IMPROVING CONCEPTUAL UNDERSTANDING OF THERMAL PARTICLE DYNAMICS VIA SIMULATION MODEL

Iftikhor Kamolov
Prof. Head of the Department of Arts, Karshi state university
Firuza Davronova
3rd year PhD student of Karshi state University

Introduction.

Improving the quality of education and ensuring that students gain both solid theoretical understanding and practical abilities are urgent priorities for today's education system. This need becomes even more critical in teaching complex, abstract objects such as chemistry, where innovative teaching methods are necessary. Traditional approaches often do not reach and try to bridge the gap between theory and application in the real world. According to Atkins, chemistry of education bridges macroscopic observations and microscopic imagination. It emphasizes three key challenges: abstraction, mathematical problems and overall complexity. This can be confused by students if they are not properly solved. To overcome them, Atkins recommends using visualization tools and simulation models to increase understanding [1]. Chemistry teaching strongly relies on the use of models as teaching tools [2]. Models allow students to explore chemical phenomena in a virtual environment, allowing them to control processes and safely conduct experiments interactively. Primarily, students gain experience in independently analyzing real data and drawing conclusions while working with the software [3]. Visually engaging tools are considered essential for enhance students the phase transitions at the particulate level [4]. Simulations that the behavior of

matter at both the particulate (submicroscopic) and macroscopic levels enhance students the alternative concepts of the particle mass model stressed that the need to improve instructional strategies and pedagogical approaches to more efficient teaching of this concept. The primary purpose of using simulation models is for recent learning and automate the process of assigning and evaluating chemistry, which is usually assigned and assessed. The investigation confirmed that the integration of 3D animations and interactive visual instruments associated with the particle model of the mass significantly benefited both the results of students' learning and the effectiveness of the teacher.

Method.

Research includes an empirical (quantitative) component. This experimental approach gathered evidence that shows that the use of an interactive model improved the understanding of abstract scientific concepts of students. After using the simulation, the data was collected through the evaluation of visualization results. In other words, studies are not only a theoretical description, but represent an empirical investigation of the tool in an educational context. Research combines descriptive analysis of the design of simulation with quantitative assessment of its impact-its permission is classified as a mixed method or design based. This means that this instrument was first developed and subsequently evaluated to determine its effectiveness of education.

The simulation tool, freely available online, was developed using HTML5, JavaScript (ES6), XML, JSON, SVG and Canvas.The code describing the dynamic movement of particles is based on Brownian's motion and simulates the balance of repulsive and attractive forces in solids, liquids and gases. In each state of matter, the movement of particles depends on the kinetic energy that corresponds to the system temperature. In liquids, attractive forces

predominate over repulsive and gravity have a stronger effect compared to gases, causing the particles to settle towards the bottom of the virtual container such as a beaker. In the solids, the particles are fixed in the organized grid structure that cannot move freely between the cells but capable of vibrating according to the temperature.

Description of the simulation tool.

After clicking on the link provided (http://modelloparticellare.altervista.org/), students approach a website showing an empty beaker on a green background. The language can be switched between English and Italian using the selection menu located in the upper right corner of the interface. In addition, it is located in the lower left corner of the drop-down menu, from which students can choose specific substances, namely water, molecular oxygen, table salt and tert-Butyl alcohol (see Figure 3). After selecting the fabric and pressing the "Start" button, the beaker, originally empty, fills the animated particles in motion. These particles visually represent a thermodynamically stable condition of the selected substance at 25 °C at atmospheric pressure. The fourth substance does not normally fit in everyday life; An important aspect of the simulation tool is its interactive phase diagram with a dynamic red marker, which continuously reflects the temperature in real time and corresponding to the physical condition of the substance. At the bottom of the interface are two interactive controls - one red for heating and one blue for cooling - which students can alternately use to virtually modify the sample temperature. The software immediately responds to these changes and corresponds appropriately to the visual representation in the beaker and the phase diagram. In addition, they have the opportunity to switch between different temperature units, including Celsius, Kelvin and Fahrenheit.

Results and discussions.

At 25 ° C (room temperature) there is oxygen in gaseous state. This is because 25 ° C (298 K) significantly exceeds the boiling point of oxygen (–183 ° C) at atmospheric pressure, which under these conditions is a thermodynamically stable gas phase. When simulating at 25 ° C, oxygen molecules (O_2) can be observed as they move quickly in all directions, remaining located relatively far apart. Each molecule travels in a straight line until it collides with another molecule or walls of containers, after which it bounces in a new direction. In the simulation, they cause frequent precipitation that each molecule moves erratically in sharp winding roads, which constantly changes their direction and speed, leading to highly irregular movement. Even at room temperature, the molecules have sufficient thermal energy to maintain constant movement. This random thermal movement - known as Brownian's motion - is responsible for the diffusion of gas molecules: over time, the rainfall causes the oxygen molecules to be distracted throughout the volume and leave from their initial positions. In short, oxygen gas at 25 ° C lives brown by the movement, characterized by random and continuous molecular movements along with frequent intermolecular collisions.

Conclusion

This technology message is an interactive software tool with an open source code developed to introduce the particle model. The software helps students to understand what is happening at a submicroscopic level when the substance passes from one condition to another (for example, from solid to liquid and vice versa or from liquid to gas and vice versa). This digital tool can effectively introduce students to the simplest model of particles of matter without required to require previous knowledge of atoms, molecules or ions. The interactive functions of the software facilitate the understanding of the thermal particle dynamics and how the particle movement is related to the temperature. This particular aspect is difficult to understand without using the

dynamic model. The proposed software has proven to be particularly effective in illustration, interactively and clearly, submicroscopic and thermal transformations using oxygen as an example and their relationship to Brownian's movement. The software also helps students to understand that each substance has its own unique state diagram. In addition, it introduces students to different temperature standards. Materials presented and discussed in this article may be particularly useful for teachers who teach chemistry for students from non-chemical disciplines.

REFERENCE:

1. Henry, C.M., 2004. Visualization and Translations: At the Chemical Education conference, they discuss the challenge of communication of chemistry. Chemical & Engineering News, 82 (40), pp. 46–48.

2. BELLI, D., LISCHI, G., Pardini, G., Milazzo, P. and Domenice, V., 2024. Free interactive digital tool for introducing particles and movement of heat particles in high school. Journal of Chemical Education, 101 (2), pp. 647–652. Available at: https://doi.org/10.1021/acs.jchemed.3C00986 [accessed to 3 April 2025].

3. Jurinovich, S. and Domenice, V., 2022. Digital tool for analysis UV - VIV Spectrum of olive oils and educational activities with students of secondary and university students. Journal of Chemical Education, 99 (2), pp. 787–798. Available at: https://doi.org/10.1021/acs.jchemed.1C01015 [accessed to April 3 2025].

4. Slapničar, M., Tompa, V., Glažar, S.A., Ninek, I. and Pavlin, J., 2020. The success of students in solving authentic tasks with 3D dynamic submicroscopic animations for specific water conditions and their transitions. Acta Chimica Slovenica, 67 (3), pp. 904–915. Available at: https://doi.org/10.17344/acsi.2020.5908 [accessed to April 3 2025].