**Sample Group Created Lesson Focused on Serendipitous Event- The Microwave Oven Invention: Beginning Teacher**

I) MATERIALS:

Demonstration- two meter or greater thin diameter rope for demonstration

Group Activity- One microwave safe bowl for groups of 3-4, approximately 1600 ml of tap water, one microwave plate/group, one non-mercury thermometer/group, one 100 ml graduated cylinder/group, preferably 3-5 microwave ovens for class of 20, one set of goggles/student, one pair of oven mitts/group

II) Objectives

1. Using a rope to demonstrate, students observe and record their understanding of high and low amplitude waves.
2. Using a rope to demonstrate and a subsequent discussion about waves, students successfully answer questions concerning electromagnetic and mechanical waves.
3. Using a microwave oven, a bowl, and a varying amount of water, students gain an understanding of temperature changes caused by thermal energy after observing their recorded data.
4. Using a microwave oven, a bowl, and a varying amount of water, students gain an understanding of particle motion.
5. Using a microwave oven, a bowl, and a varying amount of water with a subsequent discussion about thermal energy, students successfully answer questions concerning thermal energy.

III) PROCEDURES:

ROPE ACTIVITY TO UNDERSTAND WAVE ACTION (MS-PS4-1) Demonstration

1. Tie rope to door knob or other fixed structure in front of class
2. Demonstrate a variety of wave actions using the rope including slow high amplitude and fast pulsating low amplitude waves in relation to energy in a wave.
3. Discuss rope wave action with regard to specific electromagnetic wave spectrum
4. After modeling rope activity explain differences between mechanical (e.g., sound, water) and electromagnetic (radio, light) waves. Specifically how mechanical waves need a medium (i.e., water, air, etc.) while electromagnetic waves can travel in a vacuum.
5. Discuss how magnets and electricity interact to produce electromagnetic waves
6. Assess by having students draw waves that are low and high energy.

MICROWAVE OVEN ACTIVITY (MS-PS1-4)- Group Activity

1. Have groups pour 100, 200, 300, 400, 500 ml water in same bowl
2. Record temperature before heating
3. Have groups place bowls one at a time in microwave
4. Heat water for 1 minute (maximum)
	1. Wait for water to cool between uses
5. Record temperature immediately after removal from microwave and have students answer in groups specific questions about thermal energy
6. Discuss serendipitous event

IV) CONCEPTS LEARNED:

Demonstration- Electromagnetic Wave Spectrum, Wave Amplitude, Wave Energy

Group Activity- Concepts Learned- Thermal Energy, Particle Motion

V) SERENDIPITOUS EVENT: Tell story of how the micro-wave oven was invented include background on how microwaves agitate or cause liquid molecules (i.e., particle motion) to vibrate and move inducing frictional forces resulting in wave energy being converted into heat energy.

VI) SAFETY:

Demonstration- Minimal

Group Activity- Use a microwave plate to remove bowls of heated water. Pre test 100 ml of water to make sure time is adequate to raise the temperature (DO NOT EXCEED 70 degrees Celsius). Have students wear protective eyewear. Students will also use oven mitts when removing bowls of heated water from the microwave.

VII) RESOURCES:

http://www.troup.k12.ga.us/userfiles/929/my%20files/science/ms%20science/8th%20science/waves/waves\_resources\_schoolpointe.p df?id=24178

https://science.nasa.gov/ems/02\_anatomy

Roberts, R. (1989). Serendipity: Accidental discoveries in science. New York, NY: John Wiley & Sons, Inc..

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VIII) QUESTIONS FOR GROUP DISCUSSION:

Demonstration- Rope Demonstration

1. What did the rope demonstration tell you about wave energy and motion? Include words like wavelength, amplitude, energy and troughs in your response.
2. What are some examples of mechanical transverse waves?
3. How do you measure a wave-length?
4. How does frequency and wave-length relate to one another?
5. What are some examples of electromagnetic waves?
6. How do electromagnetic and mechanical transverse waves differ?
7. What is one way to cause electromagnetic waves to occur?

Group Activity- Microwave Oven

1. Why did the temperature change less when the water amount increased after heating each bowl for the same time?
2. Would the ratio of water volume/temperature change be the same if the heating time remained constant? Can your group mathematically answer that question? Were the ratios the same or did they differ? Explain your results.
3. If you could see water molecules how do you think their movement would look before heating and after heating?
4. Would a dry plate get hot in a microwave? Why or why not? Explain.

IX) POST ACTIVITY ASSESSMENT:

Draw a high-energy wave x-y axis. Label the wave-length, amplitude and the trough using the diagram.

Draw a low-energy wave using the x-y axis. Label the wave-length, amplitude and the trough.

After heating the bowls of water complete the following table.

|  |  |  |  |
| --- | --- | --- | --- |
| Amount of water (ml) | Temperature before microwave heating (0C) | Temperature after microwave heating (0C) | Change in temperature (0C) |
| 100 |  |  |  |
| 200 |  |  |  |
| 300 |  |  |  |
| 400 |  |  |  |
| 500 |  |  |  |

Extra Credit

 5) Was the same amount of heat energy put into each bowl of water? Explain

6) How much heat energy was put into each bowl of water

7) Can your group use your data to calculate the specific heat of liquid water? You can use the Internet if you do not know what the term specific heat means.

Hint: Answering question 5-6 will require multiple calculations. You will need to determine the power of your microwave oven. More than likely you will have to convert watts to joules/second at some point. Thus, time is also a factor when determining the amount of heat energy (joules/seconds) put into the water. Also you will need to know the density of water or you will need to mass your water as part of calculating specific heat. How does your calculation compare to a “text book” number for the specific heat of liquid water 4.18 Joules/grams oC?