6th Grade STEM DESIGN CHALLENGE
CORRESPONDING ENGINEERING DESIGN PROCESS STAGE IN RED

Unit 2: Metals, Nonmetals, and Metalloids
Topic: Designing Luster, Conductivity, and Malleability Test Procedures
Subject/ grade level: STEM/ Grade 6

Materials:

- Students will use commonly available materials from home to create these tests.
- Design logs
- "Properties of Metals and Nonmetals" handout
- "Scaffolded Concept Map" handout
- "Metals Nonmetals Metalloids Venn" handout
- "Metals and Nonmetals Concept Map" handout
- "Steps in a Process" handout
- "Think-Pair-Share" handout
- "Project Planner" handout
- "Math Path" handout
- "Step-by-Step Process" handout
- 21st Century Skill rubric to grade student project
- "Evaluation" graphic organizer
- Graduated cylinder
- Water
- String
- Periodic tables
- Websites
    - http://www.everythingmaths.co.za/science/grade-10/02-classification-of-matter/02-classification-of-matter-05.cnxmlplus
    - http://www.technologystudent.com/joints/conduct1.html
    - http://chemistry.tutorvista.com/inorganic-chemistry/metals-non-metals-metalloids.html
    - http://answers.yahoo.com/question/index?qid=20090209224355AAAbmDu
    - http://wiki.answers.com/Q/What_are_the_characteristics_of_metal_nonmetal_and_metalloid
    - http://chemistry.about.com/od/analyticalchemistry/a/flametest.htm
    - http://www.engineerstudent.co.uk/thermal_conductivity.php
    - http://cosketch.com/
    - http://teacher.depaul.edu/Documents/MathPath.pdf
    - http://www.education.com/science-fair/article/which-metal-conducts-heat-best/
    - http://www.arborsci.com/cool/thermodynamics-the-heat-is-on

TEKS

Science

(PS) SCI 6.4A- Use appropriate tools to collect, record, and analyze information, including journals/notebooks, beakers, Petri dishes, meter sticks, graduated cylinders, hot plates, test tubes, triple beam balances, microscopes, thermometers, calculators, computers, timing devices, and other equipment as needed to teach the curriculum.
*ⓈSCI 6.6A- Compare metals, nonmetals, and metalloids using physical properties such as luster, conductivity, or malleability.

Math

(PS) MATH.6.1A Apply mathematics to problems arising in everyday life, society, and the workplace.

MATH 6.1C Select tools, including real objects, manipulatives, paper and pencil, and technology as appropriate, and techniques, including mental math, estimation, and number sense as appropriate, to solve problems.

ELPS
C1C Use strategic learning techniques such as concept mapping, drawing, memorizing, comparing, contrasting, and reviewing to acquire basic and grade-level vocabulary
C1E Internalize new basic and academic language by using and reusing it in meaningful ways in speaking and writing activities that build concept and language attainment

CCR
Science
7A1A Distinguish between physical properties (e.g., density, melting point) and chemical properties (e.g., ability to react, combustibility). Know that chemical changes create new substances (e.g., rusting), while physical changes do not (e.g., boiling).
7A2B Understand that, as an intrinsic property, density does not change as sample size is changed, and be able to perform density calculations.

Math
8C1C Interpret results of the mathematical problem in terms of the original real world situation.
8C3A Evaluate a real world solution for accuracy and effectiveness.

Cross-Disciplinary
1C2A Use a range of standard methods, devices, techniques, and strategies to gather and analyze information.
1C3D Present the collected data visually, describe the data collection procedure, and defend choosing that procedure over other possibilities.

Lesson objective(s):

Students will be able to
1. Design three testing procedures, one for each of the following: luster, conductivity, and malleability.
2. Understand that each atom can be classified as a metal, nonmetal, or metalloid.
3. Recognize where on the periodic table the metals, nonmetals, or metalloids are located.
4. Categorize a given element as metal, nonmetal, or metalloid and know the characteristics of each.

Essential Understanding/ Guiding Questions
1. How do we describe and classify matter?
2. How can we use physical properties to compare elements?
3. How can we use physical properties to identify a substance as a metal, nonmetal, or metalloid?

Misconceptions

1. Students may confuse the microscopic properties of an atom with the macroscopic properties of a substance or object made up of atoms.
2. Students may confuse malleability and ductile with each other.

Differentiation strategies to meet diverse learner needs:

- A variety of formative assessments have corresponding graphic organizers throughout the design cycle to add more structure to reflection tasks for students who find this necessary.
- Universal Design for Learning (UDL): CoSketch website to encourage students to co-construct designs- http://cosketch.com/

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IDENTIFY NEED

Students will be given examples of different elements from the periodic table. They will not know the name of these elements, but the elements will be numbered (the teacher will have to secretly choose items). The students will be tasked with creating three different groups of these elements and share the criteria they used to separate the elements (*All should be examples of metals, nonmetals, and metalloids*). The teacher will ask students how they could provide evidence to support their three different groupings.

Design Challenge:
Working in teams of 2-3, students will research and design procedures for testing each group of elements using common everyday objects to create the tests. Using their design procedures, students will then be tasked with planning for and building their own malleability, luster, and conductivity tests to validate or negate their three original groupings.

Differentiation:
To access students' prior knowledge, choose from one of the following graphic organizers:

- "Metals and Nonmetals Concept Map"- standard version
- "Scaffolded Concept Map" – adapted version
- "Metals Nonmetals Metalloids Venn"- enrichment version

Formative Assessment:
Have teams use the "Project Planner" handout to help them define the scope of the design challenge in concrete terms.

RESEARCH THE PROBLEM

Teams will conduct research via the web to answer the following questions:

1. What different categories of elements are represented on the periodic table?
2. What are the characteristics of each category?
3. What tests can be performed to provide evidence of each characteristic?

Students will record these questions and other self-generated questions using Cornell notes in their science/design logs. Students will additionally record their answers to the questions in their design log.

Formative Assessment:
Students will share their answers with their partner (s) in a Think-Pair-Share format.

Differentiation:
For students that need more structure to conduct the Think-Pair-Share, or if you'd like to assess the process, the "Think-Pair-Share" handout is provided.

DEVELOP POSSIBLE SOLUTIONS

Students will research malleability, luster, and electrical conductivity test methods to design testing procedures for each that can be performed safely (*constraint*) and effectively using objects around the home *(constraint*). Students groups should brainstorm <u>at least two</u> for each test needed.

Possible website resources:
http://www.everythingmaths.co.za/science/grade-10/02-classification-of-matter/02-classification-of-matter-05.cnxmlplus
http://www.technologystudent.com/joints/conduct1.html
http://chemistry.tutorvista.com/inorganic-chemistry/metals-non-metals-metalloids.html
http://answers.yahoo.com/question/index?qid=20090209224355AAAbmDu (a spelling error, but good information)
http://wiki.answers.com/Q/What_are_the_characteristics_of_metal_nonmetal_and_metalloid (a spelling error, but good information)

Formative Assessment:
Teams can brainstorm together and record their possible solutions in their individual design logs or work separately to generate ideas. To do this separately, teams might hold each person accountable for generating testing procedures for one type of test method (malleability, luster, or electrical conductivity) to evenly distribute the work.

Differentiation (from the UDL website!):
One way all students can work in real time to generate possible solutions is to use the website, cosketch.com. This co-creation tool will generate a web address for team members to co-sketch (see the chat box for more information on this). Students should save if the co-sketch program will be inactive for 10 minutes or more, and after each work session. This newly generated "saved" link can then be used on subsequent days. Link: http://cosketch.com/

SELECTING THE MOST PROMISING SOLUTION

Students will then select and finalize their testing procedures to evaluate the luster, malleability, and electrical conductivity of their mystery items.

Formative Assessment: Students will select and then draw a diagram of their final selections in their design logs.

Differentiation:
For students who need a graphic organizer scaffold to help them plan out the final draft of a set of procedures, the "Steps in a Process" handout is included. Students should title it with the name of the corresponding testing procedures.

CONSTRUCT A PROTOTYPE

Teams will assemble and build their procedures with the common materials they have indicated and then conduct their tests.

Formative Assessment:
Teams should complete the handout, "Properties of Metals and Nonmetals." After recording their findings on the handout, teams will use their testing information to either confirm or negate their original category groupings.

TEST AND EVALUATE PROTOTYPE

In their design logs, students will reflect on what was learned through the testing and compare this information to their original categories and criteria.

Formative Assessment:
Have teams fill out the "Evaluation" graphic organizer to help teams self-assess each of their testing methods.

COMMUNICATE DESIGN

As a class:
On the periodic table and as part of whole group instruction, groups will use what they know about the elements already familiar to them to decide where they think the metals and nonmetals groups are located, and draw a line to indicate their location on the table. Groups will use some erasable writing instrument so each group can make their predictions in different colors when it is their turn. (*The teacher will collaborate with the students to get them to determine these regions by discussing different known elements in the areas of the table.)*

Formative Assessment (in design logs):
Teams will then share their testing procedures that they used, justify their design choices, and share their final grouping results based on their testing evidence with the class. Teams will share how their final resultant groupings compared to their initial groupings. They will then predict where they think on the periodic table each of their elements can be found.

Differentiation:
Have teams create a graphic organizer like the following in their design logs to compare their results after testing to their initial categories. This formative assessment is called "I Used to Think….But Now I Know" and is helpful for students who are struggling writers or that require more structure to design log follow up tasks.

I Used to Think	But Now I Know

REDESIGN

Teams will research and extend their conductivity testing procedures of an element by describing how the thermal conductivity of their elements could be tested. Students will research and take notes to decide on a procedure to test this physical property.

Possible Resources:
http://chemistry.about.com/od/analyticalchemistry/a/flametest.htm
http://www.engineerstudent.co.uk/thermal_conductivity.php
http://www.education.com/science-fair/article/which-metal-conducts-heat-best/
http://www.arborsci.com/cool/thermodynamics-the-heat-is-on

Formative Assessment (in their design logs):
Teams will draw and label a diagram of their procedures for testing thermal conductivity.

Differentiation:
For students that benefit from a more structured approach to this task, the "Step-by-Step Process" handout could be used to encourage students to think through their thermal conductivity tests since they will only be planning for, not actually designing this test.

MATH CONNECTION

Using one of the "mystery" metal objects, students can calculate the specific gravity to determine what the metal is (*teacher will select one for this activity).*

Calculating the Mass of the Object:
Students will begin by calculating the mass of the metal object (g) and recording it.

Calculating the Volume of the Object:
To do this, students should obtain a graduated cylinder that is large enough to hold the object and add water until the cylinder is about half full. Next, they should read the water level carefully and record this number. If the solid object is heavy, it should be lowered into the water by attaching a string or thread. While the solid object is submerged in the water, the student should record the final water level to calculate the volume of the solid object with the following formula:

Volume of solid= final water level- initial water level

Calculating the Density of the Metal:
Students will calculate the density (g/mL) of the object by dividing its mass (g) by its volume (mL). Be sure students determine the correct number of significant figures in the calculated density value.

Density of object= Mass(g) of object/ Volume (mL) of object

Using the density calculated, students should then identify the metal from the known values for density (the following table provides density values for some metals.).

Density Values of Some Metals

Substance	Density (g/mL)
Aluminum	2.7
Brass	8.4
Copper	8.9
Iron	7.9
Lead	11.3
Nickel	8.9
Tin	7.3
Zinc	7.1

Formative Assessment:
The teacher can write this question and have students solve it in their design logs as a review of these procedures. "An object made of _____ has a mass of 8.37g. When it was placed in a graduated cylinder containing 20.0 mL of water, the water level rose to 23.1 mL. Calculate the density to determine the metal."

Differentiation:
Have students use the "Math Path" graphic organizer to help them work through the steps for solving the math involved in determining metals. Link is also provided here: http://teacher.depaul.edu/Documents/MathPath.pdf