Bend But Do Break: An Inquiry Experience Into Material Properties (Resource Exchange)

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Rachelle Pedersen recently completed her Ph.D. at Texas A&M studying Curriculum & Instruction (Emphasis in Engineering & Science Education). Additionally, she has a M.S. in Curriculum & Instruction from Texas A&M University and a B.S. in Engineering Science (Technology Education) from Colorado State University. Her research focuses on motivation and social influences (e.g. mentoring and identity development) that support underrepresented students in STEM fields. Prior to graduate school, Rachelle taught high school technology and engineering education (Robotics/Engineering, AP Computer Science, and Video Production).

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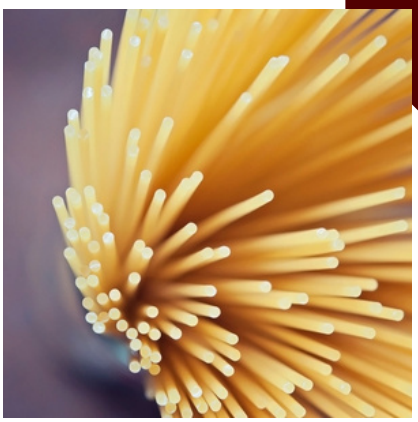
Bend But DO Break!

GEOMETRY AND MATERIAL PROPERTIES WITH NOODLES AND MORE!



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LESSON DESCRIPTION

Often when teaching about material properties, lessons focus specifically on what the material is made out of when addressing how this material might fail under forces. However, the geometry of the item is just as important in understanding failure! In this lesson, students will bend and break various types of pasta noodles (spaghetti, lasagna, manicotti) to determine how the varying geometry of a fixed material type impacts when and how the noodle breaks. Once students understand the role of geometry in structural properties, they will then investigate the role of material properties (e.g., ductile, brittle, modulus of elasticity) by keeping a fixed geometry and changing material type. This low-resource inquiry experience, when coupled with effective questioning strategies from the teacher, will help students deeply understand foundational concepts in solid mechanics (e.g., stress, strain, brittle, ductile).

GRADE LEVEL

- High School
- College Freshman

EST. TIME

- ~120 Minutes

SAFETY

Some pasta noodles will have sharp edges when broken. Monitor student participation.

MATERIALS

- Pasts noodles (spaghetti, angel hair, linguini, manicotti, lasagna)
- Grid Paper
- Markers
- Ruler/Caliper
- Safety Glasses
- Clear tape
- Hot Glue
- Exacto Knife
- Camera (optional)

ENGINEERING CONNECTION

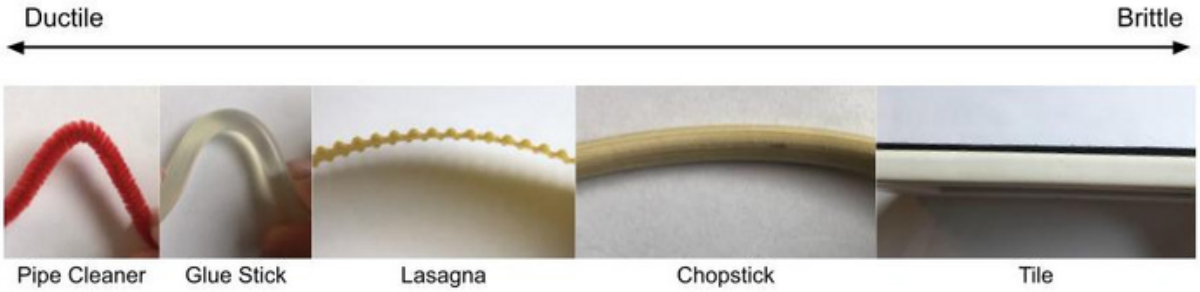
Engineers of all varieties (e.g., biomedical, civil, aerospace) use their understanding of structural properties to design, build, and develop innovations that impact society (e.g., medical implants, concrete supports, aircraft wings). Understanding how geometric and material properties (e.g., Young's Modulus) relate to structural properties of strength and bending moments allows them to predict, design, and optimize as best as possible.

IDEA #1: THE THINNER AN OBJECT IS, THE MORE IT CAN BE BENT BEFORE FAILURE

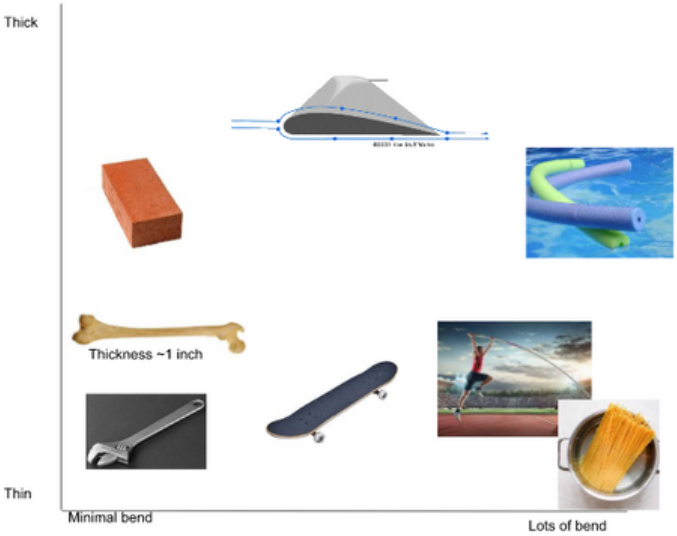
Students are tasked with developing procedures to investigate the relationship between distance from neutral that the spaghetti noodle will bend right before it breaks. Once this relationship is determined, they will then retest with a variety of noodle types (e.g., spaghetti, linguini, lasagna, manicotti) to determine the relationship between the thickness of a material and the maximum radius before breaking. This task controls the type of material so that students clearly see the impact of geometry in structural properties.

IDEA #2: THE MORE DUCTILE THE MATERIAL IS, THE MORE IT CAN BE BENT BEFORE FAILURE

Students now brainstorm a list of various materials that are all of relatively similar thicknesses. They now investigate the role that material property plays when the thickness is kept constant. Through effective questioning and scaffolding, the teacher will help students to develop concepts of ductility (bend before breaking) and brittleness (minimal/no bend before breaking) by having students rank the "bendy-ness" of the materials.



IDEA #3: STRUCTURAL PROPERTIES DEPEND ON BOTH GEOMETRIC AND MATERIAL PROPERTIES



Finally, students will combine these two relationships to understand how structural properties are determined by both the geometric and material properties of an item. Students will be given items that they need to arrange in a way that represents both relationships. Their arrangement will eventually be transformed into a graph, as seen on the left.

For an extension, have students brainstorm additional items and arrange them on the graph.

SCAN QR TO VIEW FULL LESSON