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Research Article

Using Virtual Experiments in Lessons on Oxygen - Sulfur Chemistry 10 to Develop the Experimental Chemistry Competency for Students in Teaching

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Abstract

The experimental chemistry competency is considered to be the core and specific competency that needs to be formed and developed for students in chemistry education. In recent times, there have been some educators and teachers interested in researching these capacity development measures for students. This article researches the principle, suggests the process of virtual experimental construction of oxygen - sulfur chemistry 10, and applied in teaching to students at the high school in Tay Ho-Hanoi for the school year 2019-2020. The initial experimental results show the feasibility and effectiveness of using virtual chemical experiments to develop chemistry experimental competency for students in teaching chemistry.

Keywords: Experimental chemistry competency; Virtual chemistry experiments; Students

Introduction

The application of information technology in teaching to meet learning needs in the context of the Fourth Industrial Revolution has opened up the innovation of teaching methods towards developing competency for students and is also the indispensability of education innovation. One of the core and specific competencies is the experimental chemistry competency that is formed and developed for students by using many different measures, including the construction and use of virtual chemistry experiments. In addition, the experimental chemistry competency helps students remember and understand the nature of the taught knowledge and use such knowledge flexibly and accurately to do chemistry exercises and to settle practical situations. The experimental chemistry competency is just a basis for students to integrate into the world in the professional field as well as the future life. Scientists and teachers in the world as well as in Vietnam have been interested in researching the construction and use of virtual chemistry experiments at high schools. Some recent studies showed that the use of virtual chemistry experiments is highly economical and especially appropriate for current teaching at high schools in the context of lack and non synchronization of experimental facilities and equipment. Teachers can conduct and describe virtual experiments and instruct students to carry out practice by using pieces of software in case of experiments that are toxic and difficult to observe and easily cause danger as in oxygen - sulfur chemistry 10 [2]. Besides, virtual chemistry experiments are used as a preparatory tool which helps improve the experimental chemistry competency for students [7] and [8]. According to [12], the report on the improvement of students' learning when using virtual chemistry experiments, we think that the use of virtual experiments combined with actual laboratory activities in teaching will create good conditions for students to develop their skills and competencies, including the experimental chemistry competency.

Definition and structure of the experimental chemistry competency

According to the document [4], "experimental chemistry competency" of students is *students' ability to use their existing or acquire knowledge, skills, and experience to design and organize the safe and successful conduction of chemistry experiments and scientifically explain the observed experimental phenomena in order to draw necessary conclusions and then form new knowledge and skills and apply* *them in learning as well as practical problem- solving*. According to the authors of the research works [1], [9] and [11], the structure of the experimental chemistry competency consists of 4 competencies:

- Competency for selecting, conducting and using experiments safely and accurately;
- Competency for forecasting, observing, describing and explaining experimental phenomena;
- Competency for processing experiment-related information and concluding;
- Competency for proposing, conducting, and verifying successful experiments.

Bases for selecting NB chemical virtual chemistry experiment software in teaching chemistry to develop the experimental chemistry competency for students

When considering the use of real and virtual experiments in teaching chemistry at high schools in the present period, we find the following issues:

In case a teacher conducts real experiments in the class for students' observation, most experimental tools are small, the class is crowded, and the classroom is wide. For this reason, when the teacher conducts experiments, not every student can easily observe them. Students at the back of the classroom can only listen to the teacher and cannot observe how to conduct experiments and experimental phenomena. Meanwhile, virtual experiments are conducted on a projector screen. Normally, the projector screen is placed so that all students in the class can easily observe the experiments. Besides, the teacher can increase the sizes of experimental tools so that all students, even students at the back of the classroom, can easily observe the experiments.

Another issue is experiment safety. If an experiment is conducted by using real tools and chemicals, unexpected fire and explosion can sometimes occur due to negligence. However, virtual experiments are absolutely safe, and unexpected fire and explosion cannot occur. If chemicals are wrongly used, the fire and explosion occurring on the computer screen are just virtual, not real. Besides, not every real experiment is successful. Yet, virtual experiments are preprogrammed, nearly all of them are accurate, and they can be conducted efficiently as expected. The next issue is the preparation of experimental tools. For the high school curriculum, experiments are required for nearly every hour of chemistry. In the case of simple experiments and few tools, teachers can easily prepare tools and move from a class to another class. However, in the case of experiments requiring cumbersome tools, this is not simple. For virtual experiments, teachers are not anxious about this problem. Tools are available in the software; teachers only install the experiment design software on the computer and feel secure about experimental tools, etc.

At present, there are many pieces of software for constructing virtual chemistry experiments, such as Crocodile, ChemDraw Ultra 8.0, Yenka, Macromedia Flash, Chemwindow, Chemlab Portable virtual chemistry lab, Portable crocodile chemistry, Chemist by thix, NBchemical, Science Teacher's Helper, etc. Among them, two proper pieces of software for constructing virtual chemistry experiments studied by the present article are Chemist by thix and NBchemical. For Chemist by thix, the interface is easy to interact, the operation is easy and the simulated tools and chemicals are the same as the reality. This software can develop experimental chemistry competency for students. Nevertheless, Chemist by thix has disadvantages: fee payment for chemicals in the software and requirement for students' competency for chemical metering.

Based on the above-mentioned analysis, we use NBchemical software to design virtual chemistry experiments with a view to develop the experimental chemistry competency in teaching lessons on oxygen - sulfur chemistry 10.

Principle and process of constructing virtual chemistry experiments

According to [6], the principle of constructing virtual chemistry experiments in teaching chemistry to develop the experimental chemistry competency for students is that experiments must be scientific and accurate in terms of experiment practice skills, every experiment must be aesthetic and the implementation steps must be proper, attractive and lively with obvious and quick phenomena.

Based on NB chemical virtual chemistry experiment software, the definition and structure of the experimental chemistry competency and reference to the documents [5] and [10], the process of constructing virtual chemistry experiments to develop the experimental chemistry competency for students in teaching chemistry consists of 5 steps:

Step 1: Surveying virtual chemistry experiment lesson contents.
Step 2: Constructing a virtual chemistry experiment scenario.
Step 3: Constructing an experiment framework.
Step 4: Constructing experiments.
Step 5: Adjustment.

Using virtual chemistry experiments in lessons on oxygen - sulfur chemistry 10 in teaching chemistry to develop the experimental chemistry competency for students

Based on the principle and process of constructing virtual chemistry experiments and the study on the document [5], we propose the process of using virtual experiments in teaching chemistry to develop the experimental chemistry competency in lessons on oxygen - sulfur chemistry 10 for students with the following steps:

- Step 1. Working out a lesson plan for oxygen - sulfur
- Step 2. Preparing a lesson for which virtual experiments can be conducted:
  - + Analyzing contents of the lesson on oxygen - sulfur and selecting proper experiments to design virtual experiments. For example, the reaction of sulfuric acid (H_2SO_4) can result in the reducing product: sulfur dioxide (SO_2), which is a toxic gas and can cause respiratory tract infection if inhaled.
  - + Instructing students to install NB chemical virtual chemistry experiments on the computer for presentation preparation.
- Step 3. Describing the virtual experiment process in lessons on oxygen - sulfur:
  - + Identifying and presenting the effect of objects in virtual experiments.
  - + Stating the experiment process and describing the operations in virtual experiments and carry out comparison when working with real objects.
  - + Forecasting the experiment results which will be obtained.
- Step 4. Conducting virtual experiments in lessons on oxygen - sulfur:
  - + Teachers instruct students to conduct virtual experiments and use questions to take students to the virtual experiment process.
  - + Students observe and practice the operations.
  - + Students record and process data obtained from the experiments.
- Step 5. Discussion, assessment and summary
  - + Students can explain the obtained experiment results and draw scientific conclusions.
  - + Students can analyze and assess the experiment results and then propose and adjust the experiments.

From the process of constructing virtual chemistry experiments in lessons on oxygen - sulfur, the article used “NBchemical” software to design virtual chemistry experiments “Preparing and testing particular properties of sulfur dioxide and carbon dioxide in a laboratory”, “Water retaining ability of sulfuric acid” and testing in teaching chemistry according to the following process:

Step 1: Determining experiment objectives

- Students can select the necessary tools and chemicals when conducting experiments and can use other chemicals for replacement;
- Students can present the process of conducting experiments safely;
- Students can forecast and explain the phenomenon and write the chemical equation for the reaction;

Step 2: Determining tools and chemicals and steps for conducting experiments

- Proposing experiment methods;
- Determining the process of implementing the proposed experiment method.

Step 3: Conducting the virtual chemistry experiments “Preparing and testing particular properties of sulfur dioxide and carbon dioxide in a laboratory” and “Water-retaining ability of sulfuric acid”.

The use of Nbchemical software will simulate the process of preparing and testing the properties in detail, easy observation and safety for students.

a. Install NBchemical software

Access the web: https://www.nobook.com/v2/chemistry.html and download the software; it is possible to download to a computer or mobile device or use directly on the website and run NBchemical software and begin to conduct virtual experiments.

b. Conduct experiments

Start NB chemical software: the experiment interface of the software is as follows fig [1]:

Figure 1: Some Main Function icons on the Interface screen.

Figure 2: Prepare the tools and chemicals to test the characteristics of CO_2, SO_2.

c. Carry out the virtual chemistry experiment 1

“Prepare and test the characteristics of sulfur dioxide and carbon dioxide in a laboratory”

Step 1: Click the icons for selecting the tools and chemicals to prepare the experimental practice, fig [2].

- Tools, chemicals (replaceable): charcoal, concentrated sulfuric acid (H_2SO_4) (18,0 mol/l), fuchsin staining solution ($C_{20}H_{20}N_3$. HCl), $KMnO_4$ solution (0,119 mol/l), $Ca(OH)_2$ solution (0,021 mol/l), NaOH solution (1,712 mol/l), U-shaped test tub containing anhydrous copper (II) sulfate ($CuSO_4$), alcohol burner, test tubs, tongs, absorbing air set as fig [2].

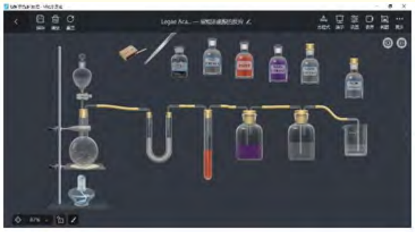

Figure 3: Fit the Tools and Chemicals.

Figure 4: Observe Experimental Phenomenon.

- Cautions for the performance of a safe and successful experiment: because concentrated sulfuric acid has the water-retaining ability, it will cause heavy burn if it directly contacts with the skin of the hands so it should be very careful when performing the experimenting and must follow the safe rules.
- Guide the air pipe into the test tube containing the test solution.

Students guess the phenomenon of happening reaction.

Step 2: Fit the tools as drawing fig [3].

- Put several charcoal pieces into a 250 ml flask. Add slowly 40 ml of concentrated sulfuric acid into the separatory funnel.
- Pour about 22 ml of fuchsin staining solution into a test tube. Then add respectively $KMnO_4$, $Ca(OH)_2$ solution, and NaOH solution into the rest bottles.
- Fit the air pipe from the flask to the U-shaped test tube and solution containers.

Step 3: Observe the phenomenon, explain, and write chemical equation, fig [4].

Unlock the separatory funnel and alcohol burner. The phenomenon showed to students:

+ In U-shaped test tub, anhydrous copper (II) sulfate ($CuSO_4$) turns from white to blue.
+ Fuchsin solution is pale and gradually fades away.
+ The colour of permanganate is pale gradually.
+ The clear lime solution is cloudy. Explain the phenomenon and write the chemical equation of the reaction.

Figure 5: Experimental Tools and Chemicals to test water retaining ability of Sulfuric acid.

Figure 6: Experimental Phenomenon that proves the Water-retaining ability of Concentrated Sulfuric acid.

Experiment 2: "Water-retaining ability of concentrated sulfuric acid"

Step 1: Prepare experimental tools and chemicals to experiment, fig [5]. Take note that a concentrated sulfuric acid must be used with a concentration of 18.0 mol/l, fig [5].

Step 2: Pour glucose into a 250ml beaker. Then add concentrated H_2SO_4 solution, observe the phenomenon, and write the chemical equation, fig [6].

Pedagogical experiment

To evaluate the effectiveness of the application of NB chemical virtual chemistry experiment software, we carried out a pedagogical experiment at Tay Ho High School – Hanoi, class 10D5 (44 students) in the school year 2019 - 2020. The experimental results were researched based on observation and survey results by questionnaire forms at the experimental class. Below are some images during the experimental process, fig [7-10]:

Figure 7: Teacher instructs students to use Nbchemical software.

Figure 8: Student practices experiments.

Figure 9: Teacher supports students to do the operations on software.

Figure 10: Student presents the Phenomenon and writes the chemical equation of illustrated reaction.

The survey results showed that 92% of the students have never heard of virtual chemistry experiment software, proving that the application of teaching by virtual chemistry experiment is still new to high school students. For NB chemical virtual chemistry experiment software, 86.21% of the students assessed that the interface of the software was beautiful and simulated like real experiments. 79.39% of the students assessed that the experimental phenomena were easy to observe and confirmed that NB chemical was easy to use and to carry out the experiments. NB chemical virtual chemistry experiment software helped students to absorb the lesson contents well, giving them the initiative and activity in searching and studying the lessons in a safe way (86.49%). Additionally, most of the students could develop their experimental chemistry competency through virtual chemistry experiment software (about 78.42%). Most students could choose the tools and chemicals, describe and explain the experimental phenomenon. However, the language of NB chemical software is Chinese, it causes some difficulties when interacting; some chemicals are not available which must be replaced or prepared. During the experimental process, some students were able to process the related data, besides, some students met with difficulties in calculating quantitative and using substitutive chemicals. After the lesson, 92.52% of the students agreed to continue studying with NB chemical virtual chemistry experiment software, and about 7.48% of the students did not like to study by this method due to the difficulties in choosing alternative chemicals to perform experiments.

Conclusion

The experimental results initially affirmed that the application of NB chemical software to construct virtual chemistry experiments in teaching creates conditions for students to promote their initiative and creativity in learning, and develops some typical competencies of Chemistry, especially experimental chemistry competency. Moreover, using virtual chemistry experiment software will easily perform several complex reactions and some reactions that produce toxic products for testers and the surroundings. An outstanding advantage of the virtual chemistry experiment is suitable for the shortage and poor quality of facilities at many high schools in Vietnam. At present, however, the virtual chemistry experiment software has just stopped at the process of preparing substances in laboratories but not in the industry as well as not in accordance with the teaching content in high school chemistry program or all objects of students; Therefore, teachers need to research and select appropriate experimental content so that it can be used effectively in teaching towards competency development for high school students in teaching Chemistry.

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