STS.014 Final Project Lesson Plan

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Lesson Plan

Title of Lesson:

- Marvelous Matter: A Journey through States and Phases of Fun!

Abstract:

- Our lesson plan focuses on students embodying particles in different states of matter to demonstrate how the relationship and arrangement of molecules varies between each state. Teaching this lesson thorough embodiment can help students understand more deeply the particle structure of a solid, liquid, or gas. Finally, the activity portion of our lesson allows students to better remember the different phase changes between states of matter in fun way
- Our lesson has 2 main parts (with a third bonus part for more advanced classes or given that there is time)
    - Part I: Lecture/ Instruction - Teacher goes over the lesson content and explains the different states of matter. Every group will then model each state and the phase changes in their square.
        - Estimated time: ~30 minutes
    - Part II: Interactive Activity - Teacher assigns groups to embody different states of matter and calls out a phase change. The students will react by embodying the phase change and calling out their new state of matter. Additionally, the teacher can reverse the activity and call out a new state of matter. The students can then respond with the associated phase change.
        - Estimated time: ~25 minutes
    - Part III (if there is time) - Teacher explains the concept of solid defects and students then model the solid defects (the lacking or misalignment of atoms in a crystal structure or lattice). The teacher can also explain plasma and the corresponding phase changes.
        - Estimated time: ~30 minutes

Keywords:

- High School Chemistry
- Honors Chemistry
- States of Matter
- Phase Changes
- Solid Defects
- Energy and Heat

Goal(s):

- Teach students about different states of matter and their molecular structure in a fun, engaging manner.

- Allow students to embody the different states and phase changes to enhance their learning experience.

Learning Objectives:

- Students should demonstrate an understanding of how the particles are arranged in solids, liquids, gasses and plasmas.
- Students should be able to name the different phase changes and what causes them to occur.
- Students understand the possible defects that can arise from solid formation and how they come about.
- The measurability of the students' understanding will come from the exit ticket informal assessment that we will conduct.
- The ranking of order of importance of concepts is as follows. If the teacher is unable to fit all the content in, concepts 3 and 4 in the list below can be omitted or saved for a future class.
    1. The difference in particle movement between solids, liquids, and gasses
    2. The phase changes between these three states of matter and the causes
    3. The possible crystal formation defects in solid formation
    4. The particle movement of plasma and phase changes related to it

Assessment:

- Instructors can check for understanding throughout the class and use an exit ticket at the end to make sure students understand what was taught on an individual level.
- Informal Assessment (aligns with part II): Check for understanding throughout the class. Ask guiding questions throughout the interactive activity which will allow students to demonstrate understanding in groups.
    - What causes a liquid to turn into a gas? What is that process called?
    - What shape does a liquid take on?
- Exit Ticket: Worksheet for testing understanding (shown in Exhibit 1 at the end of the lesson plan). Please find the exit ticket linked here. Please find the answer key to the exit ticket linked here.

Purpose/Rationale:

- Understanding the states of matter is crucial because it provides the foundation for understanding the behavior of substances in different conditions. We interact with different states of matter on a daily basis so it would be helpful to predict what happens to common substances such as water and how it can change when new factors such as heat are introduced or taken away. States of matter are also applicable to other topics such as chemical reactions and material properties.

- States of matter are typically taught through notes, statements, and graphs. Occasionally, there are some examples shown in class by pointing out solids (ex: desks, chairs.), liquids (ex: water, juice), and gasses (ex: air).
- An embodied approach could make it easier to visualize and understand, rather than just understanding the result rather than the process. Our lesson plan is also easy to implement because it requires minimal materials. Most of the work comes from organizing students.
- We are not aware of any specific state standards our lesson addresses. Based on our own experiences, many of us have learned this topic while we were in high school.

Prior Preparation:

- There is not much preparation required of the instructor to get ready for this lesson. We aimed to create a lesson that was pretty accessible from an instructor point of view. Ideally, the instructor can tape out some squares on the ground to symbolize the container that is holding a solid/liquid/gas. The instructor can then tape an X or use some sort of marking to show which side is the bottom of the container. Finally, the instructor can tape out multiple squares suitable to the size of their classroom and number of students to make sure everyone can get a chance to participate. Each square must have multiple students inside to work.
    - For example, let's say our class has 20 students. We will separate students into three groups of approximately six students each (group size can vary based on number of students in a class). We will tape three 6x6 ft^2 squares on the ground with an X marking the bottom of each "container".
- Instructor should be familiar with the topics being taught. They can review states of matter and phase changes if needed. The instructor should also print as many exit ticket handouts (Exhibit 1) as students in the class.
- Students do not need prior knowledge before this lesson but it may be helpful to send them a video or reading about states of matter such as the ones listed below in "Sources for Further Reading."

Materials/Resources:

- Resources needed: masking/painters tape, classroom with open space
- Cost: $0-$6 depending on whether the school already has masking or painters tape available
- In schools with limited resources, teachers can makeshift an area or container with other things in the classroom such as books, chairs, tables, tiles on the floor, etc..

Slide Lesson Plan:

https://docs.google.com/presentation/d/1GogPaYnCKCWUdBmJWT-x3z0TymNzG__ca35FIjJ-bNs/edit?usp=sharing

Bibliography and Sources for Further Reading:

- Bibliography:

    - States of Matter Experiments that weren't necessarily embodiment but could be useful when designing the lesson with other multimedia or hands-on activities
- Sources for further reading:
    - ChemLibreText
    - LumenLearning
    - MIT: Defects in Solids
    - Information on plasma
    - States of Matter Youtube video for kids

6-STEP PROCEDURE FOR EXPERIENTIAL EDUCATION:

#1 Introduction: "Set Up for Success" (20 minutes)

- In terms of the framing of the lesson, we believe that you can motivate students by giving real world examples. Providing real world examples of solids, liquids, and gasses such as ice, water, and water vapor, respectively. Additionally, it would be interesting to touch upon seemingly "in between" states of matter such as Play-Doh and oobleck. From our perspective as students, it has been more engaging during classes when we were able to apply what we were learning to our everyday lives.
- Go over the 3 main phases of matters and how phase changes occur. Teachers can use the graphics we've collected or any resources they have at hand. We've collected some sources for further reading linked above that might be helpful.
- Introduce content: Display the videos in the Google presentation (additional videos in the appendix of the slide deck) to demonstrate the activity and see what each state of matter and phase change should look like. Additional content explaining the particle arrangement in phases of matter and phase changes are also shown in the Google presentation.
- The lesson structure should be students doing the activity and then analyzing it afterward as both a group and on an individual level.

#2 Exploration: "Do it" (20 minutes)

- The main activity is mimicking states of matter and phase changes by having students embody atoms / molecules.
- Breaking down lesson into specific steps:
    - Initial discussion by teacher outlining what content is going to be taught/covered
    - Show the demo videos that we filmed to give them an idea/excite the students.
    - Have them play with the Play Doh first to give them some time to individually understand, internalize, and ask questions
    - Students do the embodied activity
    - Class discussions and takeaways
    - Exit ticket/worksheet
- The activity is done in groups which will facilitate teamwork and communication. Hopefully, it does not feel too unfamiliar to students since they are mainly moving their bodies around the box and it does not involve complex movements.
- Assistance from the teacher is probably needed for facilitating the activity, calling out the different states of matter, and observing that the students are doing it correctly as well as helping them. However, later, the teacher could have students assume roles of calling out what states are happening and watching their own peers once they gain better understanding!
- When we consider what could possibly go wrong, there are a few possibilities. Students in the square could each do something different, becoming chaotic or confusing to comprehend what is happening. Hopefully, the mini lecture and intro activity helps mediate this.

- To resolve this, if the teacher thinks that the "collisions" or bumping between excited particles could be problematic for the class, we invite you to have students high-five to resemble collisions.

 # 3 Sharing: "What Happened" (10 minutes)

- Ask students: "What changed about your behavior when shifting from solid → liquid vs. liquid → gas?"
    - Students will likely observe a few key factors that changed throughout the activity as they embodied the particles:
        - The speed of their movement
        - The amount of "collisions"/bumps they had with other students (particles)
        - The manner in which they fill space in the container
- The exit ticket (linked below) will provide space for students to talk more about their experience, what surprised them (if anything), what questions they still have, and if anything was confusing about the lesson.

#4 Processing: "What's Important?"

In terms of what is important to take away from this lesson, we would like to reiterate our learning objectives. It is important to take away (1+2 are essential learning goals, 3+4 are if time permit):

1. The difference in particle movement between solids, liquids, and gasses
2. The phase changes between these three states of matter and the cause
3. The particle movement of plasma and phase changes related to it
4. The possible crystal formation defects in solid formation

Our main thoughts as to what you want students to discover has been touched upon in our abstract, goals, and learning objectives above.

#5 Generalizing: "So What?" (5 minutes)

- Going back to what motivates students, there are so many real world examples of states of matter that are important to understand. Solids, liquids, and gasses surround us in the real world and learning about the structural differences improves students' understanding of how the world works. Additionally, the phase changes are important in the real world as they are shown within various inventions (heating and cooling systems) and in nature.
- Additionally, this topic of states of matter is one that is currently typically taught in high school science classes, so this is not a new concept that we are trying to integrate into the high school curriculum.

#6 Application and Wrap-Up: "Now What?" (5 minutes)

- While wrapping up the lesson, the instructor can ask the class for feedback and questions if they want to share out loud with the class. However, the instructor will also give out the exit ticket to check for individual understanding of the lesson and solicit feedback. This will

ensure that the instructor will be able to answer any questions that might come up at the end of the activity. At the beginning of the next class, the instructor can just touch upon any repeated questions.

- This idea of an non-evaluative exit ticket can be applied to various different situations and lessons. It is a good way of collecting feedback and checking for individual learning without the pressure of being evaluative.

Exhibit 1: Exit Ticket

Name:
Date:

Marvelous Matter: A Journey through States and Phases of Fun!

1. In what state of matter are particles tightly packed in a fixed arrangement?

2. In a gas, describe how the particles move about a container? At what speed relative to other states? Do they collide?

3. What is the name of the phase change when a gas becomes a liquid?

4. What is the name of the phase change when a solid becomes a gas?

5. Reflection: What surprised you about this lesson? What questions do you still have? Do you have any ideas to improve this lesson?

And

Exhibit 2: Exit Ticket Answer Key

Name: Answer Key
Date:

Marvelous Matter: A Journey through States and Phases of Fun!

1. In what state of matter are particles tightly packed in a fixed arrangement? Solid

2. In a gas, describe how the particles move about a container? At what speed relative to other states? Do they collide? In a gas, the particles move around the entire container with no distinct arrangement. They move faster than in a solid and liquid, and the particles collide with each other

3. What is the name of the phase change when a gas becomes a liquid? Condensation

4. What is the name of the phase change when a solid becomes a gas? Sublimation

5. Reflection: What surprised you about this lesson? What questions do you still have? Do you have any ideas to improve this lesson?

Sources To Images Used In Google Presentation:

- https://sciencenotes.org/phase-change-diagram-and-definition/
- https://www.expii.com/t/arrangement-of-particles-in-phases-of-matter-comparison-11086
- https://ocw.mit.edu/courses/3-091-introduction-to-solid-state-chemistry-fall-2018/c4f0dce91209404085985da5e2959523_MIT3_091F18_REC17.pdf