How Do Candles Work? A Lesson on Observation

**Concept Statement:**

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| * Observations are what the senses take in regarding the world around the person. Observations can either be qualitative or quantitative, but all observations are rich in description and accurate in word/number usage. Observations are used to formulate new questions, hypotheses, and theories regarding the phenomenon being observed. * Observations are a critical component of science. Without observations, science cannot test hypotheses/models, formulate new questions for study, or draw accurate conclusions. Michael Faraday made significant contributions to the fields of chemistry, physics, and materials science that have resulted in much of the technology that exists today. * Much of Michael Faraday’s work has resulted in development of materials and technologies that we use today such as electric motors, cathode ray tubes, and catalytic converters. His discovery of various organic compounds have led to further syntheses of other organic compounds. |

**Sources of Lesson:**

Faraday, M. (1850). *The chemical history of a candle*. Hoboken, N.J: BiblioBytes. (reprint in 1990).

Rao, C. N. R. (1991). *Current Science 61*(12) p 787-789. Reproduced in *Resonance* (2002) p 2-5.

Walker, M., Groger, M., Schluter, K. (2008). *J Chem Ed 85*(1), p 59-62.

**List of appropriate TEKS: (19 TAC §112.35)**

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| **TEKS #** | **Student Expectation** |
| 2(E) | The student uses scientific methods to solve investigative questions. The student is expected to:  plan and implement investigative procedures, including asking questions, formulating testable hypotheses, and selecting equipment and technology, including graphing calculators, computers and probes, sufficient scientific glassware such as beakers, Erlenmeyer flasks, pipettes, graduated cylinders, volumetric flasks, safety goggles, and burettes, electronic balances, and an adequate supply of consumable chemicals; |
| 2(F) | collect data and make measurements with accuracy and precision; |
| 2(H) | organize, analyze, evaluate, make inferences, and predict trends from data; |
| 3(A) | Scientific processes. The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to:  in all fields of science, analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, including examining all sides of scientific evidence of those scientific explanations, so as to encourage critical thinking by the student; |
| 3(F) | research and describe the history of chemistry and contributions of scientists. |

|  | **Objectives** | **Evaluation Questions** |
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| 1 | Students will be able to write qualitative and/or quantitative observations about a candle before, during, and after it burns. | What happens when a candle burns? Describe the process in 3-5 complete sentences using good descriptive terms. |
| 2 | Students will be able to write inquisitive questions about a candle before, during, and after it burns. | What was one of your questions about the candle during the lab activity? Can it be answered through further observation or experimentation? Why/why not? |
| 3 | Students will be able to describe the importance of careful observations in scientific work. | Describe the importance of careful observation in science. What are the results of doing sloppy or careless observations? |
| 4 | Students will be able to describe the significance and impact of Michael Faraday’s work on modern science. | How important is Michael Faraday to modern science? Explain using at least one example to support your reasoning. |

**Resources, Materials, Handouts, and Equipment List:**

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| **ITEM** | **Quantity** | **Source** | **Who is this for?** |
| Safety goggles | One pair per student; one pair for teacher | Lab supplies | Student and teacher |
| Birthday candles | One per student | Grocery store or general store | students |
| Play dough (support for candle) | 2-3 cans per class | General store | Students |
| Book of matches | One per pair of students | Grocery store or general store | students |
| Glass beakers of various sizes ranging from 400 mL to 1 L | 5-10 | Lab supplies | students |
| 50 mL and 100 mL graduated cylinders | 5-10 | Lab supplies | students |
| 250 mL Erlenmeyer flasks | 4-5 | Lab supplies | students |
| Triple beam or electronic balances | 4-5 | Lab supplies | Students |
| Metric rulers | One per student | Lab supplies | Students |
| Stop watches | One per student | Lab supplies | Students |
| Litmus paper – red and blue | 2-3 vials of each | Lab supplies | Students |
| Alcohol thermometer | 5-10 | Lab supplies | students |
| PowerPoint, computer, and projector | 1 | Classroom | teacher |
| Computer or tablet with internet access (if not doing the Elaborate for HW) | One per student | Classroom or school media resources | students |

**Safety:**

* Students will be working with fire in this activity. All books and extraneous papers must be kept out of the lab area. Long hair must be tied back. Goggles are required for this activity. Instruct students on how to quickly put out fires by smothering with a large glass beaker and know exactly where fire extinguishers are located so you can put your hands on one quickly in case a fire gets out of control.
* Matches should be used properly. They are lit by striking away from the body and are used long enough to light the candle. Blown out matches should be doused with a bit of water before throwing away.
* Warn students about playing with materials in the lab. The play dough is used solely for supporting the candle. The candle will produce melted wax that is hot enough to produce a first degree burn on skin. All glassware and other lab equipment will be treated as tools not as toys. Goofing around and pranking on others will result in removal from lab and a phone call home to their parent.
* If a student breaks glassware, they should report it immediately to the teacher. The teacher will aid in cleaning up the glassware, and broken glass will be disposed of in an appropriate glass disposal receptacle.

**Advanced Preparations:**

* Prepare the lab area by setting out the glassware, stopwatches, thermometers, rulers, and litmus paper in a central location for students. Place balances around the lab area so that students can easily move to a balance to make measurements as needed. Students will make observations but will not be directed as to what kind of quantitative or qualitative observations.
* Make sure goggles are sanitized and locations of fire extinguishers are known.
* Put class agenda and objectives on board. Have PowerPoint ready to go and displayed. Draw a sample empty data table on the board.

**PowerPoint (Embed as Object here): **

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| **Objective Statement**: The goal of this lesson is to practice making careful observations and asking good, testable questions using a simple object – a candle. In addition, you will learn about the scientist who studied candles and used them to teach science to common folks. This scientist also had a profound impact on current science and technology that we take for granted today. | | |
| **ENGAGE Time: 5 minutes** | | |
| **What the Teacher Will Do** | **Probing/Eliciting Questions and Students Responses** | **What the Students Will Do** |
| 1. State goal for lesson and objectives for lesson. 2. Ask question “How do candles work?” Give students at least 20 seconds to silently think about their answer and allow them to jot down a few notes. Do not accept any answers before the 20 seconds are up. 3. After the 20 seconds are up, call on students for their answers. Allow for some discussion and clarify responses as needed. 4. After student responses have been exhausted, tell students they will now practice observation skills using a candle. They will observe a candle before, during, and after it burns and record their observations in a table. Tell them they will make a combination of qualitative and quantitative observations. Then, ask questions about observations. | * How do candles work? (initial question)   During discussion:   * \_\_\_\_\_, do you agree with what \_\_\_\_ said? Why/why not? * \_\_\_\_\_, can you add to what \_\_\_\_ said? * Are there other things that we haven’t thought of?   After discussion of the burning of a candle, ask the following review/intro questions:   1. What is an observation? (something your senses perceive and your brain processes to help make decisions about the world around you) 2. What is a qualitative observation?   (an observation that involves verbal description of the phenomena/object and includes good, rich use of adjectives and adverbs)   1. What is a quantitative observation? (an observation that involves numbers with units obtained by measuring with an instrument such as a ruler or balance) | 1. Students attentively listen to teacher’s statement of objectives. 2. Students silently think about how a candle works for at least 20 seconds. Some may write down thoughts. 3. Students raise their hands to answer, wait patiently and quietly for the teacher to call on them, and listen to their classmates’ responses being prepared to add to the discussion when called upon by the teacher. 4. Students provide clear, cogent responses to teacher’s request for answers with minimal filler words. |

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| **EXPLORATION Time: 30 Minutes** | | |
| **What the Teacher Will Do** | **Probing/Eliciting Questions and Student Responses** | **What the Students Will Do** |
| 1. Put slide up on screen with lab instructions on it: “Observe a candle before it’s lit, while it’s burning, and after it’s blown out. Make careful observations being alert to observing aspects of the burning that you have not observed before. Record your observations in the table as well as any questions that arise in your mind while you are making the observations.” Tell them they are required to make at least 10 observations before burning, at least 10 observations during burning, and at least 10 observations after burning. Tell them they are also required to write at least 5 questions throughout the activity. 2. State safety issues and precautions that must be taken (see Safety notes above). 3. Tell students they will work individually to make the observations but will share glassware and other lab materials. 4. Have students set up a data table with a column for observations and a column for questions on a piece of notebook paper. Students must show their table before being dismissed to the lab. 5. Have a student helper give each student a birthday candle and a small piece of play dough. Instruct students to use the play dough as a support base for the candle. 6. Give them 20 minutes to complete the activity. Each student must throw away used matches and candles into trash can. Used play dough can be collected and used again. All glassware must be cleaned and returned to the location when students are finished with the activity. 7. Students who finish early and have cleaned up their lab space can sit down at their desk and begin classifying their observations as qualitative or quantitative. 8. During the last 10 minutes, tell remaining students to stop making observations and clean up their lab space. Then, they should sit down and classify their observations as quantitative or qualitative. | Potential questions to ask during the activity (NOTE: This is very much a hands-off activity by the teacher. Give guidance only in terms of proper use of balances or stop watches.):   1. What else do you notice about \_\_\_? 2. What questions are coming to mind as you observe this candle? | 1. Listen to teacher’s instructions regarding the activity and safety. 2. Build a data table on a sheet of notebook paper. Obtain and properly wear goggles. 3. Set up and observe the candle before, during, and after it is lit. Use measuring tools appropriately. Write down accurate observations (30 minimum, total) and questions using good descriptive adjectives, adverbs, nouns, and verbs. Quantitative observations have numbers reported accurately with correct units of measure and what the measurement is (e.g. – length of candle is 5.4 cm) 4. After making observations, lab space is cleaned up, trash thrown away in trash can, and materials are returned. Students return quietly to their desk to classify their observations as qualitative or quantitative. |

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| **EXPLANATION Time: 20 Minutes** | | |
| **What the Teacher Will Do** | **Probing/Eliciting Questions and Student Responses** | **What the Students Will Do** |
| 1. Obtain class’ attention, then pose a series of questions about the candle and its flame. Accept answers that are reasonable and based entirely on the evidence gathered in the activity. Invite other students to add to, or disagree with responses based on their own observations. This discussion should be no longer than 10 minutes. 2. Transition to a short discussion about observations. Write down definitions of observation and inference on board after asking questions. 3. Transition to a brief lecture about Michael Faraday – his life story, scientific work, and famous lectures on the candle. | 1. Questions about the candle (on powerpoint):  * What does a candle flame look like? * What happens to the candle over time? * What does a candle produce when it’s burning? How do you know? * What does a candle need to keep it burning? * What actually burns in a candle flame? * What happened to the wax at the top of the candle: what was it like? What did it do? * Where does the candle flame burn the hottest?  1. Questions about observations:  * Which type of observation did you make the most? * Show by finger count how many quantitative observations you made. Give me an example. * Is detail important when making observations? Why/Why not? * What is the difference between an observation and an inference? | 1. Raise hand when wanting to respond to questions. Wait paitiently and silently to be called on. Listen to classmates’ responses and be ready to follow up when called upon. 2. Students will listen attentively during the lecture on Michael Faraday. Students will ask pertinent questions to clarify what teacher says. |

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| **ELABORATION Time: 45 Minutes** | | |
| **What the Teacher Will Do** | **Probing/Eliciting Questions and Student Responses** | **What the Students Will Do** |
| Michael Faraday has contributed much to the study of chemistry, physics, and materials science.   1. Instruct students that they will now research how Faraday’s work has influenced modern science and technology. Have them select one particular discovery from either Chemistry or Physics (see PowerPoint slides) and have them research the technology that has resulted from this specific discovery. This can be completed as a homework assignment or in-class. Internet access is required. 2. After completing the assignment, have each student share what they found. Then, summarize the lesson. |  | NOTE: This can be done as either an in-class assignment or as homework. Access to the internet is required.   1. Students will research through either the library or internet how one of Faraday’s discoveries has influenced modern science and technology. They will write in a paragraph using complete sentences and complete thoughts a description of the technology and how Faraday’s work has contributed to the development of the technology. 2. Students will share what they found with the class using good speaking voices, little filler words, and looking at the audience. 3. Students will listen attentively to their classmates as each one shares their research. |
| **Closure Statement**: In this lesson, two goals were accomplished. First, you practiced your observation skills and practiced writing testable questions with the candle activity. We then discussed many of the properties of candles and flames. We also learned about Michael Faraday, his natural curiosity about the world around him, and his drive to learn more. Mr. Faraday’s scientific work in the nineteenth century led to the development of what we now consider fundamental ideas of chemistry, electricity & magnetism, and materials science. You have researched his work and discovered the modern applications of his work in ordinary devices. | | |

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| **EVALUATION Time: 15 Minutes** | | |
| **What the Teacher Will Do** | **Probing/Eliciting Questions** | **What the Students Will Do** |
| Instruct students to get out a clean sheet of paper and answer the questions on the PowerPoint slide. Give them 15 minutes to complete this. Collect all papers at the end of the 15 minutes. | Questions on the assessment:  What happens when a candle burns? Describe the process in 3-5 complete sentences using good descriptive terms.  What was one of your questions about the candle during the lab activity? Can it be answered through further observation or experimentation? Why/why not?  Describe the importance of careful observation in science. What are the results of doing sloppy or careless observations?  How important is Michael Faraday to modern science? Explain using at least one example to support your reasoning. | Students will clear their desks and get out a clean sheet of paper and a pen/pencil. They will answer the assessment questions silently on their own paper using complete sentences and complete thoughts. The students will turn in their completed assessment and sit silently while the rest of the class finishes. |