Introduce the virtual simulation experiment system to make the combination of online and offline experiments. Let students pre operate the virtual simulation experiment system and write pre-reports, and then conduct offline experiments. This can not only improve students' enthusiasm, but also cultivate their ability to think and solve problems. For example, Mlabs software developed by MoolsNet company set up practice mode and exam mode. In the practice mode, there is a prompt function. In the exam mode, this function is turned off. Mlabs also set up "online help" function, stating the purpose, principle and operation steps of the experiment, which can help students better understand the experiment content and master the operation skills. In addition, the instrument analysis experiment section of the Mlabs lists many scientific research instruments, such as nuclear magnetic resonance (NMR), scanning electron microscope (SEM), X-ray photoelectron spectroscopy (XPS), high-resolution transmission electron microscopy (HRTEM), etc. Due to the high cost, these instruments have not been used for offline undergraduate experimental teaching, but through the virtual simulation experiment system, students can not only complete the entire virtual experimental operation, but also understand the experimental principle more deeply through the animation demonstration and virtual disassembly teaching. Compared with the closed mechanism of actual large-scale instruments, this is a major advantage of virtual simulation experiment teaching[10]. In addition, due to the difference between virtual experiment teaching and offline experiment teaching, it enables students to master more experimental skills. For example, the instrument involved in the atomic absorption experiment in the Mlabs software is graphite furnace atomic absorption, while the instrument involved in the offline experiment is flame atomic absorption. Through the study of online and offline experiments, students can master two atomic absorption methods at the same time.

ISSN:2790-167X DOI: 10.56028/aehssr.4.1.218.2023

2.2 From the teacher level

2.2.1 Before experimental class

Introduce mind mapping into the preview report of instrument analysis experiment. Most students only copy the content of the textbook or the handouts without thinking and analyzing when they write the preview report, which leads to a little understanding of the experimental content when they actually operate. This is not conducive to the cultivation of students' innovative consciousness, so it is particularly important to introduce mind mapping into experimental teaching.

Mind mapping is to start from a theme, conduct hierarchical and classified management of related information, establish an orderly divergent mind map, and guide and record the thinking process. You can use natural curves, keywords and other methods to sketch the thinking process information on white paper, or you can use computer software such as Word, PowerPoint and other software to draw[11]. For basic instrument analysis experiment, let students preview and make a mind map based on the experimental textbook, listing the purpose, principle, steps and unsolved problems, etc. For the difficult problems, the teachers help solve them in class[12]. For the open instrument experiment, take the determination of iron content in vinegar by flame atomic absorption method as an example. Fig. 1 is a student's mind map. Atomic absorption spectrophotometry is a quantitative analysis method using the absorption degree of the ground state atom of the element to the characteristic radiation. The general steps of quantitative analysis include sample pretreatment, sample determination, result calculation, etc. The experiment is divided into four parts: experiment purpose, experiment principle, experiment steps and instrument structure. The instrument structure includes light source, atomizer, spectroscopic system and detection system. The experimental steps are divided into sample pretreatment, solution preparation and test. Sample pretreatment generally includes wet digestion, dry digestion, microwave digestion and ultrasonic extraction. Solution preparation includes intermediate solution preparation and standard series solution preparation. The test includes precautions and test procedure. After making the basic mind map, students can explain each item of the mind maps and write the experimental design scheme by consulting the literature. For example, which digestion method is used for sample pretreatment and which instruments and reagents are involved. When preparing standard series solutions, the concentration of unknown samples should be located in the middle of the standard curve as much as possible. For this reason, students should first check the content of Fe element on the vinegar outer packages, then calculate the content of Fe element in the pretreatment sample according to the dilution multiple, and then design the concentrations of the standard series solutions. In the experimental class, students can improve the experimental scheme according to the actual experimental results, with the teacher providing guidance on the side. The mind map enables students to understand the experimental content at a glance and establish the initial scientific thinking, which is important to improve their innovation and scientific research ability.

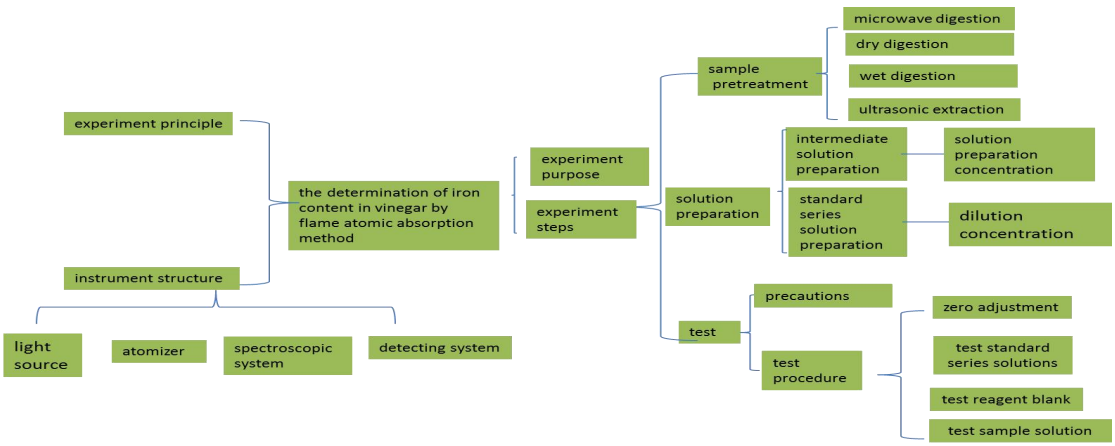

Fig. 1 The mind map of atomic absorption experiment

ISSN:2790-167X DOI: 10.56028/aehssr.4.1.218.2023

2.2.2 In experimental class

The teacher should first explain the construction of the instrument and the experimental principle, check the preview reports of the students, and improve the unreasonable areas. When students are carrying out the experimental operation, the teacher should pay attention to them at any time, so as to give timely guidance when they encounter problems. At the same time, if students' operation is not standardized, the teacher should correct it in time. In addition, the teacher should give each student an experimental data card so that they can record the original data and experimental phenomena in time. After the students finish the experiment, the teacher should grade the performance according to the students' operation process and experiment results, and assign the task of writing experiment summary reports. The experiment summary report should include experimental design scheme, experimental data processing, experimental results and discussion, error analysis, etc[12]. Besides, open instrument experiments can be conducted by students in groups. For the problems encountered in the experiment, let them pool their ideas, discuss the problems and find solutions. This is conducive to cultivating students' enthusiasm and team spirit. In addition, for the broken instruments to be scrapped, they can be disassembled and explained so that students can have a visual impression of the construction of the instruments. Moreover, students can also be encouraged to use the learned knowledge and easily available experimental materials to make experimental equipments by themselves.

2.2.3 After experimental class

For basic instrument experiments, it is necessary to integrate the experimental preview report, experimental operation, and experiment summary report, and score them in an appropriate proportion. For the open instrument experiments, in addition to the experimental preview report, experimental operation and summary report, the degree of completeness of the pre-reviewed literatures and design scheme should also be considered. At the same time, for the errors or problems in the experimental summary report, teachers can use the online learning platform to initiate online Q&A sessions to explain to students one-on-one and timely help them solve their problems[7].

2.3 **From the student level**

The experimental subjects arranged by teachers or the subjects selected by themselves should be taken seriously. Before the experimental class, the literature and relevant materials should be fully consulted and the preview report should be carefully written. Be diligent in thinking when operating experiments in the experimental class. After the experimental class, write a summary report carefully. In addition, students should also learn to use Word or Origin software to process experimental data. The purpose of instrument analysis experiment is not only to cultivate students' practical ability, but also to improve their ability to innovate and solve problems independently. So when students encounter experimental problems, they should first find their own solutions, and then seek help from the teacher if they cannot solve them. For example, in the combustion heat measurement experiment, the nickel wire is required to contact the sample tablet but not the crucible, otherwise it will cause a short circuit and the sample tablet will not burn. According to the operation steps in the guide book, many students failed in the experiment. To solve this problem, some students proposed to replace the iron crucible with a porcelain crucible and some students proposed to bind the tablet with nickel wire first, then fix them with cotton thread, and then tie the two ends of the nickel wire to the electrodes on both sides to keep the tablet in suspension. Therefore, as long as students are diligent in thinking, many problems will be readily solved.

3. Summary

The teaching reform of instrument analysis experiment is a long-term systematic project. Universities and teachers should always take the cultivation of students' experimental interest,

ISSN:2790-167X DOI: 10.56028/aehssr.4.1.218.2023
innovative consciousness and scientific thinking as the guide. By making full use of modern technology, improvements are made from many aspects, such as expanding open experimental projects, adding virtual experiments, introducing mind maps and so on, so as to provide students with a good experimental environment and constantly improve the experimental teaching effect in practice.

References

[1] Zheng Huiqin. Optimization of chemistry experiment course system and reform of teaching mode in application-oriented college. Chinese Journal of Chemical Education, 2017, 38(14): 10-14.

[2] Huang Zhongchen, Han Fang, Wang Lihua. Reform of atomic absorption experiment teaching. Research and Exploration in Laboratory, 2010, 29 (8): 125-126.

[3] Li Junbo, Liang Lijuan, He Yuxin. Exploration and practice of the reform of college chemistry experimental teaching system in engineering colleges. Education Modernization, 2009, (85): 94-96.

[4] Liu Yulei, She Ming. Exploration on the construction of college experimental teaching system under the background of "new engineering". Experimental Technology and Management, 2009, 36 (11): 19-22.

[5] Jiang Lili, Geng Shudong, Liu Guanchen, et al. Exploration of new experimental teaching mode for material chemistry specialty in local engineering colleges and universities. Journal of Jilin Institute of Chemical Technology, 2019, 36 (8): 17-20.

[6] Tang Yinan, Sheng Hanjing, Lu Ya, et al. Strengthen the application of instrumental analysis in comprehensive experiments of organic chemistry in independent undergraduate colleges. Shandong Chemical Industry, 2020, 49(24): 151-153.

[7] Yuan Yiping, Luo Ming, Hu Yueyue, et al. The exploration of college chemistry experiment teaching mode in the post-epidemic era. Chemical Enterprise Management, 2022, (25): 37-41.

[8] Zhang Hua. Research on open teaching mode of analytical chemistry experiment. The Farmers Consultant, 2017, (10): 155.

[9] Teng Qiaoqiao, Jiang Weihua, Meng Qi. Exploration of innovative opening experiment teaching in organic chemistry. Guangdong Chemical Industry, 2019, 46 (24): 99.

[10] Zhu Pingping, Feng Hongyan, Shao Wei, et al. Innovation and effect for online assisted teaching mode in college chemistry experiments under internet background. University Chemistry, 2020, 35 (5), 278 – 282.

[11] Hui Cenyi, Zhou Yijun, Wang Wenshu, et al. application of mind mapping in organic chemistry experimental teaching in universities. Research and Exploration in Laboratory,2013,32(3):153-157.

[12] Wu Hongmei, Guo Yu, Zhang Zhenbin, et al. Reform of teaching mode of organic chemistry experiment for enhancing independent creativeness of undergraduate students. Chinese Journal of Chemical Education, 2014, (14): 34-36.