Internet of Things (IoT) at UCF

UNIVERSITY OF CENTRAL FLORIDA

UCF RET Site: Collaborative Multidisciplinary Engineering Design Experiences for Teachers

2002110: M/J Comprehensive Science 3 Adv

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READ THIS FIRST

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- Remember to do your 3R reflection include an updated copy of your lesson plan, developed assessment tools, presentation materials, to the evaluator. See implementation plan instructions developed by the evaluator. Send within a week after completing the lesson to bonnie.swan@ucf.edu

RET Site: Exploring Photosynthesis: Using Environmental Sensors to Monitor the Photosynthetic Rate in Aquatic Plants

Lesson/Unit Plan

Subject Area(s): Processes of Living Systems
Course(s): M/J Comprehensive Science 3 Advanced
Grade Level: 8
Suggested Length of Lesson: approx 4 days

Lesson Summary: Students are designing and conducting their own hands on lab that will help them to demonstrate photosynthesis and how it relates to the carbon cycle. They are utilizing a dissolved oxygen sensor in order to prove that photosynthesis is taking place. Further, they will be monitoring the pH of the experimental setup and observing the movement of the carbon molecules during the process of photosynthesis. They will be answering the Essential Question: *How does the law of conservation of mass relate to photosynthesis? How does radiant energy from the sun change into chemical energy through the process of photosynthesis?*

Prerequisite Knowledge: Students should come into this lesson with these foundational understandings:

- matter is anything that has mass and takes up space
- energy is the ability to do work
- matter and energy cannot be created or destroyed, just transformed
- plants use energy from the Sun, air and water to make food

Materials/Technology Needed

- spinach leaves
- hole punch/straw
- distilled water
- baking soda
- syringe
- dissolved oxygen sensor (AMTAST)
- pH sensors
- UV lamp
- Elodea (anacharis)
- Bromothymol Blue Solution
- test tubes
- test tube holders

Where this Fits/Lesson Dependency

- Within the "Processes of Living Systems" unit.
- After Matter, Law of Conservation of Matter, and Chemical and Physical Changes
- Leads into Carbon Cycle Later

Lesson Objective(s)/Learning Goal(s) (2-4)

- The students will be able to describe and investigate the process of photosynthesis, especially the roles that light, carbon dioxide, and water play
- Students will be able to cite evidence that living things follow the law of conservation of mass
- Students will be constructing a scientific model of the carbon cycle that shows how matter is transferred within and between organisms and their physical environment

Standard(s)/Benchmark(s) Addressed (2-4)

- *Standards:*
  - ***SC.8.L.18.4****: Cite evidence that living things follow the law of conservation of mass and energy*
  - ***SC.8.L.18.1****: Describe and investigate the process of photosynthesis, such as the roles of light, carbon dioxide, water and chlorophyll; production of food; release of oxygen*
  - ***SC.8.L.18.2****: Describe and investigate how cellular respiration breaks down food to*

	provide energy and releases carbon dioxide. – ***SC.8.L.18.3**: Construct a scientific model of the carbon cycle to show how matter and energy are continuously transferred within and between organisms and their physical environment.*
Standards for Mathematical Practice ▪ MAFS.8.SP.1.4 Understand that patterns of association can also be seen in bivariate categorical data by displaying frequencies and relative frequencies on a two way table ▪ MAFS.8.SP.1.1 Construct and interpret scatter plots for bivariate data to investigate patterns of association between two quantities ▪ MA.8.A.1.1 Construct and interpret tables, graphs, and models to represent, analyze, and solve problems related to linear equations, including analysis of domain, range, and the difference between discrete and continuous data	**Instructional Strategies** ▪ 5E Instructional Model: o Engage- access prior knowledge, hook o Explore- activity that facilitates a concept change o Explain- generate an explanation for the new phenomenon o Elaborate- understanding is challenged and deepened by a new experience o Evaluate- assess understanding ▪ Inquiry Based Learning ▪ Collaborative Groups ▪ Cooperative Learning
Evidence of Learning (Assessment Plan) ▪ Pre-test: includes questions on the carbon cycle and the process of photosynthesis ▪ Lab write up (formative assessment) ▪ Post-test: identical to pretest (summative assessment *Write this bulleted list of places you will get assessment data*	

Description of Lesson Activity/Experiences

1. *Engage:* Prior to the start of the lesson, the students are given a pretest that includes the process of photosynthesis and asks them to name the products and reactants. This is given as an exit ticket a day or two before the actual lesson begins. On the first day of the lesson, in order to access their prior knowledge and hook them into the lesson, we begin with a demonstration. Using spinach leaf chads that are sunk into a beaker of water and placed at an optimal distance from a light source, we observe that plants give off bubbles- more when they are closer to the light source. The students are lead to the conclusion that these plants are undergoing photosynthesis and these bubbles that are produced and eventually cause the chad to rise to the surface of the beaker are oxygen. That is then verified using a dissolved oxygen sensor in mg/L.

Steps to prepare demonstration:

1. Dissolve 1 gram of baking soda in 100mL of water
2. Create chads by hole punching portions of the spinach leaf without any major veins.
3. Using the 10mL syringe (without a needle), remove the plunger and load chads into the syringe. Replace plunger and push out excess air.
4. Pull up Water into syringe with chads- invert and remove all the air that floats to the top
5. Create a vacuum by placing thumb over opening on the top of the syringe and pulling the plunger back
6. Hold the plunger back for several seconds, and watch the air bubbles escape the leaves
7. This should pull air out of the leaves force water into them- repeat several times until all the leaf chads sink
8. Make sure you take a dissolved oxygen reading of the water in mg/L prior to introducing chads please note that sensor can take 10 seconds to 5 minutes to stabilize

9. Place the chads into your test beaker containing the remainder of 100mL of water and begin test right away
10. (or….place chads in a capped test tube with minimal air in the dark for later use)

Steps to run the demonstration.

1. Make sure you have a baseline dissolved oxygen reading before you begin.
2. Place 10-15 sinking chads into beaker containing 100 mL of distilled water and 1 gram of baking soda.
3. Place beaker under UV lamp with a heat sink covering the beaker (shallow bowl containing more water to absorb the heat)
4. Time how long it takes all the leaf chads to begin to float to the surface (usually around 5-10 minutes) as the light reactions within the leaf split the water and to release oxygen bubbles.
5. Take dissolved oxygen measurement after all the chads are floating to verify oxygen production

2. *Explore/Explain*-The second demonstration is hands on for the students, can be done while the first demonstration runs, and begins by discussing what the plants might be doing. The students are guided to create a diagram on their worksheets of the processes of photosynthesis together as a class. When it is suggested that carbon dioxide is needed for photosynthesis, we all conduct a whole class demonstration of how bromothymol blue indicator solution can be used to show the amount of carbon that is present in a beaker of water. The students are given a straw and asked to create a solution of distilled water and bromothymol blue indicator solution. When they blow carbon dioxide through the straw it is taken into the water, and that change is verified by a color change from blue to yellow. They are instructed that they will have this solution available as a resource to them when they design their own lab. The students will likely not recognize that is because the water becomes more acidic due to carbonic acid but this will be addressed in a later part of the unit as we enter carbon cycle. They are then asked to check in on their floating chad demonstration, record any results and complete the checking for understanding questions

3. *Explain* Whole class watches video by Nova entitled "Photosynthesis" *(played at end of day one or beginning of day 2 depending on time allotment)*

4. *Elaborate*:

   On the following day, the students are asked to design a scientific experiment that explores one of two student selected research questions:

   1. **How does light affect the photosynthetic rate of plants?**
   2. **How do limiting factors affect the photosynthetic rate of plants?**

   In designing their experiment, the students are given access to the following materials:

   1. 300 mL beakers
   2. test tubes
   3. test tube racks
   4. stoppers
   5. Distilled water (must use)
   6. Baking Soda
   7. Straws
   8. Bromothymol Blue solution (must use)
   9. Elodea aquatic plants (must use)
   10. Dissolved oxygen sensor
   11. pH sensors
   12. Lamps
   13. Timers

The students are asked to work within their groups to formulate and have approved their procedures before supplies are provided, and then to conduct their experiment, record and analyze their results. They are given two class days for designing, setting up,and running their experiment. The final data points should be collected on the third day when the experiment ends and data analysis begins

5. *Evaluate*- The day after the lab is completed, they are given an additional day for analyzing data, drawing conclusions, and making connections to the overall concept. As their lab write up is completed (including graphical analysis and data tables- scatter plots are a requirement), they are asked to draw conclusions in the checking for understanding questions about what conditions are optimal for photosynthesis. Then they are given the post test that again asks about the products and reactants of photosynthesis, as well as questions regarding what caused the color change (and reduction of carbon in the water) during the process of photosynthesis.

Recommended Assessment(s) and Steps

- Pretest
- Formative assessments- lab write ups
- Post Test

How is this different from the Evidence of learning above? MOre detail about the specifics of assessment and the steps involved this is how you should go about gathering that evidence

Materials/Resources Used

- AMTAST dissolved oxygen sensor (can be any market DO sensor- just get familiar with it
- pH sensors
- NOVA Video: https://florida.pbslearningmedia.org/resource/tdc02.sci.life.stru.photosynth/photosynthesis/
- *(note to reviewer- please explain to me how this is to be different from the materials list?)*

Engineering Connection (60-100 words/3 sentences) Unlike most of our labs, in this case the experimental procedure is not given, it must be designed by the students themselves. All I present is the question they should be testing, and I provide them with an available materials list. From there it is up to the student to design a proper scientific procedure for testing that element. This will require collaboration and problem solving within the groups.

Engineering Category (choose one)

X	science and/or math concepts to engineering (primarily science & math with some engineering)
	engineering analysis or partial design (primarily engineering with some science/math)
	engineering design process (full engineering design)

Key Words: Law of Conservation of Mass, Photosynthesis, Environmental sensors

Introduction/Motivation (written as if talking to students) "So far this quarter we have been talking about the Law of Conservation of Mass and chemical and physical changes. Today we are going to begin to look at those concepts in more detail in a living system. I am going to begin with a demonstration. What I have here is water that I have dissolved a little baking soda into. Does anyone remember what the chemical formula for baking soda is? That's right, $NaHCO_3$. And here, I have simple spinach leaves, just like you would buy at the grocery store. What I am going to do is create little disks called chads out of the spinach leaf. To do that, I take my straw and I punch out about 20 little disks from the leaves, trying to choose the areas in between the major veins in the leaf. Now if I were to place these disks into my beaker of water, they would automatically float, and that will not work for my demonstration, so what I am going to do now is remove the air that is trapped inside the leaf. (*continue through process of removing air*). Before we begin the experiment, I want to measure the amount of oxygen that is dissolved in this beaker of water. I am going to use this dissolved oxygen sensor to get a reading in the units of mg/L. It takes a minute or two for the reading to stabilize. (record reading) Now I place the chads into my beaker of water and I place it under my light source with the protection of a heat sink bowl here, and we start our timer. This isn't going to be an immediate reaction, but we should see a pretty significant change in a few minutes here. Does anyone want to try to predict what that change might be?" (students predict that they will float again as oxygen in produced and we go into the discussion of the photosynthetic process.

Closure (written as if talking to students) "Over the last few days we have done some rather extensive experimenting with plants and photosynthesis. I am really proud of the way your groups came together to collaborate on this experiment. Let's take a moment to share some of our results and talk about what we have learned. Group one, can you share with me what research question you chose? And how did you set up your experimental design? What were your results? Excellent work! Group two, what research question did you choose? And what was your experimental design? What did you discover? (*Continue with all the groups*). Ok, so now that we are concluding our research, let's look back at our essential questions and see if we were able to answer those. *How does the law of conservation of mass relate to photosynthesis? How does radiant energy from the sun change into chemical energy through the process of photosynthesis?* Now that you are all experts, let's show this post assessment who is boss."

Lesson Background & Concepts for Teachers

- Teachers need to understand the Law of Conservation of Mass
- Teachers need to have a strong understanding of the process of Photosynthesis, and the light and dark reactions.
- Teachers need to become familiar with the individual instructions for their own pH and dissolved oxygen meters
- Teachers should be familiar with environmental sensors and how they operate
- Teachers should understand polarization and oxidation reduction reactions to understand the role they play in electrochemical sensors.

Important Vocabulary

Term	Definition
Law of Conservation of Matter	matter is neither created or detroyed, it simply changes forms
Law of Conservation of Energy	energy is neither created or destroyed, it simply changes forms
autotrophic	an organism capable of synthesizing its own food from inorganic substances using light or chemical energy. Green plants, algae, and some bacteria
oxygen	O2 product of photosynthesis
carbon dioxide	CO2- what provides the carbon atoms that are incorporated into sugar during photosynthesis
photosynthesis	process that converts light energy into chemical energy that is stored in glucose
cellular respiration	the process that releases energy by breaking down glucose
mass	the amount of matter in an object, measured in grams
matter	anything that has mass and takes up space
molecule	two or more atoms chemically bonded together
sensor	device that detects a physical stimulus and transmits a resulting impulse
indicator	a compound that changes color in the presence of an acid or a base
pH	measure of hydrogen ion concentration- tells how acidic or basic something is
glucose/sugar	simple sugar that is an important energy source for living organisms
chloroplasts	an organelle that absorbs sunlight and uses it to drive photosynthesis
chlorophyll	green pigment located in chloroplasts that absorb light energy
chemical change	
reactant	what you begin with in a chemical reaction (inputs- left side of equation)
product	what you end with in a chemical reaction (outputs- right side of equation)

Troubleshooting Tips

- I used a AMTAST DO sensor, and it should be noted that it takes a good hour to calibrate it as described in its manual. This is because it is a polarographic DO sensor consisting of a silver anode and a gold cathode in a potassium chloride solution. When it is turned on it needs a 5-60 minute warmup period to polarize the electrodes before calibrating or measuring.

- pH meters should also be calibrated with buffer solutions prior to use by following the instructions in the manual of your individual model
- Any other complications discovered upon implementation of this lesson plan will be added here

Other Helpful Information

- 5E Lesson planning framework is outlined as follows:

Table 1. Intentions of each phase of the 5E instructional model

Phase		Teaching objectives and tasks
Engagement		Accessing the learners' prior knowledge, promoting curiosity and elicit prior knowledge, causing cognitive conflict and problems to explore.
Exploration		inquiring independently, or condition a preliminary investigation to generate new ideas.
Explanation	S	explaining their understanding of the concept.
	T	introducing a concept, process or skill.
Elaboration		Extending students' conceptual understanding and skills through new experience.
Evaluation	S	assessing their own understanding and abilities.
	T	Evaluating students' progress toward achieving the educational objectives and process.

- video tutorial demonstrating the preparing of spinach chads:

https://www.youtube.com/watch?v=ZnY9_wMZZWI

Attachments

List here any lesson or activity attachments not included within this document, such as the following:

- Pretest/Posttest
- Worksheet for initial demonstration
- Lab write up for experiment

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