Analysis of the Application of Virtual Simulation Software in Food Testing Technology Course with Atomic Absorption Spectrum\textsuperscript{1}-- Taking the Example of Determining Calcium in Drinking Water by Atomic Absorption Spectrometry

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Abstract: Atomic absorption spectrometry is the core content of instrumental analysis and also one of the most commonly used skills in modern detection positions. It can improve the teaching effect to train students on this skill with virtual simulation software. In this project, the experimental group (virtual simulation teaching) and the control group (traditional teaching) were adopted to make a check test in the teaching project of determining calcium in drinking water by atomic absorption spectroscopy, with the purpose of introducing information teaching means and improving teaching quality with simulation software.

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1. Introduction

Atomic Absorption Spectrometry (AAS)\textsuperscript{[1]} is also called atomic absorption spectrophotometric analysis. Atomic absorption spectrum\textsuperscript{[2]} analysis is characterized by high sensitivity, good precision, high accuracy and fast analysis speed, so it is widely used to measure directly more than 70 kinds of trace metal elements in samples such as rock ore, soil, air particulates, water, plants, food and biological tissues and non-metallic elements and their compounds such as sulfur, nitrogen and halogen with an indirect way. This method is widely used in environmental protection, chemical industry, biotechnology, food science, food quality and safety, geology, national defense, health inspection, agriculture and forestry science and other departments.

2. Advantages of Virtual Simulation Software for Atomic Absorption Spectrophotometer\textsuperscript{[3]}

The virtual simulation software of atomic absorption spectrophotometer can help students master the method of atomic absorption spectroscopic analysis quickly and effectively. In the laboratory, due to the insufficient quantity of machines in colleges and universities, students have little time and less opportunities to manipulate. Meanwhile, large analytical instruments are expensive, so it is impossible for students to practice at any time. Through virtual experiment of instrumental analysis\textsuperscript{[4]}, students

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can easily understand the experimental steps and the operation process of instrument and equipment, master the basic principles and operations of the experiment and greatly broaden the depth and breadth of experimental teaching, which can perform a rehearsal for the computer practice. Students can also intuitively understand each part and the internal structure of the instrument through virtual experiment of instrumental analysis[5], and repeat the unsatisfactory or unskilled practices to really improve their experimental skills.

3. Research Process

3.1. Experimental methods
Select virtual simulation teaching group and traditional teaching group for comparison. Choose Class 1 of 2017 Food Testing Technology (37 students) as the experimental group with virtual simulation teaching, while Class 2 of 2017 Food Testing Technology (38 students) as the control group with traditional teaching to attend the class named "instrumental analysis". The teaching program for measuring calcium in drinking water[6] with atomic absorption spectroscopy was selected for a check test. After this teaching project is completed, use the measurement data of calcium[7] ions in water for evaluation.

3.2. Statistical Method
Use SPSS13.0 software to process the data, represent the measurement data with \((x \pm s)\), compare each group by t test, with \((P<0.01)\) as the difference, which has the statistical significance. Use descriptive statistical analysis to calculate the frequency distribution of survey data.

3.3. Teaching Activities of Experimental Group

3.3.1. Pre-Class Activities
Teachers upload course materials, release preview notices, divide students into groups according to tasks and skill levels, upload group assignments and understand the working principle of AAS according to simulation software.

3.3.2. Class Activities
Teachers summarize six operating steps, namely "light, power on, set up, fire, measure and power off" to complete the task of determining calcium in drinking water by virtual simulation software of atomic absorption spectrometry. Students make simulation operation and summarize the problems in operation in group.

Figure 1 shows the factors affecting the stability of atomic absorption spectrophotometer.

![Figure 1: Factors affecting the stability of atomic absorption spectrophotometer](image-url)
3.3.3. Main Issues

Find out some differences between actual computer practice and virtual simulation software: 1. long time for power-on self-test and peak searching; 2. different icons of online software, marked on the operating instructions; 3. different concentrations of standard solution: standard solution concentration is 0, 0.5 and 1.2 ug/ml when operating virtual simulation software, and is 0, 1, 3, 5 and 7 ug/ml when in computer practice, with 2 parallel samples; 4. generally, setting parameters can keep in their default state and do not need to be modified; 5. the pressure of air compressor is 0.2-0.3MPa and that of acetylene is 0.05-0.08MPa.

3.3.4. Computer Practice

Organize students to make computer practice after mastering the operating steps of AAS by using simulation software. Divide the students into four groups and the water needing to be measured by each group is as shown in the picture below:

![Figure 2: Students' water sample](image)

After the end of the project, students in the experimental group and the control group make a statistical comparison on the correlation coefficient and time.

| Serial number | Measurement object | Sample ID | Abs | Concentration [μg/ml] | Actual concentration [μg/ml] | SD | RSD [%] | Date            | Time          |
|---------------|--------------------|-----------|-----|-----------------------|-------------------------------|----|---------|----------------|---------------|
| 1             | Standard sample    | -0.000    | 0.000 | 0.0003                | -84.8018                     |    |         | October 20, 2020 | 09:29:46      |
| 2             | Standard sample    | 0.033     | 1.000 | 0.0008                | 2.4395                       |    |         | October 20, 2020 | 09:30:18      |
|   | Sample   | Calcium D | Abs   | Concentration | Date/Time       |
|---|----------|-----------|-------|---------------|----------------|
| 3 | Standard | 0.068     | 2.000 | 0.0014        | October 20, 2020 09:30:42 |
| 4 | Standard | 0.108     | 3.000 | 0.0018        | October 20, 2020 09:31:07 |
| 5 | Standard | 0.148     | 4.000 | 0.0008        | October 20, 2020 09:31:29 |
| 6 | Standard | 0.221     | 6.000 | 0.0011        | October 20, 2020 09:36:04 |
| 7 | Sample   | 0.000     | 0.057 | 0.0002        | October 20, 2020 09:36:45 |
| 8 | Sample   | 0.147     | 4.030 | 0.002         | October 20, 2020 09:37:23 |
| 9 | Sample   | 0.145     | 3.976 | 0.0011        | October 20, 2020 09:38:01 |

Figure 3: Sample chart of experimental group's calcium determination

![Sample chart of experimental group's calcium determination](image)

Figure 4: Sample of calcium correlation coefficient in experimental group

![Sample of calcium correlation coefficient in experimental group](image)
4. Results
The experimental group and the control group make a comparison on the time to complete the teaching project of determining calcium in drinking water by atomic absorption spectrometry with differences of statistical significance (P<0.01), as shown in Table 1.

Compare the experimental results of the experimental group and control group, and the differences are of statistical significance (P<0.01). The experimental effect is greatly improved (as shown in Table 2).

Table 1 Comparison of experiments between the experimental group and control group (x±s, min)

| Group            | n  | Sample pretreatment time | Computer testing and data processing time |
|------------------|----|--------------------------|------------------------------------------|
| Experimental     | 10 | (54.9±3.93)              | (25.4±1.43)                              |
| Control          | 10 | (75.0±4.55)              | (34.2±2.15)                              |

Note: Compare with control group, P<0.01;

Table 2 Comparison of experimental results between experimental group and control group (x±s, min)

| Group            | n  | Experimental measurement | The proportion of correlation coefficients >0.999 (%) | The proportion of relative errors >6% (%) |
|------------------|----|---------------------------|-----------------------------------------------------|----------------------------------------|
| Experimental     | 10 | (2.48±0.05)               | 87.5                                                | 62.5                                   |
| Control          | 10 | (2.39±0.09)               | 85                                                  | 72.3                                   |

Note: Compare with the control group, P<0.01.

5. Conclusion
The application of virtual simulation software system of atomic absorption spectrometry can stimulate students' interest in learning and solve the problem of lack of large analytical instruments. Through the use of virtual simulation software system, students can understand the experimental principle and master the operation steps of the instrument before computer practice. The students' autonomous learning ability has also been improved by repeated practice for the key points of operation, with remarkable experimental teaching effect, which is worthy of promotion in experimental courses such as instrumental analysis.

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