MATERIALS™ EXPLORERS

THE MATERIALS THAT MOVE US: PUTTING IT ALL TOGETHER

Throughout *Materials Explorers*™ you've seen the importance of materials selection in designing a product. You've also learned about the scientific method, a logical or systematic approach to problem solving. Now, you'll be able to apply that knowledge to conceptualize and design your very own product.

In this module students will be able to:

- Evaluate a solution to a complex, real-world problem that can be solved through materials applications
- Analyze and evaluate different material properties
- Develop a practical solution to a complex, real-world problem
- Present the solution through a poster presentation and optional prototype

Capstone Project

MAKING A DIFFERENCE

Background

From airplanes, to smartphones, to medical advancements: the entire history of our world has been shaped by scientists and engineers who identified a problem and worked towards a solution. Sometimes it was by challenging what was considered possible but, many times, it was by looking at a commonplace object and figuring out how it could be improved.

When designing a new product or part, scientists must also select the most suitable material. This is done by carefully considering the qualities their product will need and the conditions it has to endure before selecting the material that best meets those needs. Here's a practical example: if you were asked to design a new type of baseball bat, what qualities would be most important to your final product? Cost would certainly be an important factor to you since it's also important to your customers. Weight would also matter because players don't want a bat that is too heavy to swing comfortably. The bat would also need to be durable enough to withstand the impact of a baseball (often several thousand **Newtons** of force) yet malleable enough for your machines to easily produce their iconic shape. Finally, you might want a bat that resists corrosion despite years of being stored in field houses or storage sheds.

With all these requirements, it's easy to see why aluminum baseball bats are almost as popular as the traditional wood design. Aluminum is malleable, durable, lightweight, corrosion resistant, and cost effective—meeting all the requirements identified above. However, innovation doesn't stop just because a new product is created: there's always the chance to improve through another generation of designs and products.

Although aluminum and wood are very different from one another, both have properties that make excellent baseball bats. What are some important qualities to consider when producing a bat?

Capstone Project

You can also make the world a better place by identifying opportunities for improvement around you and proposing either a “next generation” design or something radically new. Stumped for ideas? Try asking classmates, friends or family about something they use frequently that causes them frustration. Or, try looking around at your school or community for situations that could be improved by a new or different application of materials. Then, think about what kinds of materials you would need in order to address these problems.

The use of iron and steel in building construction allowed the creation of skyscrapers in the late 1800s. Since then, materials innovations have made it possible to construct even taller skyscrapers at a lower price.

Problem:

Look around your home, school or greater community: there are likely many opportunities for improvement through a closer consideration of material selection and product design. You have the opportunity to make those improvements by either designing a completely new product or by improving a preexisting design and by selecting the best materials for creating your product.

Task:

1. Think about your home, school, neighborhood or even the world. Identify a problem that can be solved by constructing something original or by designing a radical improvement to a current product. If you are struggling to think of an idea, conduct a needs assessment by questioning your peers, family members, teachers or neighbors. Keep in mind that sometimes the day-to-day products that we take for granted can also benefit from a redesign.
2. Consider the way your design will be used and how this will influence it. Review the following list of properties and determine which three would be most important when selecting materials for your creation. Keep in mind, some parts of your design may have different requirements. If so, you must identify the three most important properties for each part or component.

- Appearance
- Conductivity
- Corrosion resistance
- Cost
- Density
- Formability
- Melting point
- Strength
- Toughness

Definition

Newtons
The International System of Units (SI) unit of force.

Capstone Project

3. After selecting the three most important properties for your product, research which material(s) best fit those properties.
4. Create a poster to present your design concept, highlighting the materials used for your design and the properties that made you select them. Your poster must meet all of the requirements listed below.
5. Present your design to your class.

Requirements:

Develop a poster that outlines the following:

- The problem that is solved by constructing your item.
- The three essential properties that guided your material selection.
  Note: If the essential properties vary by component, list three essential properties for each part of your design.
- The materials selected and the reason you selected them.
- A sketch of your proposed product including a scale and labels of the material(s) being used.

Questions

1. **Material selection is an important step in designing products. Address each of the following material selection considerations with regards to your project: cost, reliability, ease of joining materials, ease of fabrication, mechanical properties, and electrical properties.**
2. **Materials belong to different "classes" or categories such as metals, ceramics, foams, polymers, composites, and elastomers. For each of the materials used in your product design, research and identify the class of materials to which it belongs.**
3. **When deciding which materials are appropriate for a specific task, material scientists often reference "materials selection charts." These charts map out the properties of different classes of materials and help scientists easily compare materials to one another.**
   i. **Research a materials selection chart that uses any one of the three material properties identified as "essential" in your poster presentation (for example, you may wish to search a materials selection chart showing density and strength, or one showing strength and cost).**
   ii. **Which class of materials performs best according to the chart?**
   iii. **Is it the same class of material as the one you initially selected for your design? If not, would you change your design now? Explain why, or why not.**

Teacher Resources & Answer Key

Standards:	NGSS:	HS-ETS1-3

Notes:

1. Encourage students to get creative with their projects, so long as their solutions are realistic. For example, they can make a project out of beautifying a local space by designing statues or park equipment, but their discussion of material choice would have to consider materials that could withstand environmental conditions, would be durable, and affordable. On the other hand, their project could also be improving an existing product. For example, they might want to develop a more durable phone charger since they frequently have problems with their chargers breaking.

2. Student sketches should include a scale and should be labeled to identify each material used. Posters must explain why each material was selected.

Rubric:

	4	3	2	1
Need	Clear connection to community. Problem is clearly situated in community context with a clear solution.	Connection to community is present. Problem is situated in community context with a clear solution.	Connection to community is present, but weak. Problem is not situated in community context and has no clear solution.	Does not clearly connect to community. No context. No clear solution.
Properties	Identifies three properties essential for materials selection.	Identifies two properties essential for materials selection.	Identifies one property essential for materials selection.	Does not identify properties essential for materials selection.
Material Selection	Clearly identifies materials and explains why materials were selected.	Materials are not clearly identified but there is an explanation of why materials were selected.	Materials are clearly identified but there is no explanation of why materials were selected.	Does not identify materials or explain why materials were selected.
Sketch	Sketch is created to scale and address each material used.	Sketch is created to scale but does not address each material used.	Sketch is not to scale and addresses most materials used.	Sketch is not to scale and does not address each material used.

Teacher Resources & Answer Key

Questions and Answers

1. **Material selection is an important step in designing products. Address each of the following material selection considerations in regards to your project: cost, reliability, ease of joining materials, ease of fabrication, mechanical properties, and electrical properties.**

   Answer: Student answers will vary but should demonstrate an understanding that properties vary by materials and that factors such as production process and consumer preferences influence the design of a product.

2. **Materials belong to different "classes" or categories such as metals, ceramics, foams, polymers, composites, and elastomers. For each of the materials used in your product design, research and identify the class of materials to which it belongs.**

   Answer: Student answers will vary.

3. **When deciding which materials are appropriate for a specific task, material scientists often reference "materials selection charts." These charts map out the properties of different classes of materials and help scientists easily compare materials to one another.**
   i. **Research a materials selection chart that uses any one of the three material properties identified as "essential" in your poster presentation (for example, you may wish to search a materials selection chart showing density and strength, or one showing strength and cost).**
   ii. **Which class of materials performs best according to the chart?**
   iii. **Is it the same class of material as the one you initially selected for your design? If not, would you change your design now? Explain why, or why not.**

   Answer: Student answers will vary but should take into account that the material that ranks highest in one category may not automatically be the best choice (for example, the strongest material might be difficult to form into the desired shape or may corrode easily or might make the product too expensive).

MATERIALS™ EXPLORERS

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ARCONIC FOUNDATION

Materials Explorers™ is a STEM educational outreach initiative of The Minerals, Metals & Materials Society (TMS). TMS is non-profit, international professional society with a mission to promote the global science and engineering professions concerned with minerals, metals, and materials.

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