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The Design and Application Effect of Positioning Plate for Chemical Experiment in University Chemistry Experiment Teaching

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***Abstract*—With the expansion of Chinese universities, the speed of school introducing new teachers and the construction of experimental classrooms has produced a significant hysteresis quality due to the rapidly growing number of students. Moreover, because the laboratory has higher requirements than the ordinary classroom construction, the supporting hardware is more or the transformation cost is high and the cycle is long, laboratory resources have always been a key factor in limiting student productivity. Under the existing teacher conditions and laboratory conditions, how to mobilize students' sense of autonomy has always been a difficult problem to solve. After a long period of first-line teaching work, a set of practical positioning plate system for laboratory experiment teaching classrooms was explored. Through the humanized design and supporting laboratory operating principles, it can mobilize students' independent consciousness, so that students can get rid of the group psychology, consciously regulate their own experimental behaviors and steps, reduce external disturbances, reduce random movements and misuse of articles, effectively reduce the experimental failure rate and reduce the total duration of experiments.**

Keywords—chemical positioning plate; chemical experiment class; design

I. INTRODUCTION

The university's chemistry and biology labs are different from the mechanical and electronic lab courses. Students need to acquire more skills of tools usage and reaction principles. The operation specifications of each tool are complicated, and there are many points to pay attention to. It is difficult to master them without a lot of exercises. These skilled operating skills require students to have a strong willingness to spend their spare time deliberately practicing [1], as well as a school open laboratory to provide students with a place. From the school's system of open laboratories, there are indeed related policies to ensure that the laboratory is open to undergraduate students to do experiments. However, the actual situation is that students will only use the open laboratory during the period of the graduation thesis or some projects, and the laboratory is not equipped with experimental teachers. The experimental process of the students is difficult to supervise. Students who have been deliberately trained to practice experimental operations have not yet been discovered. Students may not have the willingness to practice deliberately. The following points may be met:

- The compulsory lab is too random, making it difficult for students to establish scientific awareness.
- Fear of experimental failure, irregular operation caused the experimental data to fail to verify the expected results, students lost interest in the experiment.

In view of the above problems, this paper describes the experimental teaching team to gradually establish the students' scientific awareness and normative consciousness by introducing the positioning plate. Under the premise of not emphasizing the initiative, the use of the design induction mechanism [2], and the sub-conscious matching guidance mechanism enable students to achieve high standards of self-determination, so as to obtain the expected training effect. From the feedback of students, the positioning board is operability, scalability, and easy to organize. There were no negative effects in the long-term trial. It can be promoted nationwide, and even university research institutes can promote it.

II. CHEMICAL POSITIONING PLATE

The chemical positioning plate is a thin plate used to position glassware, small tabletop instruments, and small tools. Before the experiment, according to the items used in the experiment, the order of the items that can be used, the position of the items that can be used, according to the vertical projection shape of the articles used, the actual size of the positioning plate lining is designed, and then the inner lining is plastically sealed into a positioning plate with hardness and toughness. Through design optimization, the application of the item and the basic information form of the operator can be filled into the lining of the positioning plate. The upgraded version of the chemical positioning plate can be used to make the waterproof shape of the standard glassware and other objects to be positioned, and directly attached to the blank lining chemical positioning plate according to the relevant procedures and requirements of the

experimental class. The upgraded version of the chemical positioning board has the advantage of not requiring the size of the item and does not require to be familiar with computer and design software. As long as the students understand the experimental process, they can easily make the corresponding chemical positioning plate, and they can find the positioning sticker that needs to be adjusted during the trial and reposition it. "Fig. 1" is a real-life picture of the positioning plate used by the students in the instrumental analysis experiment class. This positioning plate requires professional designers to position the measured glassware on the A3 paper (see "Fig. 2"), and then plastically seal it. The lower right corner of the positioning board is the content information of the experimental participants. Students use the Mark pen to sign on the plastic film. After the experiment, the names can be erased with ethanol, which can achieve the purpose of repeated use. On the upper stage, there is no reagent placement for the positioning plate, which is a reference sample for the typical laboratory reagents.

Fig. 1. Chemical positioning plate real map.

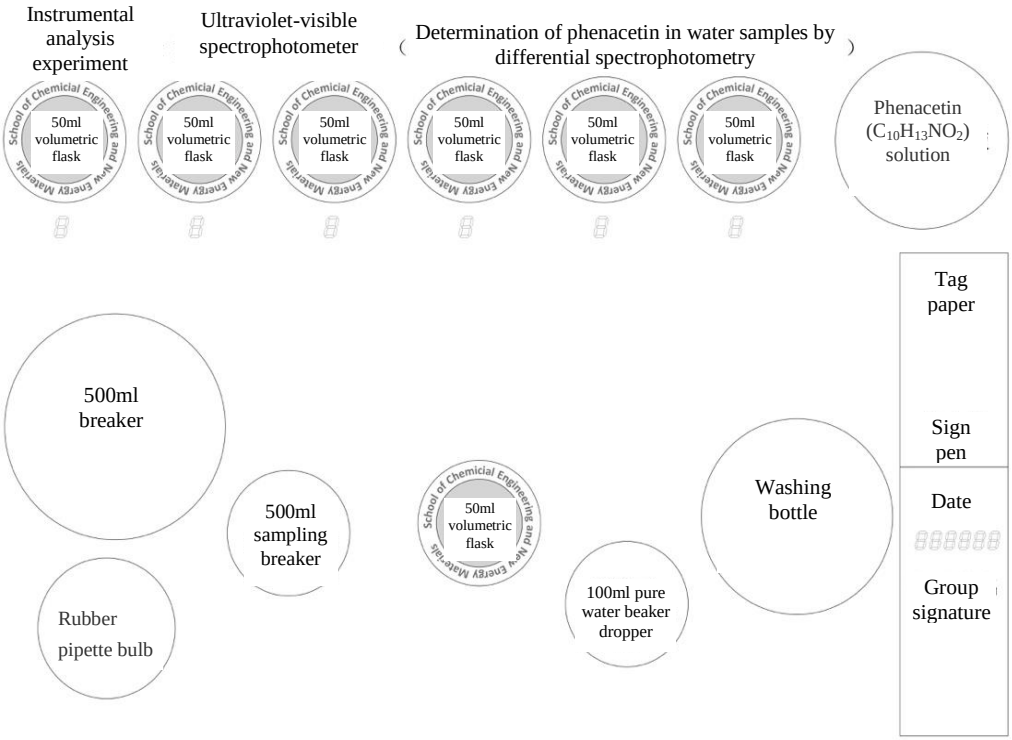

Fig. 2. Chemical positioning plate design.

III. Some of the Conditions That Affect the Experimental Process in Chemical Experiments

In the years of experimental teaching courses, the following general phenomena are found.

A. The Situation That Students Can't Find Specific Glassware or Reagents

In most cases, they are on his desk, but they are really invisible, just like holding a mobile phone to find a mobile phone. At this time, students will have two behaviors: asking the teacher for glassware and going to the next table to take the glassware of the others.

Sometimes the teacher is standing in front of the laboratory. The teacher is also inert, and often the spare glassware is given to the students. Students who took glassware at the neighboring table generally couldn't remember to return the items, causing the item not to be in the location.

B. The Situation That Students Break Glassware During the Experiment

There will be four common behaviors:

- The students will take the broken glassware and ask the teacher for a new one. (In this case, the student is subject to penalty points or currency penalties.)
- The students would like to hide the broken glassware or sneak it into the trash can, and then use the glassware used by nobody in the lab or borrow the classmate's to use.
- If the experiment is done, the glassware that was broken during the process of cleaning up the desktop, students may choose to hide directly, and nothing happens when they do.
- Although the glassware is broken, it is kept in use without being completely damaged or placed on the table when it is intact. In this case, the next group of students who did the experiment will find that it is a broken glassware. When the class is just in class, they will ask for a new one from teacher. At this time, it is difficult for the teacher to determine who broke the glassware in the last class.

C. The Situation That Some Items Students Do Not Know What to Do with, or the Items Do Not Belong to What Is Needed in This Experiment

In the experiment, there may be multiple glassware of the same model, but the uses are different. For example, two small beakers (50 mL) appear in "Fig. 2". One is for sampling and the other is for constant volume. If there is no chemical experiment positioning plate, it is difficult for students to distinguish the use of two beakers from the perspective of the entire experimental process. This is the principle of discernability of information in design [3]. Usually the student's experiment is to do one step and then see what to do next. There is also a case where there is a period between the two experiments in the same laboratory. This interval is to ensure that the experimental teacher overhauls the instrument, supplements reagents and supplies. During this period, there may be some extra circumstances that cause the lab to have extra items and not clean up in time. After a long time, there will be various items in the laboratory, including items that are not used, disposable items that have been used, items that have been damaged but not thrown away, and particularly small items such as magnetic rotors. There are student's personal items such as books, notebooks, and pens. There are also other things such as aging items that are not suitable for continued use, such as rubber tubes. These items exist in the laboratory first to give the students a sense of confusion in the laboratory, and then the students will find the items that can be replaced in the laboratory to make emergency response when the experiment encounters problems. These items particularly affect the overall experimental experience of the students. It is the purpose of the experimental class to make the experimental phenomenon. In fact, the whole process quality monitoring of the experiment is the focus of all the experimental courses. Since it is impossible to supervise the whole experiment of everyone in reality, self-monitoring is a new concept that the experimental class should recognize. The students' mistakes, the teacher often said that he had all explained it, but they still made mistakes and complained from time to time. In the author's opinion, since it is a common phenomenon, confessing is equal to not explaining, a more effective solution must be came up with. Complaining that the level of students is not enough is not a responsible educational philosophy.

There is also a case where the items used in the experiment were found on the wrong table. For example, the case of reagents on the wrong table often occurs. The reagents on the table were not seen by the students. The students thought that there was no reagent, so they went to the neighboring table to take the reagents from other tables. Since the other tables may have been finished the experiment, no one has supervised the location of these reagents.

D. The Situation That the Experiment Teacher Did Not Put All the Items Needed for the Experiment or Put More Items That Were Not Needed

In experiments with more supplies, the experiment teacher may miss items or use some items that can be temporarily replaced due to insufficient stock. This does not have much impact on the completion of the experiment, but it has a very bad demonstration of the cultivation of students' scientific attitude.

After three years of actual verification, we have confirmed that we should not try to meet the special equipment for each step in the experimental design. Because sometimes the same appliance appears in multiple programs, it is sufficient to provide only one, such as repeatedly using the measuring cylinder to measure different liquids. Preparing a measuring cylinder when measuring a liquid will increase the number of desktop items and take up too much space. The measuring cylinders of different specifications should be determined based on the amount of liquid. Using as few as possible and as close as possible to the range are the two aspects to determine how much the items were needed. More than one thing requires students to judge with more thoughts. By reducing thinking, mistakes can be avoided.

E. The Situation That There Are Items in the Laboratory That Are Unrelated to the Current Experiment (Some Things That Can't Be Removed Can Be Left in the Lab with a Clear Logo)

The lab often keeps items that have not been cleaned up in the last experiment. These items are left in the lab, and students will mistakenly think that these are what they needed for the experiment when conducting new experiments. Due to the unfamiliarity of the experimental process, the items left over from the previous lesson are often used. In some cases, these items can also mislead students to build wrong experimental devices.

F. The Situation That Students Take Away the Laboratory Items and Medicines (Individual Appearance, and Extremely Difficult to Find)

For example, if a student breaks a mercury thermometer in a dormitory, he needs sulfur powder. Or there are students who take the rubbing paper back and wipe their glasses, take the filter paper back to filter the coffee, or other special needs or extreme events that cause laboratory drugs to be lost.

IV. Advantages of Using Chemical Experiment Positioning Plate and Matching Precautions

First, the earliest appearance of the design chemical positioning plate was to solve the situation in the case of the conditions mentioned in the last part. Students standing in front of their own laboratory can quickly determine whether the vessels required for the experiment are complete. The earliest chemical positioning plate only had the projected outline of the item and contained the item name specification information. The first version did not show information on the use of the item. After the improvement, the chemical positioning plate can show the information of the usage of the items, indicating such as waste liquid beakers, sampling beakers, pure water beakers, etc. to distinguish the same, or the purpose of the use of different specifications. Since the application of the chemical positioning plate, there have been many additional advantages that were unexpected. For example, in the cases mentioned in the last part, if the student breaks the item, the student cannot pass the acceptance test after completing the experiment. Because the chemical positioning plate reduces the burden on the teacher to inspect the desktop, the desktop that was previously incapable of being checked one by one due to the variety and confusion of the items becomes quick and efficient. The students have no possibility of getting away with it. They can only ask for a new one from the teacher when they just break the vessel. In the past, the situation that the glass shards were scattered in ordinary trash cans, drawers, and partitions has never happened again. For the situation of one of the cases mentioned in the last part, the trained students of Zhuhai College of Jilin University can collect the things that are not in this experiment and collect them in the glove box at the podium before listening to the course. The criterion is that something that does not appear on the positioning plate is something that is not part of this experiment. Of course, the water bath kettle and vacuum pump will not appear on the chemical positioning plate, but usually it will not be cleaned by the students. Some items are indeed items belonging to the experiment, but the position on the positioning plate has been occupied by one. The extra ones may be missed by other groups. Students need to put extras in the glove compartment at the podium. Students with missing items go to the glove box to find missing reagents or supplies. In fact, this situation is rarely happened, because the teacher would check the tables before the students go through the experiment, so the situation of the items on the wrong desk is rarely seen. In view of the situation of one of the cases mentioned in the last part, the chemical positioning plate that was originally used to check the completeness of the supplies for students, at this time, helps the experimental preparation teachers to check the readiness. Each group of required items, multiple sets of shared reagents, can be inspected with a chemical positioning plate. The inspection is simple and there are vacancies on the positioning plate, indicating that there is something missing. There is something but not in place, indicating that this thing is not what the experiment needs.

Second, the application of the chemical positioning plate reduces the time for the student's experimental operation. The reduced time includes the time to find the items, the time of borrowing the items or reagent back and forth, the time of thinking about the use of the item or thinking about a certain step without knowing which item to use, and the time of communication and discussion. Even the number of ineffective walking is reduced, and most of the time students can experiment in front of the experiment table without going to the pool.

Third, in actual use, students take the initiative to take photos and spread on social networks of the chemical positioning plates. The chemical positioning plate enhances the student's professional identity. At the end of the student's review, students can recall and think through the entire process of the simulation experiment by watching the positioning plate or the photos of the positioning plate. These pictures will be useful even after the student graduates.

Forth, the policies accompanying the chemical positioning plate must be strictly adhered to in order to use beyond the purpose of the chemical positioning plate, reducing randomness for cultivating scientific researchers' rigorous scientific attitude. It is particular important that there can't be items in the laboratory that are not related to the experiment. Related reagents must not appear two bottles if it should appear in one bottle. The items on the left should not be placed on the right side. Everything is normative only when it is in its original state. In the final acceptance state, students can be required to be standardized. At the end of the experiment, as long as the students emphasize the placement of the items in their pre-use, they can solve the irregular behavior and lazy attitude of most students with the least amount of energy. In the end, it can achieve the true purpose of education — not only to pass on knowledge, but also to change the behavior of students, to be a responsible person for their actions. Only by setting standards can students self-measure their levels of responsibility.

V. Difficulties in the Management of Chemical Positioning Plates

First, one of the difficulties is to unify thinking and try to use chemical positioning plates. It is not easy to change the experimental preparation habits of experimental technicians for many years. For example, in order to reduce the number of times of adding reagents, the experimenter will prepare multiple bottles of the same reagent on the stage at a time. Once the author was on the shift, the experimenter told the author about the matter, and told the author that the reagents for the pendulum did not matter. Of course, teachers can dispense some medicines or reagents at a time, but the teachers need to put them in a fixed place that students can't

easily get, such as a special reagent replacement box. When the reagent is not enough for the student, the teacher should replace the entire bottle of reagents instead of adding reagents to the reagent bottle. The instrument is also a process, the teachers only do on-site replacement, and it is not allowed to delay student time in the experimental class. In the experimental course, it will be important to try to avoid the need for the laboratory staff to deal with things on the spot, record the events, and optimize the experimental preparation process afterwards.

Second, the second difficulty lies in the increase of the workload of the teacher. In the past, when the items were randomly placed, it is impossible for the teacher to check the completeness of the experimental items one by one. Therefore, in the past, teachers did not need to carry out such inspections, and it was the job duties of the laboratory staff to check for missing. After applying the positioning board, the teacher can see the problem from the positioning plate at a glance. However, it has increased the work of teachers. It is believed that this involves the students' experimental habits. In the score book, students' experimental habits need to be scored. The specification of the experimental items should be the point of the teacher's supervision.

Third, the production of chemical positioning plates requires additional manpower and material resources, which requires the attention and support of the laboratory leaders. The production of chemical positioning plates also requires the experimenter to have a very clear understanding of the details of the experimental process and the actual situation of the operation. Positioning plates that violate ergonomics and impede experimental procedures should not be produced.

Forth, it is necessary to encourage students to come up with their feelings and suggestions on the use of chemical positioning plates. The reason for identifying and restoring its true feelings is whether its appeal really needs to change some of the default settings in the chemical positioning plates. Or other factors have caused poor performance on the positioning plates. For example, some people are used to using the left hand as the operator. Then they may need to make a mirror adjustment to the placement of the items.

VI. CONCLUSION

The chemical positioning plate has been developed from version 1.0 to version 2.0. Although the 2.0 version lacks normativeness compared to the 1.0 version, its flexibility makes the 2.0 version suitable for more scenarios. Students who have experienced the benefits of chemical positioning plates still want to make positioning plates and then carry out related experiments after work. Even some home environments, factory environments, and business environments can use similar positioning boards to regulate behavior. It is particularly important that it is easy to make. It is recommended that the schools should still apply version 1.0. Normative design can lead to normative behavior, which is more applicable to the student community.

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