NSF RET Lesson Plan

Lesson Title: Phase Change Material Application	**Grade Level/Subject:** 11th-12th, Chemistry
Maximum # of Students: Students in Classroom	**Total Time Required:** 8 - 50 minute class periods

Prior Knowledge Needed:

This lesson should occur AFTER students have mastered or have at least been introduced to the states of matter, and phase changes.

Materials:

- **Phase change material (case 1)**
    - https://insolcorp.com/templok-pcm-tile-by-insolcorp-2/
- **Model House: 3 needed (3-4 students per group)**
    - https://hands4building.com/collections/starter-kits-1/products/kids-teens-workshop-house-project-curriculum-link-included
- **Temperature Monitor: 3 needed (1 per house)**
    - https://www.amazon.com/ThermoPro-Bluetooth-Indoor-Thermometer-Hygrometer/dp/B08NJ9MWQ1/ref=sr_1_3?crid=3UV99TJ12WFY8&keywords=remote%2Btemperature%2Bmonitor%2Bwith%2Bapp&qid=1658164678&sprefix=remote%2Btemperature%2Bmonitor%2Bwith%2Bapp%2Caps%2C88&sr=8-3&th=1

Performance Objectives/Learning Targets:

- Students will be able to demonstrate the effectiveness of a phase change construction material in a realistic setting.
- Students will discover the methods of heat transfer through a phase change material in a semi-realistic construction simulation.

Standards:

Energy (PS3)		
PS.PS3.3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*		
Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints placed on a device could include the cost of materials, types of materials available, having to use renewable energy, an efficiency threshold, and time to build and/or operate the device. **Assessment Boundary:** Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.		
Science and Engineering Practice	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Designing Solutions: • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.	• At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. • Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.	**Energy and Matter:** • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

Lesson Procedure

Before:	• Introduce discussion of insulation for housing: Why it is important, where it is located within the house, its function, and how the temperature outside can affect the temperature inside the house even with insulation. • How could a phase change material affect this process? • Teacher will need to review phase changes, and types of insulation • Materials list should be purchased. • Teacher should survey locations on campus for possible location suggestions for class
During:	• Teacher should prepare materials for each day (*see day outline above). • Phase Change Application Powerpoint: https://docs.google.com/presentation/d/1QIMm-_h_C6Qklr_Vwc_04UBziDJozMKu/edit?usp=sharing&ouid=110923549229655522327&rtpof=true&sd=true • Phase Change Rubric: https://docs.google.com/document/d/1BNo4AotNAhk5u3_cwgMolyCvwIrhmjPY/edit?usp=sharing&ouid=110923549229655522327&rtpof=true&sd=true • Phase Change Application Lesson: https://docs.google.com/document/d/1NebbaivGKdKQMoDPiQkAP0txwlPrJUIy/edit?usp=sharing&ouid=110923549229655522327&rtpof=true&sd=true

After:	● Day 7/Day 8 (*see day outline below): Use attached rubric to assess students' presentations and use closure/ summary to conclude the project. ● Make sure that all materials have been gathered and returned to the lab

- **Day 1:** Introduce Engagement Activity, Ask Inquiry Questions, Mini Lesson Lecture
  - Slideshow, Print-outs of objective, rubric, and timeline
  - Icecream Jacket question
- **Day 2:** Construct House
  - Show Construction Video
  - Hand out blueprints
- **Day 3:** Finish Instruction, Set houses outside in class determined locations
  - Suggestions for locations (shade, direct sunlight, protected area, etc.)
- **Day 4:** Start collecting data from thermometers, Prepare Presentation
- **Day 5:** Collect Data, Prepare Presentation
- **Day 6:** Finish Collecting Data, Finish Presentation
- **Day 7:** Presentations
  - Use rubric (presentations should be no more than 12-15 minutes including a question period)
- **Day 8:** Closure/Summary

5E Model: *(Engage, Explore, Explain, Evaluate, Elaborate)*

- Engage: IceCream Jacket Discussion: Will ice cream melt faster with or without the jacket?
- Explore: PCM Testing with house - students design experiment (Teacher provides material and instructions to build a house)
- Explain: Virtual phase change lab from McGraw Hill Resources: Students will choose a substance then manipulate the mass of substance vs energy input
  - OR PhET Simulation: https://phet.colorado.edu/sims/html/states-of-matter-basics/latest/states-of-matter-basics_en.html
- Evaluate: Students will present their findings to the class. Their presentation will be graded using a rubric.
- Elaborate: Students will present their findings to the class. Their presentation will be graded using a rubric.

Differentiation:

- Differentiated Learning:
    - Students will be allowed to present in a variety of ways (suggestion: Slideshow, video, poster, or student suggestion upon approval)
    - Make sure groups are divided so that if a student has known learning disabilities they will fit well within their group. Ask probing questions while students are working to assess the delivery of content and project learning and adjust if necessary.