Classification of Materials

Adapted from PNNL Teachers Handbook*

Abstract:

Materials are often taken for granted - they are just there, used in products that students use every day. This introductory activity raises students' conciseness of materials and begin to establish basic concepts about materials, their characteristics (properties) and how this relates to their function. Students will develop simple methods that can be used to distinguish between metals, polymers, ceramics, and composite materials. Students will then have the opportunity to classify random samples of everyday materials into one of these four major material categories and to report their results.

This module was adapted from the Materials Science and Technology Teachers Handbook Pacific Northwest National Laboratory, Richland, WA 1994.

Module objectives:

Classification is a higher level thinking skill. As students justify their placement of materials into certain categories, it gives them a chance to reinforce their ability to think critically about the properties of materials, potential applications, and the appropriate selection of engineering materials. After completing this module students should be able to place a randomly selected material into one of four categories: metal, ceramic, polymer, or composite.

Student learning objectives: Students will be able to:

- Plan and carry out an investigation to place randomly selected materials into one of four categories: metal, ceramic, polymer, or composite
- Communicate the rationale for placing the materials into the selected categories based on material properties
- Discuss how structure and function of bulk materials, which are collections of atoms, are based on material properties

Unit data:

- **Key words:** fibers, composite materials, metals, ceramics, polymers, hardness, ductility, and conductivity.
- Type: Lab

- Target grade levels: All
- **Time required:** one 50-minute class period
- Prerequisite knowledge: None

Core competencies for Engineers and Technicians:

0.A Demonstrate Good Communication Skills
7.A illustrate the General Nature of Metals
7.K Compare Thermal, Physical and Other Properties of Materials

Equipment and supplies needed:

- An assortment of different materials from various sources in the environment (for example, parts of appliances, fabrics, bottle fragments that are both glass and plastic, nails, wires, fiberglass, and insulating materials.) The instructor needs to collect these locally.
- There are many places to get samples of materials. You can use old appliances, or go to junkyards, flea markets, or various industries. Materials are all around us. Be sure to find out what materials the samples are that you have selected. Recommend including fibers like Kevlar, glass wool, fiberglass, and composite materials. Mylar and reflective Mylar can be used to give students something to think about in classifying them.
- Be sure to include a few items that are composite materials so students will have to ponder where to place them. It is best to have at least one sample per student.

Instructor background information:

Materials Scientists and Engineers generally classify the materials that make up our world and everything around us into four major categories; metals, polymers, ceramics, and composites.

Most people recognize metals, for example, as lustrous elements that are good conductors of heat and electricity. Metals tend to be malleable and ductile and are, in general, denser than the other elemental substances. Some important applications for metals include transportation, aerospace, computers and other electronic devices that require conductors, food processing and preservation, construction, biomedical applications, household appliances, and electrical power production and distribution.

Polymers in the natural world have been around since the beginning of time. Starch, cellulose, and rubber all possess polymeric properties. Polymers are large molecules, or macromolecules, composed of many repeated subunits. Polymers range from familiar synthetic plastics such as polystyrene to natural biopolymers such as DNA and proteins that are fundamental to biological structure and function. Their large molecular mass relative to small molecule compounds produces unique physical properties, including toughness, viscoelasticity, and a tendency to form glasses and semi-crystalline structures rather than crystals.

Ceramic materials are inorganic, non-metallic, often crystalline oxides, nitrides or carbide materials. Some elements, such as carbon or silicon, may be considered ceramics. Ceramic materials are brittle, hard and strong in compression, weak in shearing and tension. They withstand chemical erosion that occurs in other materials subjected to acidic or caustic environments and many ceramics can withstand very high temperatures, such as temperatures that range from 1,000 °C to 1,600 °C.

A composite material is a material made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure. The new material may be preferred for many reasons: common examples include materials which are stronger, lighter, or less expensive when compared to traditional materials. A common composite material is fiberglass, in which glass fibers are mixed with a polymeric resin.

If we cut the fiberglass and look at the material closely under a microscope the glass fibers and polymer resin are easy to distinguish.

Items to note in the use of this module include:

- Classification is a higher level thinking skill. As students justify their placement of materials into certain categories, it gives them a chance to reinforce their ability to think critically about choices.
- If you use pieces of glass or other objects with sharp edges, it may be wise to dull the edges using an abrasive. Warn students to be careful of sharp edges.
- Once you have gathered samples, keep them in a box to ensure you retain good samples for next year. As you obtain different material samples, you can add them to the box, as appropriate.

This module starts the student thinking about materials. The following module, 1.1.2, helps them to see why materials are used as they are, depending on the properties of the material.

Module procedure:

1. Display the materials on a table or desk in front of the classroom.
2. On the table or desk, set aside space for four areas labeled metals, polymers, ceramics and composites, where students may place an object after they have identified the material.

- Have students, one at a time, select an object of their choice and place it in the category they feel is appropriate.
- After students have categorized all objects, select various samples and have the students who classified those objects justify why they were placed in certain categories.
- The class then can discuss the best ways to classify materials. Depending on the level or the class, this discussion can be extended by asking students to develop a model to assist them in categorizing the materials based on material properties.

Reference

***Materials Science and Technology Teachers Handbook**, Pacific Northwest National Laboratory, Richland, WA 1994, Available under "Classification of Materials" at http://materialseducation.org/docs/resources/msthandbook/7_Experiments%20Demonstrations-%20Introductory.pdf

This module is also Module 1.1.1 in the Materials Science Digital Handbook

Evaluation packet:

Student evaluation questions (discussion or quiz):

1. How did you decide if the material was metal, polymer, ceramic or composite?
2. What properties of materials did you use to help in the classification?
3. Suggest a test that would have helped you to decide what type of materials each object was made of.

Instructor evaluation questions:

1. At what grade level was this module used?
2. Was the level and rigor of the module what you expected? If not, how can it be improved?

3. Did the activity work as presented? Did they add to student learning? Please note any problems or suggestions.
4. Was the background material sufficient for your discussion with the students? Comments?
5. Did the activity generate interest among the students? Explain.
6. Please provide your input on how this module can be improved, including comments or suggestions concerning the approach, focus and effectiveness of this activity in your context.

Course evaluation questions (for the students):

1. Was the activity clear and understandable?
2. Was the instructor's explanation comprehensive and thorough?
3. Was the instructor interested in your questions?
4. Was the instructor able to answer your questions?
5. What was the most interesting thing that you learned?

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