Introduction to Phases of Matter

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TOPIC AND AUDIENCE

Topic: Differentiating between the three primary phases of matter
Audience: Elementary Education (Grades 2-4)

LEARNING OBJECTIVES (Based on Bloom's Taxonomy)

At the conclusion of these sessions, students will be able to:

--OBJECTIVE 1 -- List the three primary phases of matter (Domain: Cognitive; Level: Knowledge)

--OBJECTIVE 2 -- Distinguish basic differences in physical qualities of the three phases of matter (Domains: Cognitive and Psychomotor; Level: Comprehension)

--OBJECTIVE 3 -- Observe the three phases of matter of ice/water/steam (Domain: Psychomotor; Level: Observing)

--OBJECTIVE 4 -- Apply knowledge of the three phases of matter of ice/water/steam to make a snowman (Domain: Cognitive; Level: Application)

SEQUENCE OF INSTRUCTION/LEARNING EVENTS

(Storyboard matched to corresponding learning objectives)

Scene 1: Class enters environment and is divided into three groups.

Scene 2: Advance organizer commences. During a regularly scheduled movement/dance class, instructor demonstrates three dance forms that correlate to physical qualities of the three primary phases of matter for students to observe.

Scene 3: Each group will imitate instructor and collectively embody, by dance, the three phases of matter. Instructor alternates cueing the three dances by distinct visual representations [ice cube, water, steam] correlated to varying tempos of music.

Scene 4: Students will be asked to compare and contrast physical attributes of each dance type. Which dance was the most energized/frenetic? Which group looked tight, firm and strong? The students in which set expanded and filled the room? [OBJECTIVE 2]

Scene 5: With students seated at desks or tables (whether immediately following or at a later lesson), instructor introduces the idea of an 'atom' as the basic, fundamental building block of matter. The instructor correlates the students in the dance as individual atoms. When atoms interact with each other, they create something similar to how the students created a dance. Individually, each atom (student) doesn't seem like much, but together they can create something bigger and more noticeable.

Scene 6: Instructor displays images of drinking water in a glass, ice, and steam for the students to identify. Instructor asks the students if these are made up of the same type of matter. [OBJECTIVE 3]

Scene 7: Instructor explains that drinking water, ice, and steam are all made up of the same types of matter and contain the same building blocks (atoms). When the atoms "dance" with each other differently, they make different things. These different presentations of the same type of matter are known as phases of matter. There are three phases of matter: solid, liquid, and gas. [OBJECTIVE 1]

Scene 8: Instructor asks students to match each phase of matter (liquid, gas, solid) to the different types of dance moves.

Scene 9: Instructor introduces the concept of atoms moving at different speeds (similar to the way the students moved in the dance). When they move fast, they create heat and expand to fill a room (gas). When they stop moving, they come together and form tight links (solid). When they are moving but more slowly, they can flow together as one (liquid). [OBJECTIVE 1, 2]

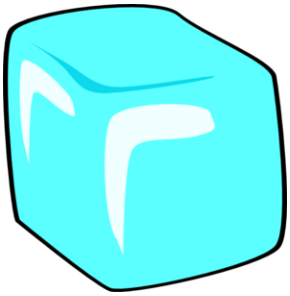
Scene 10: Instructor correlates ice, drinking water, and steam to the different phases of matter and asks how the atoms in each phase are moving. [OBJECTIVE 1,2]

Scene 11: Instructor displays a picture of a snowman and asks students to consider how a snowman goes through the different phases of matter during its lifecycle (snow falls to the ground (solid), solid phase is used to make the snowman >> eventually the snowman melts into water (liquid) >> when the sun comes up, the melted snowman will evaporate into the air (gas). [OBJECTIVE 4]

ADVANCE ORGANIZER

Based on Mayer's (1979)

As described above in Scenes 1 through 4, the advance organizer builds on students' prior knowledge of choreographed dance, which they have been learning in their weekly movement/dance class. This particular advance organizer is a sort of psychomotor script that is prompted by these three visuals, or organizational cues:



The instructor teaches the following choreography. Upon cueing the ice cube, students come together in a barely moving circular dance in which their arms are tightly linked; slow-paced music plays in the background. Upon cueing the water, the students loosen their grips on one another, expand the diameter of the circle, and begin to move lethargically; moderately-paced music will be heard. Upon cueing the steam, students release their connections and dance vibrantly across and throughout the room; fast-paced music will be playing.

Checklist

Components of advanced organizer

1. Have a short set of verbal or visual information: This advance organizer (dance lesson) contains the verbal and visual cues described and shown above.
2. Be presented prior to learning of a larger body of to-be-learned information: The dance would be taught in a movement/dance class prior to the introduction of states of matter.
3. Contain no specific content from the to-be- learned information: The dance foreshadows specific content about states of matter with its visual cues, but at this stage, is only coding the visuals to their respective choreographies.
4. Provide a means of generating the logical relationships among the elements in the to-be-learned information: By setting up a tripartite framework, the dance organizes the students to think in threes, and to link states of matter to physical embodiments of states of being.
5. Influence the learner's encoding process: Learners at this age are still learning with their bodies; enabling them to encode this knowledge through both the cognitive and psychomotor domains reinforces the learning.

DESIGN APPROPRIATE SCHEMA SIGNALS

The movement-based advance organizer described herein could readily be used to introduce topics from other disciplines (such as science, as here) throughout the school year. The subject teachers could collaborate to employ the following schema signals:

- A multipart system (such as the tripartite framework used here)
- Visual cues
- The “judicious use of analogies or comparisons” (Armbruster,1986)
- The use of motor activity/skills being to encode learning

TYPES OF KNOWLEDGE DISCUSSED

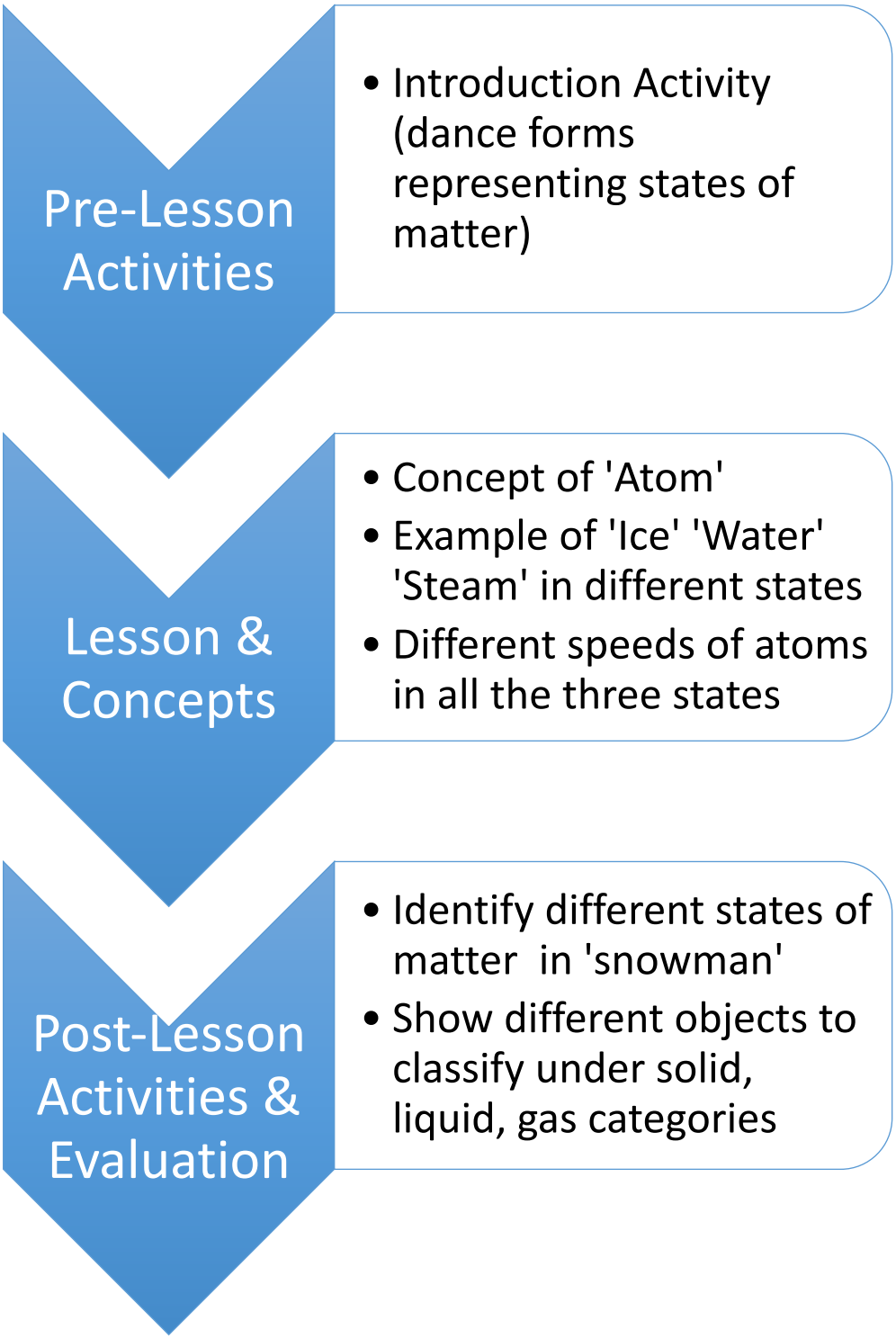
The topic that we are teaching through this design plan is a science concept. Our aim is to build a mental model for students that helps them understand the concept of different states of matter in a more generalist way. This way it won't restrict their understanding of solids, liquids and gases to the textbook examples. The dance forms will help them relate to the distribution of the molecules in the three forms of matter. The fun activity will build a schematic framework in the mind that they will be able to use to analyze different matter states into these three categories.

ISSUES AROUND PREREQUISITE OR PRIOR KNOWLEDGE

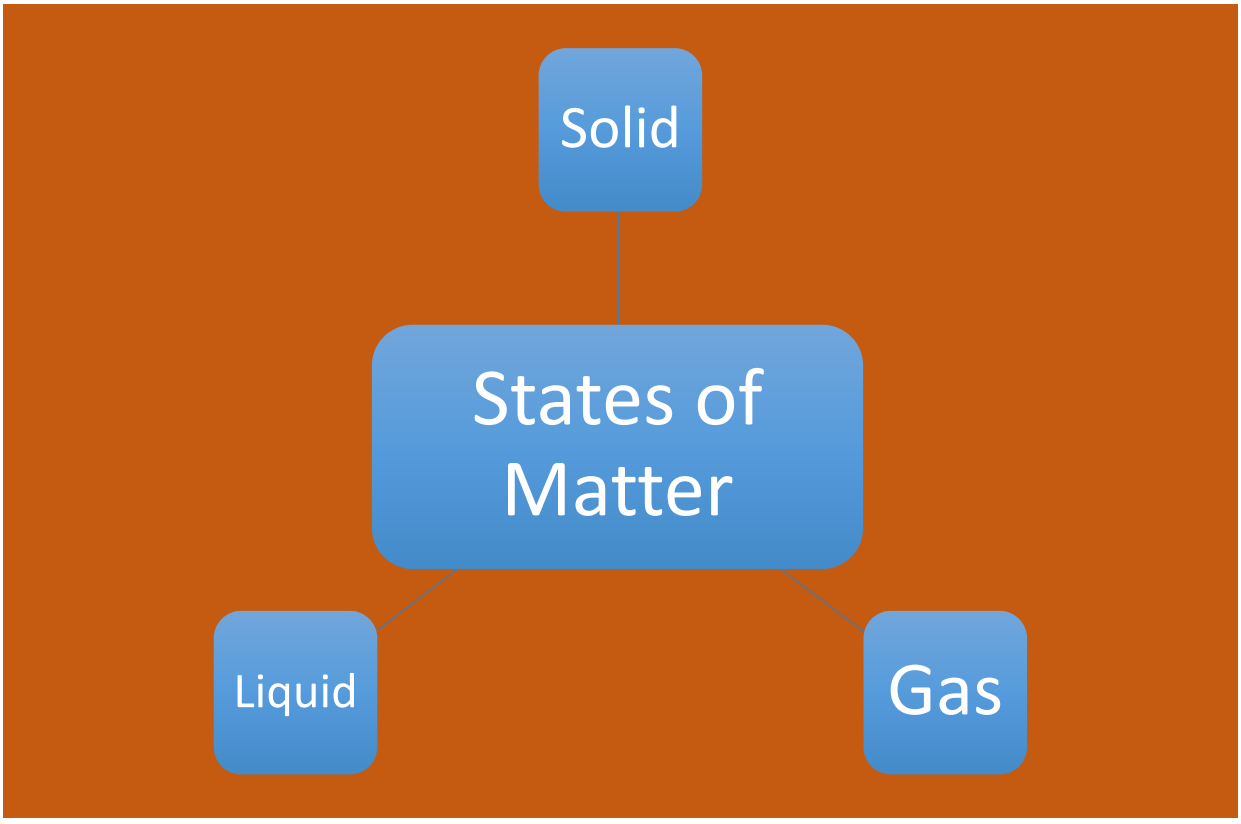
Upon the introduction of the advance organizer's three visual cues, we would query the students for basic familiarity with ice, water, and steam. We would ask students in what contexts they have encountered each of these materials (e.g., ice: snow storms, the freezer; water: swimming, bathing, from the faucet; steam: boiling water, stack emission). We would also ask how the materials feel differently to the touch, and how they respond differently to stimuli. We would ask the students to attempt to describe their properties, thus setting up their linkage to certain dance moves.

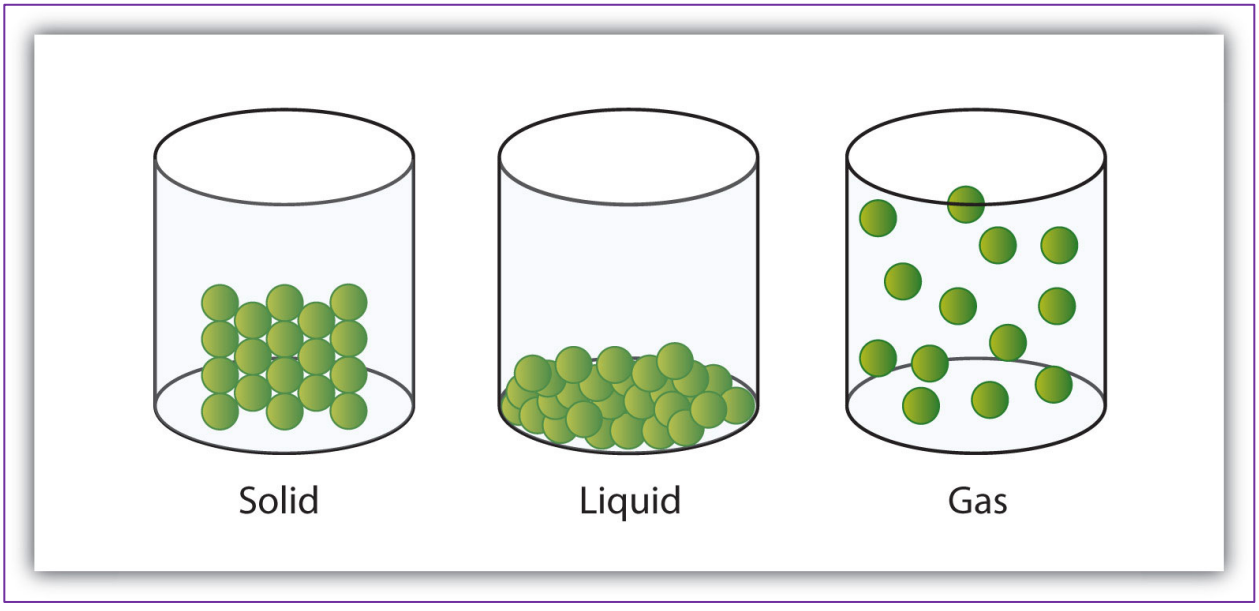
HIERARCHY OR CONCEPT MAP REPRESENTING KNOWLEDGE ABOUT TOPIC

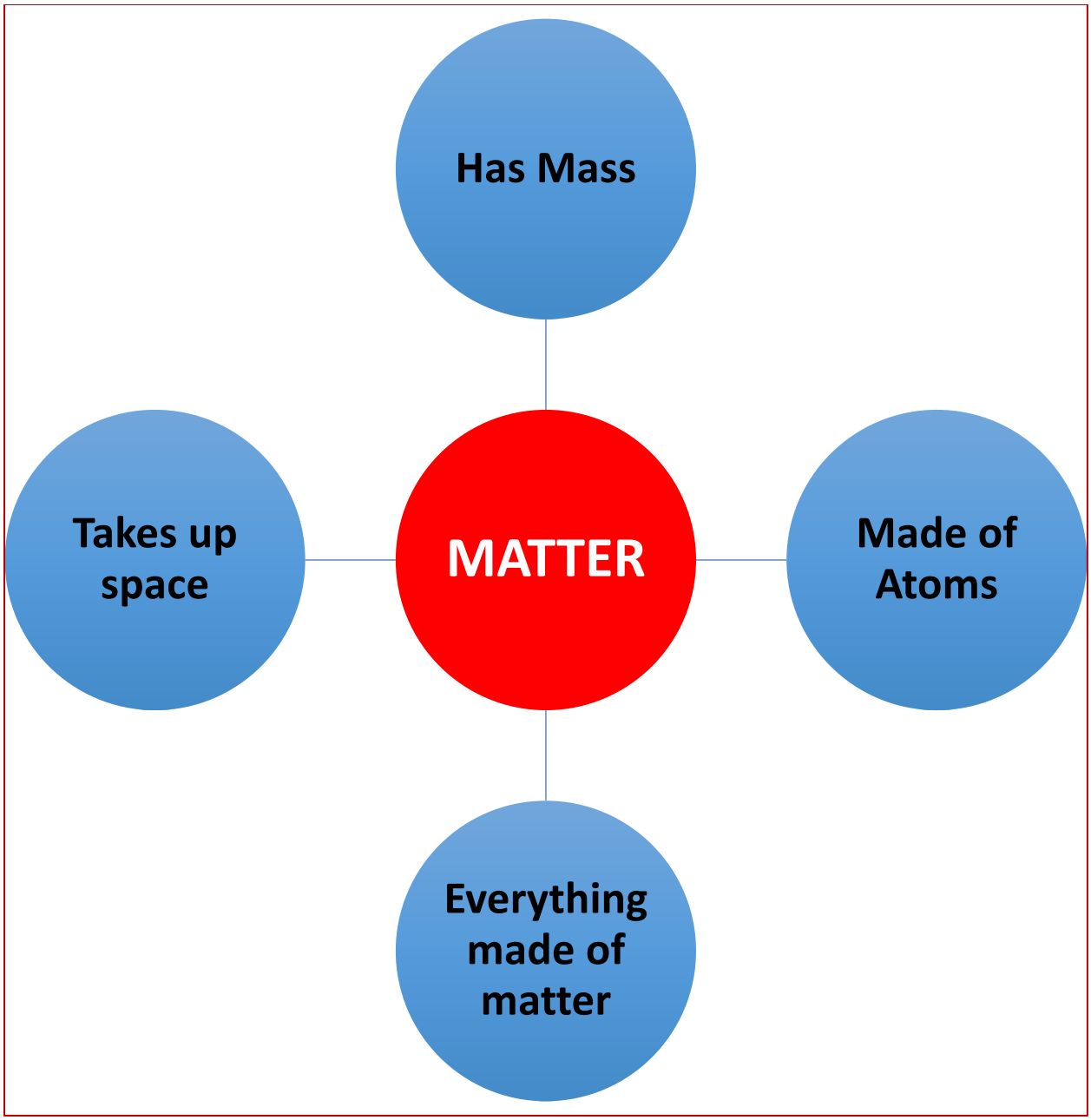
Concept Map for the teacher to conduct the lesson:



Representation of concept material for the students:







NARRATIVE/SKETCH OF INTERFACE OR ENVIRONMENT WHERE LEARNING WILL OCCUR

Learning will take place in a synchronous learning environment within a classroom setting. A dichotomous format will facilitate both the experiential (dance) and didactic (lecture/discussion) component of this learning activity. The initial setup will be open to allow for free movement that will be utilized during the dance portion of this learning session. The latter portion will be set up with desks forming a semicircle with the instructor standing in the center. This will allow all students to sit at the front of the classroom promoting equal engagement. This type of physical setup also facilitates group discussion so the students are facing each other. The instructor can

also more easily flow through the classroom to ask questions to the entire class or to specific students. The front of the classroom will also have a projector connected to a computer to display images and onscreen text.

DESCRIBE HOW THE COGNITIVE THEORIES SUPPORT YOUR DESIGN/PROTOTYPE/STORYBOARD? HOW WILL STUDENTS BENEFIT FROM THE POINT OF VIEW OF THE INFORMATION PROCESSING THEORY AND SCHEMA THEORY?

From the point of view of the **Information Processing Theory** (Atkinson & Shiffrin, 1968), knowledge has to pass from sensory memory to working memory. From there, with sustained attention, the information gets encoded by deeper processing and stored in long-term memory for retrieval at a later stage. Sensory input in the form of visual, auditory, and tactile senses will be engaged to mimic the movement of atoms in the three phases of matter. The tactile facet of the Information Processing Theory helps to account for the effectiveness of the advance organizer described above, which incorporates distinct physical movements for each of the three phases of matter. In addition, visual images of water, ice, and steam that the students have previously encountered outside of class, will also be presented to further process and encode information from working memory into long-term memory. As such both tactile, visual, and auditory cues can assist in retrieval of information from long-term memory at a later time.

The **Dual-Coding Theory** (Pavio, 1986), there are two channels, verbal association and visual imagery, which are responsible for processing of words and pictures, respectively. The instructional material is presented here in a way that requires students to actively engage in the learning process by activating schematic networks which facilitates in the retrieval of knowledge. When asked to recall a phase of matter (e.g., the steam state of water), the student can retrieve either the word “steam” or the image of the boiling teapot individually, or both simultaneously. Teaching a student to code a stimulus (i.e., each of the three phases of matter) in two different formats (verbal and visual coding) increases the student’s chance of remembering the meaning (i.e., storing it in long-term memory).

To support the transition to working memory, the lesson attempts to process and encode the information by relating it to concepts or ideas the students already know and to which they can relate. For example, to discuss the movement of atoms in generating heat relating to the gaseous phase, the instructor will relate this concept back to how students felt when they were dancing rapidly. Did they get hot and start sweating? Were they moving fast or slow? Did they start dancing all over the room, similar to how gas molecules move around widely in a large space? This also helps to make the concept more memorable for the students. In addition, rehearsing the information by applying it immediately after discussion assists in processing knowledge within working memory. The activities and schematic conceptual maps will help ensure that the information will be able to surpass barriers and reach the short-term memory. Intentional repeated exposure and use of the concepts as well as examples for classifying states of matter, will help in long-term encoding of this lesson and integration within the schematic structures of long-term memory. Rehearsal of concepts also aids in schematic automaticity which will allow students to free up working memory to problem solve issues

building on this knowledge. For example, in a practice environment, students can apply these concepts to explain the impact of incorporating a solid, liquid, or gas into an expandable object such as a balloon. Therefore, it can be said that repeated exposure and use of the material helps in building automated schema which not only reduces the cognitive load on the working memory, but also ensures that the material is well-integrated with the long-term schematic structures.

From the point of view of **Schema Theory** (Rumelhart, 1980), the advance organizers serve two purposes in this design plan:

- Activate prior experiences with different states of matter, for example, water in solid (ice), liquid (water) and gas (steam) forms.
- Helps build a schematic framework so that students can identify the new information about phases of matter and classify them into different categories.

The diagrammatic representations and dance activity will help establish a mental model for students that they can use to understand the constituent structure of the different states of matter. It can be extended beyond the textbook knowledge to the real-world by applying the mental model for classification of objects around them. Significantly, because the concepts are being taught with different forms, using verbal, visual and physical coding, separate schema are created that have the potential of being accessed together or independently. Thus, even if one cue is not present, another one may trigger a relevant schema. In addition, eventually when the schema will get automated, there won't be any need of providing the cues for it because the student will be able to respond to it by activating those schematic networks. The transfer of learning from one context to another will further help in deeper and meaningful processing of schema related to classification of states of matter.

References:-

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Pavio, A. (1986). Mental Representation: A dual-coding approach. New York: Oxford University Press.

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