Constructing Knowledge Models through Task-Driven Modern Handheld Application Technology: A Study on the Chemical Properties of Sulfur Dioxide

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Abstract. Based on constructivist learning theory, this paper explores and studies the knowledge related to students' learning situation and classroom background by examining the teaching of "Chemical Properties of Sulfur Dioxide." By utilizing modern handheld application technology to enhance traditional textbook experiments, the study designs experiments related to the chemical properties of sulfur dioxide. This approach facilitates students' conceptual transformation from qualitative observation to quantitative observation and gradually enables the construction of new knowledge in thinking models. Additionally, the paper discusses the teaching process of "Chemical Properties of Sulfur Dioxide" driven by learning tasks, aiming to provide guidance for middle school teachers and enhance students' learning effectiveness.

Keywords: Modern Handheld Application Technology; Constructivism; Sulfur Dioxide; Teaching Design; Task-Driven.

1 Introduction

Constructivism is a concept that in recent years has garnered considerable attention among science education researchers[1]. Originating from Swiss psychologist Jean Piaget, is a theory about learning and cognition. It emphasizes the learner's initiative and the constructivity of knowledge during the learning process. Specifically, constructivism posits that a learner's learning is a process of generating meaning in social and cultural interactions, a process in which learners build knowledge through exploration and communication. This theory emphasizes aspects such as cognition, situation, cooperation, conversation, and the construction of meaning. Have the following characteristics.

Interaction and Collaboration: Constructivist theory promotes the idea of interaction and collaboration in learning. It emphasizes the importance of social interaction and collaboration in the construction of knowledge. The theory believes that learners can gain a deeper understanding of the knowledge by interacting with others and exchanging ideas. It encourages teachers to arrange group activities and discussions in the class, so the students can learn from each other and construct their knowledge collectively.

Problem-Based Learning: Constructivism supports the use of problem-based learning. This approach encourages learners to actively engage in solving real-life problems, which can help

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them develop critical thinking and problem-solving skills. Moreover, problem-based learning can make the learning process more meaningful and interesting for learners.

Assessment and Evaluation: Constructivism has implications for assessment and evaluation. It suggests that assessment should be integrated into the teaching and learning process, and it should focus on learners' understanding and application of knowledge, rather than just memorizing facts. Constructivist assessment practices include formative assessments, self-assessment, and peer assessment.

Constructivism represents a multifaceted and contested epistemological mindset with important implications for classroom teaching, but it amounts to little more than an educational slogan in the absence of conceptual understanding and clarification[3].

High hopes are held for constructivism, with two proponents in science education saying that it "can serve as an alternative to the hunches, guesses, and folklore that have guided our profession for over 100 years" (Mintzes andWandersee, 1998, p. 30)[4].

In conclusion, constructivism has greatly influenced modern education. It encourages a more student-centered, interactive, and meaningful learning experience. It also highlights the importance of critical thinking, problem-solving skills, and lifelong learning. However, it requires teachers to have a deep understanding of the theory and make necessary changes in their teaching practices.

2 Teaching Content

The teaching content mainly includes: introduction to the characteristics and chemical properties of sulfur dioxide, demonstration of the bleaching property of sulfur dioxide with the help of handheld application technology, and guiding students to analyze and summarize the chemical reaction process of bleaching.

During the experiment, students can use handheld application technology to collect and process experimental data in real time, which makes the experiment more efficient and accurate. After the experiment, teachers can guide students to analyze the experimental data and summarize the chemical properties of sulfur dioxide.

The handheld application technology can also support the creation of a virtual laboratory, where students can conduct experiments independently. This not only enhances the students' practical abilities but also stimulates their interest in learning. An increasing number of K-12 school teachers have been using handheld, or palmtop, computers in the classroom as an integral means of facilitating education due to the flexibility, mobility, interactive learning capability, and comparatively inexpensive cost[5]. They can also repeat the experiment without any additional cost or risk, which greatly improves their understanding of the chemical properties of sulfur dioxide.

In conclusion, the introduction of handheld application technology into the teaching of sulfur dioxide's chemical properties can not only improve the efficiency and accuracy of experimental teaching but also promote students' understanding of abstract scientific concepts, stimulate their interest in learning, and cultivate their ability to apply information technology. In the future, more attention should be paid to the integration of handheld application technology and other teaching methods to promote the comprehensive development of students.

The study also suggests that further research needs to be conducted on how to make full use of handheld application technology in other parts of chemical education to facilitate the teaching and learning process.

3 Teaching Strategies

This step involves the students summarizing the experimental phenomena, extracting the key points, and forming a clear and systematic understanding of the chemical properties of sulfur dioxide. The teacher guides the students to summarize the content and encourages the students to propose their own conclusions based on the experimental phenomena and analysis of results.

The students are encouraged to build a property model of sulfur dioxide, which includes its chemical reactions and the conditions under which these reactions occur. The students are also asked to explain the reasons behind these properties and reactions. This model serves as a tool for understanding and predicting the chemical property of sulfur dioxide, and can be used as a reference for understanding the properties of other substances.

This step is crucial in developing the students' ability to think systematically and logically, and to apply their knowledge in real-world situations. The combination of handheld computing and wireless communication with electronic measurement and control provides an enormous potential for education in areas of science and technology[2]. It also fosters the students' ability to construct and modify models based on evidence, which is a key competence in the field of chemistry.

In conclusion, the task-driven teaching approach can effectively stimulate students' interest in learning, promote their active participation in class activities, and improve their ability to independently construct knowledge. It can also foster the development of students' core competencies in the subject of chemistry, including their ability to observe and analyze phenomena, to propose and test hypotheses, to construct and modify models, and to apply their knowledge in real-world situations.

4 Teaching Process

4.1 Constructing Scenarios to Foster Interest

The teaching flow chart is shown in Figure 1.

[Teacher's Question] This news item reports that a "particular batch of tremella (self-proclaimed) has a sulfur dioxide residue that exceeds the acceptable standard." Students, consider this: what is the connection between sulfur dioxide and the color alteration of tremella? Let's explore the answer within the confines of this class.

[Teaching Design Intent] Developing life scenarios based on tangible issues serves to ignite students' learning curiosity. By introducing such scenarios at the commencement of the class, we can effectively stimulate students' disciplinary thought processes, enhance their engagement, and thereby augment the overall classroom effectiveness.

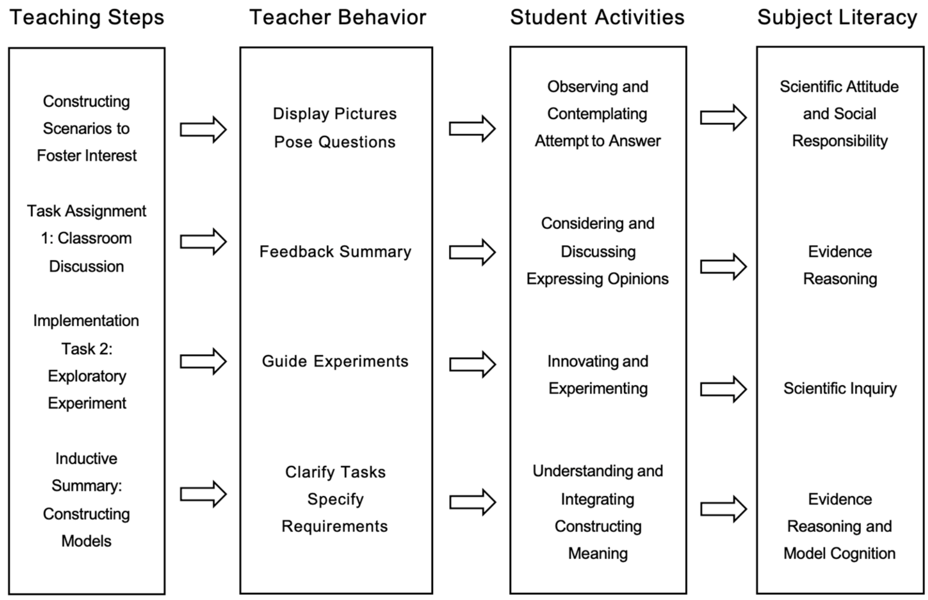

Fig. 1. Teaching flow chart.

4.2 Task Assignment 1: Classroom Discussion

[Learning Task 1] Students, consider the following question: Which property of sulfur dioxide is exploited by illicit activities to alter the color of tremella?

[Expected Student Behavior] Bleaching properties; Acidic oxide characteristics ...

[Teacher-Led Transition] As the old adage states, "there are a thousand Hamlets in a thousand people's hearts," suggesting that everyone has their unique interpretations. So, what property does sulfur dioxide exhibit throughout this process? Now, please collaborate in groups and perform an experiment to ascertain the answer!

[Teaching Design Intent] This teaching design is premised on students' pre-existing cognition. It begins with substances familiar to students to stimulate their interest in learning and ignite their exploratory curiosity. This method then segues into the study of the chemical properties of substances, which aligns more closely with the cognitive processes of students. It further guides students to identify issues, then collaborate and investigate to resolve them, thereby deepening their understanding and application of the knowledge gained. As students progressively overcome challenges, they experience the process of scientific inquiry, which enhances their innovative abilities and facilitates the acquisition of more comprehensive chemical knowledge.

4.3 Implementation Task 2: Exploratory Experiment

In this section, students are divided into groups to conduct activities (homogeneous within groups, divided into a total of 7 research groups). The required experimental supplies are as follows: sodium hydroxide solution, phenolphthalein solution, concentrated sulfuric acid, solid sodium sulfite, handheld instruments, computers, test tubes, rubber-headed droppers, alcohol lamps, separation funnels, wide-mouth bottles, rubber stoppers, etc.

[Learning Task 2] Sulfur dioxide itself possesses various properties, such as oxidizing, reducing, acidic oxide properties, bleaching, etc. Because of its diverse properties, we can't immediately determine which property of sulfur dioxide is used for the color change of Tremella, and can only obtain the answer we want through experiments. Below, students, based on the available experimental equipment and chemicals in your hands, please design a complete and feasible experimental research plan (Hint: Make good use of modern handheld technology).

[Expected Student Behavior] Designing an experiment: Assemble concentrated sulfuric acid, solid sodium sulfite, a separating funnel, and a wide-mouth bottle into a simple sulfur dioxide preparation device. At the same time, pour a certain amount of sodium hydroxide solution with added phenolphthalein and C.1.Acid Violet 7(18055) into the test tubes. Before the reaction begins, use handheld instruments to measure the pH of the colored phenolphthalein solution and C.1.Acid Violet 7(18055). After the reaction begins, introduce sulfur dioxide gas into the test tubes containing the colored phenolphthalein solution and C.1.Acid Violet 7(18055), observe the experimental phenomena; then heat the two test tubes separately with an alcohol lamp, observe the experimental phenomena; then again use handheld instruments to measure the pH of the colored phenolphthalein solution and C.1.Acid Violet 7(18055); finally, add sodium hydroxide solution drop by drop into the two test tubes and observe the experimental phenomena.

[Summary of experimental phenomenon] Test tube containing colored phenolphthalein solution: Before the reaction: pH greater than 7, alkaline; After the reaction: the colored phenolphthalein solution decolorizes, the color does not change after heating, the pH is less than 7, acidic, the color gradually returns after dropwise addition of sodium hydroxide solution. Test tube containing C.1.Acid Violet 7(18055): Before the reaction: pH approximately equal to 7, neutral; After the reaction: the C.1.Acid Violet 7(18055) decolorizes, the color returns to its original color after heating, pH less than 7, acidic, the color does not change after dropwise addition of sodium hydroxide solution.

The specific experimental phenomena are shown in Figure. 2, 3, 4, 5, 6, 7, 8.

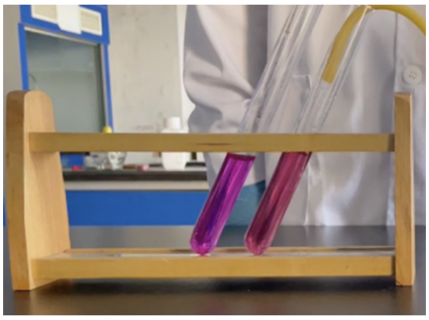

Fig. 2. The test tube a (on the right) containing phenolphthalein solution and the test tube b (on the left) containing alkaline phenolphthalein solution.

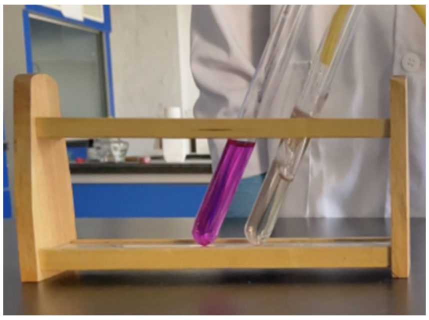

Fig. 3. The fading phenomenon of the solution after sulfur dioxide is introduced into test tube a (on the left) containing phenolphthalein solution.

Fig. 4. The phenomenon where the color of the solution in test tube a, which contains faded phenolphthalein solution, is restored after heating.

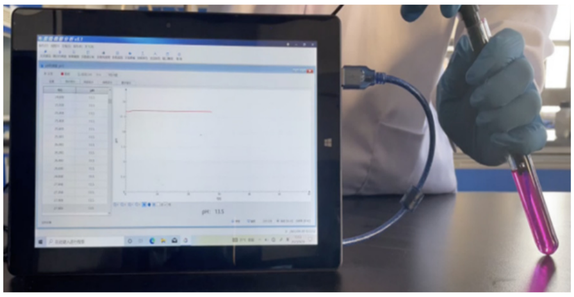

Fig. 5. The pH value curve before the reaction starts, as measured using handheld technology, in test tube b containing alkaline phenolphthalein solution (pH=13.5).

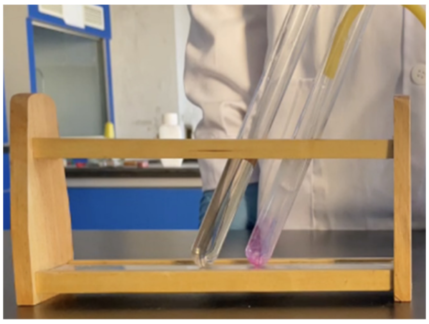

Fig. 6. The fading phenomenon of the solution after sulfur dioxide is introduced into test tube b containing alkaline phenolphthalein solution.

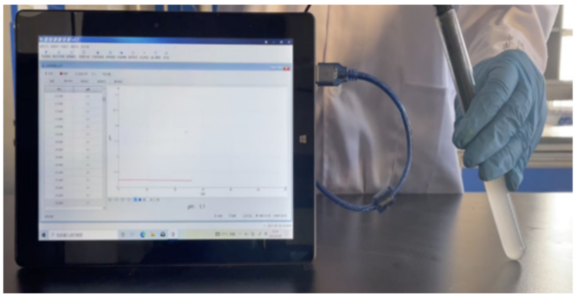

Fig. 7. The pH value curve after the reaction starts, as measured using handheld technology, in test tube b containing faded phenolphthalein solution (pH=1.1).

Fig. 8. The phenomenon where the color of the solution in test tube b, which contains faded phenolphthalein solution, is restored after gradually adding sodium hydroxide solution.

[Teacher’s Question] Students, based on the experimental phenomenon, please summarize the chemical properties of sulfur dioxide reflected in this experiment.

[Expected Student Behavior] Analyze the experimental phenomena to derive the experimental principle. The reaction mechanism between sulfur dioxide and colored phenolphthalein solution is an acid-base neutralization, which reflects the properties of sulfur dioxide as acidic oxide; the reaction mechanism between sulfur dioxide and C.1.Acid Violet 7(18055) is that sulfur dioxide itself combines with colored substances to form colorless substances, but this substance is unstable and reversible, after heating, the colorless substance will be decomposed again, which reflects the bleaching nature of sulfur dioxide. At the same time, this bleaching characteristic has both reversibility and instability.

[Teacher’s Question] The above is the summarized properties of sulfur dioxide. So, going back to the original question, do students now understand which property of sulfur dioxide makes the "poisonous tremella" not fade even in the hot summer?

[Expected Student Behavior] Bleaching Property.

[Teaching Design Intent] This part is the innovative part of this lesson. This exploratory experiment has two innovative features, namely, integrality and modernity. The integrality in this experiment is mainly reflected in that, in this exploratory experiment, the sulfur dioxide produced is allowed to react with both C.1.Acid Violet 7(18055) and colored phenolphthalein solutions, allowing students to understand the properties of sulfur dioxide from multiple perspectives. Compared with the experiments in textbooks, students can learn about the various chemical properties of sulfur dioxide in a more intuitive and comprehensive way. The modernity in this experiment is mainly reflected in the combination of this experiment with modern handheld application technology. Through sensors, students can switch their perspective from macro to micro. With the macro-visualization of micro-mechanisms, it is of great help for students to understand abstract reaction mechanisms. The combination of exploratory experiments and modern handheld application technology, using software processing and computer chart display, can obtain more accurate data, giving students a more intuitive feeling and making the experimental results more convincing.

4.4 Inductive Summary: Constructing Models

[Classroom Knowledge Synthesis] Students are encouraged to encapsulate the content of this section into diagrams or tables based on the preceding learning experiences.

[Expected Student Behavior] Students are to distill the main concepts of this section and illustrate them in a structured manner.

The knowledge model is shown in Figure 9.

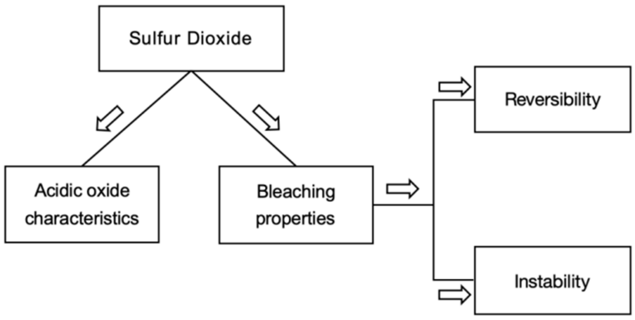

Fig. 9. Model of the chemical properties of sulfur dioxide.

[Teaching Design Intent] The objective is to facilitate a synthesis from both the experimental phenomena and subject knowledge, and to represent it in the form of a model. This approach is designed to reinforce students' recollection of the knowledge and comprehension of the methods, bolster their conceptual understanding of the subject, and significantly enhance their grasp of subsequent knowledge.

5 Conclusions

This section adopts a methodology rooted in constructivist teaching theory, capitalizing on the capabilities of contemporary handheld application technology. A task-driven teaching approach is employed, utilizing digital, innovative inquiry-based experiments as a medium within the classroom. This encourages students to fully engage their individual initiative in the learning process. The approach places a strong emphasis on nurturing students' disciplinary thinking, facilitating effective construction of discipline-specific knowledge models.

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