Module Title: Composite Materials		
Lab compiled by: Tom Stoebe, MatEd Partner	Address:	Email: tgstoebe@earthlink.net
Time to complete module: 50 min.		
Description of module, lab or demonstration: Students will get hands-on experience as they are introduced to the world of composites. In particular, the use of common tongue depressors or Popsicle sticks and Elmers glue provides for an effective demonstration for defining composites and their unique structure and how their intriguing structure allows for such amazing mechanical properties.		
Pre-requisite knowledge and skills: Although it is not required, students may benefit from a general knowledge of composite structures, in particular, the matrix-fiber structure of wood.		
Materials Category:	Structure of Materials ❒ Metals ❒ Ceramics ❒ Polymers ❒ Composites ☑ Other ❒	
Target Grade Level(s) (Check all that apply)	Middle School 6-8 ☑ High School 9-12 ☑ Two-year College 13-14 ☑ Four-year College 15-16 ☑	
MatEd core competencies that the training meets: • 7.010 Describe the general nature of fiber reinforced composites • 7.006 Describe the general nature of woods • 11.001 Describe a composite material		
List of equipment and supplies needed: • A Supply of tongue depressors (or popsicle sticks if tongue depressors are not available) • Woodworking glue • Means of weighting down the specimens during the drying process (A book should work fine) • 30- safety glasses (PPE)		
Curriculum overview and notes to instructor:	**Instructor Background and Notes** The Boeing Composites Glossary defines a composite material as one that: A) Consists of two or more physically distinct and mechanically separable phases; B) Can be made by mixing the separate materials in such a	

	way that the dispersion of one material in the other can be done in a controlled way to achieve optimum properties; and C) Has properties are superior, and possibly unique in some respects, to the properties of the individual components. Composites are usually classified into 3 categories. Lamellar composites have layers such as in our experiment, usually glued together. The most obvious example is plywood. Particulate-reinforced composites have particles suspended in a matrix to add strength. Concrete is an example. Most commercial composites are fiber reinforced, such as the fiberglass used in boats and the high strength graphite fiber reinforced materials used in aircraft. In the latter case, the fibers provide strength while the matrix provides toughness. In this simple experiment, just gluing the pieces together to make a beam adds strength and stiffness. Simply speaking, the glue prevents the wood from sliding past one another, adding stiffness and preventing deformation. However, when tested in bending, it is also found that the beam is stronger not only than one tongue depressor but also stronger than a tongue depressor of double thickness. As in most composites, the resultant beam is stronger than either of the composites. In this experiment, the increase in strength and stiffness is clear just by hand bending. This simple testing method is not unusual and is often used in technology. If desired, one can set up a more scientific bending experiment by supporting both ends of the beam and hanging weights from the middle, perhaps by adding weights to a bucket suspended from the center of the beam. The time consuming part of this experiment is to make up the glued beams. The students can do this the day before, or an assistant can do this. The glue should be evenly spread and the tongue depressors held in contact by weights until dry. Doing this in a warm room speeds the drying. Be sure to remind the students that wood itself is a composite (before one of them does so). Wood is a hybrid that most closely could be classified as a fiber reinforced

	composite.
Mode of presentation: Laboratory or Demonstration	
Module	**Abstract** This module provides a specific example of the effect on strength and stiffness of a material when it is manufactured as a composite. In this case, one piece of wood (here a tongue depressor or a popsicle stick) is the control, and it can be bent as needed. By gluing two of these pieces of wood together (using just Elmers glue), the strength and stiffness increases not by a factor of 2 (for 2 tongue depressors) but by a factor of almost 4. This can be demonstrated but it is more convincing if the students can feel the difference in strength and stiffness for themselves. For a class activity, the instructor or an aid would need to glue together a set of pieces of wood sufficient for one per group of 2 or 3 students. **Experimental Process** 1. Discuss the concept of composites and discuss a few examples (or show some examples if you have any) 2. Pass out tongue depressors to all students-ask them what properties they have. Also discuss wood as a composite! 3. Demonstrate the properties of one of the beams you have made-stiffer and stronger 4. If available, pass out similar beams, perhaps one per group of 2 or 3 students, and ask them to confirm your observation 5. If desired, continue with tests by hanging weights on the beam. Compare to the simple tongue depressor. 6. Discuss the role of the matrix (the glue) and the wood in what is observed. **Further Study** 1. What would happen if 3 tongue depressors were glued together? Try it! 2. Investigate the structure of wood- why is it classified as a composite? 3. Investigate the structure of other common composites such as concrete and fiberglass. How are they used? What properties are enhanced? 4. Research advanced composite use on an advanced aircraft such as the Boeing 787. What advantages come from using the composite instead of metals?
References:	Armstrong, W.P. (2006). *The anatomy of wood*. Retrieved

	August 19, 2007 from, http://waynesword.palomar.edu/trjuly99.htm Australian Academy of Science. (November 2000). *Put it together- the science and technology of composite materials*. Retrieved August 20, 2007 from, http://www.science.org.au/nova/059/059key.htm
Briefly describe how the effectiveness of the module was evaluated:	The effectiveness of the module was evaluated in "10 Simple and Effective In-class Experiments and Demonstrations for Materials Education." The review provides several notes and observations for the module.
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