Module Title: Fracture Resistant Ceramics (The Corelle Plate)		
Lab compiled by: Tom Stoebe, MatEd Partner	Address:	Email: tgstoebe@earthlink.net
Time to complete module: 10-20 minutes		
Description of module, lab or demonstration: Through this simple and quick classroom demonstration, students will observe first-hand the incredible toughness of the Corelle plate, a common household item. The inclusion of additional discussion, as appropriate for student level, will allow students to relate this incredible behavior back to the design and processing of the ceramic plate.		
Pre-requisite knowledge and skills: A general knowledge of ceramics and their structures may be beneficial; however, it is not necessary for the demonstration.		
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 ☑	
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MatEd core competencies that the training meets: • 6.017 Apply concepts of thermal expansion and differential thermal expansion • 7.008 Describe the general nature of ceramics • 13.002 Describe glass materials including molecular structure		
List of equipment and supplies needed: • Several Corelle Plates (2-3) • 30- safety glasses (PPE)		
Curriculum overview and notes to instructor:	**Instructor background and notes** Corelle plates are made of a 3-layer structure of glass. The inner core is a glass with a high coefficient of thermal expansion, while the top and bottom layers are a clear glass glaze with a lower coefficient of thermal expansion. The plate is manufactured at high temperature, with all three layers bonded together. Upon cooling, the inner core contracts more than the outer core. As a result the outer layers are placed in compression while the inner core is in	

	tension. The compressed outer layer resists any cracks since molecules are pressed together by the compressive layer. In this case, cracks will generally not form unless a high level of stress is applied. However, Corelle plates do break! They are safe in the microwave because the microwave energy does not interact with the glass structure, but the broiler or stove top are a different story since heating the plate will remove the difference in stress between the layers (a broiler and stove top will cause uneven heating as well). Further, the glass structure is subject to a phenomenon called "slow crack growth," not uncommon in glasses and ceramics, whereby surface scratches (perhaps due to use of eating utensils). This is why Corelle is often guaranteed against breakage for only 2 years. Generally, banging the plate on a table or lectern will not cause breakage. For a new plate, dropping on the floor seldom causes breakage. When the Corelle plate is older, dropping on the floor may cause breakage, especially on a concrete floor. If dropping on the floor, it is best to drop it so it will hit flat rather than on an edge. It is also best to remove bits of sand from the floor, as a point contact enhances the potential of failure. When the plate does break, be aware that it breaks into many sharp pieces, as you might expect from a glass structure. This is because once a crack reaches the core structure, which is under tension; the crack propagates rapidly, allowing for a rather noisy failure. This is why the plate should be kept away from students when banging or throwing. However, some demonstrators elect to throw the plate into an unused corner of the room, hoping for failure, since the failure will be one the students will remember for some time!
Mode of presentation: Demonstration	
Module	**Abstract** Ceramics are known to be strong in compression, but weak in tension. The cause of this behavior is that in tension, there is no plastic deformation that could potentially stop a crack- rather, once a crack forms, it continues to propagate until failure. Current research is focused on developing tougher ceramics, but one everyday example, discovered in 1970, demonstrates the possibilities. This example is the Corelle plate. In this demonstration, the toughness of the Corelle plate is shown, and the instructor can then lead a discussion to help the students further understand that the

	behavior is directly related to the process utilized during plate manufacturing. **Experimental Process:** Note that this demonstration should be taken only by an instructor or advanced student only! 1. Use the plate to get the students' attention by banging it on a table or lectern. 2. Show the students the plate, identify it by name, and ask if any of them have these plates at home-many do or have had them and will remember (especially if they broke at home) 3. Bang the plate on the table or lectern again and ask why does it not break? 4. Ask the students if the plate will break if dropped onto the floor. Then drop the plate and discuss the results. 5. Now read the back of the plate, "not for broiler or stove top use." Ask students why this could be a problem? 6. Explain the structure and processing of the plate to the students. Ask the students again why the plate does not break. Also, re-ask the question in #5. 7. (For advanced students) Discuss the effects one would expect if the process for manufacture of the plate were not carefully followed. Focus on material choice, bonding process for the layers, cooling process from processing temperature. 8. For fun (if you are brave), take an old Corelle plate and throw it into an unoccupied corner of the room (or outside patio) to see if it can be broken. Discuss the results (And bring a broom!) **Further Study:** 1. Use a book on ceramics engineering or material science, develop precise processes for forming the plate 2. Conduct internet research on Corelle and write a report on what is available that describes the processing involved with the processing of Corelle. 3. What other methods can you find that are used to produce tough ceramics? Why are they not used for dinnerware? 4. What other applications of this layered glass process can you think of? Be specific and as creative as you can be.
References:	World Kitchen LLC. (2007). *About Corelle glass dinnerware*. Retrieved August 19, 2007, from

	http://www.corelle.com/index.asp
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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