Unit 7.3 Overview

Building Materials: How we use our Natural Resources

This is the third unit of the 7th grade Mi-STAR curriculum. It primarily uses the theme Energy and Earth Resources as it explores thermal energy transfer, nonrenewable resources, and human impacts on Earth systems. There are 10 lessons within this interdisciplinary unit. Throughout this unit, students will seek to answer the unit question:

How can resource availability affect our lifestyles, and how can our lifestyles affect resource availability?

Next Generation Science Standards

Unit 7.3 has four primary NGSS Performance Expectations associated with its lessons. Within these Performance Expectations are three of the eight Science and Engineering Practices, three of the seven Cross-Cutting Concepts, and eight Disciplinary Core Ideas; all of which are presented here.

MS-ESS3-1: Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes. [Clarification Statement: Emphasis is on how these resources are limited and typically non-renewable, and how their distributions are significantly changing as a result of removal by humans. Examples of uneven distributions of resources as a result of past processes include but are not limited to petroleum (locations of the burial of organic marine sediments and subsequent geologic traps), metal ores (locations of past volcanic and hydrothermal activity associated with subduction zones), and soil (locations of active weathering and/or deposition of rock).

MS-PS1-3: Gather and make sense of information to describe that synthetic materials come from natural resources and impact society. [Clarification Statement: Emphasis is on natural resources that undergo a chemical process to form the synthetic material. Examples of new materials could include new medicine, foods, and alternative fuels.] [*Assessment Boundary: Assessment is limited to qualitative information.*]

MS-PS3-3: Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.* [Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.] [*Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.*]

MS-ESS3-4: Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems. [Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.

Lesson 1: Home Designs Around the World

Lesson Overview: The use of building materials and methods for the construction of homes has evolved over time and varies among different regions of the world. For example, when humans first settled, homes were built by the materials available on hand, including grass, wood, stone, and dry clay (brick). The search for more durable materials to build long-lasting dwellings has led to a variety of other materials to be used, including concrete and steel. Today, in certain parts of the world, synthetic materials are being used, such as composite siding and fiber cement board. The selection of materials for home construction depends on a number of factors, including the lifestyle of the occupant, material properties, resource availability, local climate, financial constraints, and cultural values. One consideration that is increasingly prevalent in the selection of materials and home design is energy efficiency (minimizing the transfer of thermal energy lost from or gained by the home). Scientific research and technology has helped create more energy-efficient homes through the use of synthetic materials. However, Earth's systems can be impacted by the extraction of raw materials, the production of synthetic materials, and the disposal of materials at the end of their useful life. In this lesson, students examine a range of home construction designs and materials from around the world and over time. They consider the reasons why certain materials are chosen over others when building homes. Then, students examine the relationship between a home's design and the conservation of resources by comparing a straw bale house to their own homes (or a typical Michigan house). At the lesson's conclusion, students are introduced to the Ongoing Unit Challenge scenario in which they begin to evaluate the best wall insulation material for a new community center.

Introduction to the Ongoing Unit Challenge: Introduction to the Ongoing Unit Challenge: Your local mayor is competing for an environmental sustainability award that, if won, could bring much-needed tourist dollars, federal grant money, and good publicity for your community. The city council has decided to build a community center that will provide new programs for the local population. In order to improve the mayor's possibility of winning, (s)he has commissioned several engineering firms (small student groups) to test individual insulation materials for the walls of the building that balance energy efficiency with the environmental impact of the specific insulation material. Each group (engineering firm) will use knowledge based on the upcoming lessons of the unit to measure certain characteristics of their material to decide whether it might be a good one to use. At the end of the unit, all groups will come together to share their results and decide which material would be best to use for the community building and give the project the best chance of winning the environmental sustainability award.

Lesson Questions

- ➔ *Why do the designs and materials used in home construction vary among different communities and over time?*
- ➔ *How are the designs and materials selected for home construction related to resource conservation?*

Constructing Explanations and Designing Solutions *- Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system.*(MS-PS3-3)		**Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** *- The uses of technologies and any limitation on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.* (MS-PS1-3) **Influence of Science, Engineering, and Technology on Society and the Natural World** *All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.* (MS-ESS3-1)

Lesson 2: Decision Criteria and Constraints

Lesson Overview: The design of a solution to an engineering problem must consider two factors. The first are the requirements for the design. These are referred to as the criteria. The second are the design restrictions, or limits, that are imposed externally. These are referred to as the constraints. For example, a criterion for a building design would be the properties of the building materials. A constraint for the building design would be the availability of resources. In this lesson, students begin to think about the criteria that will guide them in their selection of building materials to be used in the unit-long challenge. These will include insulating value, local availability, renewability, and impact on the environment from the use, extraction, and disposal of their material. The Engage and Explore will introduce students to the concept of a Decision Matrix and how this tool can be used in engineering and construction projects. Groups will be given a wall insulation material for the ongoing unit challenge, and the class will set up a decision matrix by choosing a weight for each of the criteria mentioned above.

Introduction to the Ongoing Unit Challenge: Students are introduced to both their ongoing unit challenge insulation materials and the Decision Matrix engineering tool to help them make decisions based on their material's properties throughout the challenge.

Lesson Questions

- ➔ *How can we determine which solution will be the most successful in solving an engineering problem?*

Constructing Explanations and Designing Solutions *- Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system.* (MS-PS3-3)	**ETS1.A: Defining and Delimiting an Engineering Problem** *The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions*.(PS3-3 secondary) **ETS1.B: Developing Possible Solutions** *A solution needs to be tested, and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem.* (PS3-3 secondary)	**Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** *- The use of technology are driven by societal needs and difference in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.* (MS-PS1-3)

Lesson 3: Properties of Natural and Processed Materials

Lesson Overview: Students will identify natural and synthetic materials using known chemical and physical properties of matter. The natural and synthetic materials that students examine are ones used by people on a daily basis because their properties are useful. Synthetic materials are derived from natural resources and designed and developed for their useful properties. People choose natural and synthetic products based on the needs of the situation.

Introduction to the Ongoing Unit Challenge: Students observe the structure and properties of their insulation materials that enhance their function to meet humans' needs. Students obtain information about wall insulation from websites then weigh the "Material Properties" criteria in the Decision Matrix.

Lesson Questions

- ➔ *What are the properties of materials that make them useful to humans?*

Obtaining, Evaluating, and Communicating Information: *- Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.* (PE 1-3)	**PS1.A: Structure and Properties of Matter** *Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.* (PS1-3)	**Structure and Function** Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used. (PS1-3) **Connections to Engineering, Technology and Applications of Science** **Interdependence of Science, Engineering, and Technology** *- Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems.* (PS1-3)

Lesson 4: Thermal Energy in Action

Lesson Overview: Students test the rates of heat transfer through cups made of a range of different materials. They analyze temperature measurements to determine the variables which affect the rate of thermal energy transfer. Students will observe that some materials are better at conducting (or insulating) thermal energy than others and that a material's properties can either maximize or minimize thermal energy transfer. This sets the stage for testing the insulating value of the materials selected for the ongoing unit challenge. Results will be recorded on each group's unit-long decision matrix.

Introduction to the Ongoing Unit Challenge: Students learn about thermal properties of materials and that products can either enhance (conduct) or minimize (insulate) thermal heat transfer. Activities in the Elaborate guide students to consider their ongoing unit challenge insulation material and calculate the R-value as an input into the Decision Matrix.

Lesson Questions

- ➔ *How can we slow the rate that heat is transferred?*

Constructing Explanations and Designing Solutions *- Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.* (MS-ESS3-1)	**PS3.A: Definitions of Energy** *-Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present*. (MS-PS3-3) **PS3.B: Conservation of Energy and Energy Transfer** *- Energy is spontaneously transferred out of hotter regions or objects and into colder ones.* (MS-PS 3-3)	**Energy and Matter** - The transfer of energy can be tracked as energy flows through a designed or natural system. (MS-PS3-3)

Lesson 5: Synthesizing a Synthetic

Lesson Overview: Students look at how natural resources are changed to create synthetic materials which have particular properties that make them useful for specific needs (concrete, etc.). They discover that synthetic materials originate from raw materials that are natural resources, both renewable and nonrenewable, that undergo chemical changes to enhance designated properties.

Introduction to the Ongoing Unit Challenge: Students read provided sources to identify the inputs and processes required to create their insulation material for the ongoing unit challenge. Students evaluate whether the materials are naturally occurring or synthetic. Students rate the criteria in their Decision Matrix.

Lesson Questions

- ➔ *Where do synthetic materials come from?*
- ➔ *How is matter changed to create the materials we use?*

Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 6–8 builds on K–5 and progresses to evaluating the merit and validity of ideas and methods.

-Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or now supported by evidence. (PS1-3)

PS1.B: Chemical Reactions

Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (PS1-3)

PS1.A: Structure and Properties of Matter

Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (PS1-3)

Structure and Function

- Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used. (PS1-3)

Energy and Matter

- The transfer of energy can be tracked as energy flows through a designed or natural system. (PS3-3)

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Lesson 6: Different Places, Different Resources

Lesson Overview: In this lesson, students continue to further investigate the wall insulation material for the unit-long challenge by answering the question, "Why are natural resources found in certain locations and not others?" Examining how past and current geological processes creates an uneven distribution of natural resources allows for an investigation of how non-renewable resources are limited by the rate and distribution of the geologic processes that create them. Resource distribution changes when humans begin extracting and consuming resources. Resource availability and distribution also changes due to the timescales it takes to regenerate a resource. The class uses a very general example (salt) to begin thinking about how it forms and how large deposits are distributed and what geological factors played a role in its formation. Students will use models (maps) to identify patterns in resource distribution and generate an understanding that geological processes dictate natural resource distribution. Students will then be provided information and maps regarding the distribution of their wall insulation raw material and make interpretations about its local availability and renewability, which will be incorporated into the Ongoing-Unit-Challenge Decision Matrix.

Introduction to the Ongoing Unit Challenge: Students use data gathered during the Elaborate to provide values for "Local Availability" and "Renewability" in their Decision Matrix.

Lesson Questions

- ➔ *Why are natural resources found in certain locations and not others?*
- ➔ *Why is natural resource distribution and availability important to society?*

Engaging in Argument from Evidence *- Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.* (ESS3-4) **Constructing Explanations and Designing Solutions** *- Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.*(MS-ESS3-1)	**ESS3.A: Natural Resources** *Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.* (MS-ESS3-1)	**Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** *- The use of technology are driven by societal needs and difference in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.* (MS-PS1-3)

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Lesson 7: Human Population and Resource Consumption

Lesson Overview: Human population growth and changing lifestyles are increasing human consumption of natural resources. This consumption, in turn, has an impact on the Earth's systems through the use and disposal of materials. In this lesson, students examine the relationship between population growth, consumption of resources, as well as the impacts of resource use and disposal on Earth's systems. Students also explore how engineering solutions can minimize some of these negative impacts to Earth systems.

Introduction to the Ongoing Unit Challenge: Students reflect on how population growth increases demand on natural resources. Students investigate whether depletion of nonrenewable resources affect the availability of their insulation material. Criteria of renewability and local availability are revisited/reweighed in the Decision Matrix.

Lesson Questions

- ➔ *How is human population growth connected to changes in resource consumption?*
- ➔ *What role can science and technology play in natural resource conservation?*

Engaging in Argument from Evidence *- Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.* (ESS3-4)	**ESS3.A: Natural Resources** *Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.* (MS-ESS3-1) **ESS3.C: Human impact on Earth's systems** *Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.*(MS-ESS3-4)	**Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** *- All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.* (MS-PS1-3)

Lesson 8: Life Cycles of Products

Lesson Overview: Societies require tremendous amounts of natural resources to meet the needs of growing populations; more than any point in the past. Every material we buy at the store requires natural resources or other inputs at every stage in its life cycle. In this lesson, students consider the life cycle of natural resources. They think about how certain resources are used to create the products they use. They examine how these products are made from raw materials that are obtained from the natural environment. Then, they look at how those materials are processed and manufactured to create the goods needed by modern society. They also contemplate what happens to products after they are no longer useful. Students discover that each material or product we use has a life cycle and that each stage of the product's life cycle has inputs and outputs. The transfer of energy (and matter) can be tracked as energy (or matter) flows through a designed or natural system. The Life Cycle Assessment is an engineering tool to quantify the economics, human impact, energy required, materials, environmental impact, and wastes produced at each stage of a product's life cycle from cradle (design) to grave (disposal).

Introduction to the Ongoing Unit Challenge: Groups will now consider the Lifecycle of their insulation material. Students review written information on the life cycle of the material and compile the information below. Students revisit the Decision Matrix to rate the value for "recycled content, energy used, chemical inputs and air pollution." The students will use information from this lesson and others to create a presentation for the whole class in the final lesson.

Lesson Questions

- ➔ *What are the different stages in the life cycles of the products that we use?*
- ➔ *How can a life cycle assessment be helpful for conserving natural resources?*

Obtaining, Evaluating, and Communicating Information

- Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or now supported by evidence. (MS-PS1-3)

Constructing Explanations and Designing Solutions

- Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system. (MS-PS3-3)

ESS3.C: Human Impacts on Earth Systems

Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-4)

ETS1.B: Developing Possible Solutions

A solution needs to be tested, and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary) (MS-PS-3-3)

Energy and Matter

- The transfer of energy can be tracked as energy flows through a designed or natural system. (MS-PS3-3)

Influence of Science, Engineering, and Technology on Society and the Natural World

-All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. (MS-ESS3-1)

-Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. (MS-PS3-1)

Energy and Matter

- Matter is conserved because atoms are conserved in physical and chemical processes. (secondary)

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Lesson 9: LCAs and Impacts on Earth Systems

Lesson Overview: Human population growth and changing lifestyles are increasing human consumption of natural resources. This consumption, in turn, has an impact on Earth systems: during extraction of raw materials, production of refined materials, use of materials, and in disposal of materials. In this lesson, students will examine this relationships between population growth and consumption as well as consumption and changes to Earth systems. Students will also explore how engineering solutions can minimize some of these negative impacts to Earth systems.

Introduction to the Ongoing Unit Challenge: Students will review a case study describing one stage of their material's LCA and the impact on Earth Systems. Student will recommend/design a solution to reduce the negative effects of the impact based on scientific ideas. The students then compile this information to be shared as part of their presentation during the final lesson.

Lesson Questions

- ➔ *How does the extraction and use of natural resources impact Earth's systems?*

Engaging in Argument from Evidence

- Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (ESS3-4)

Constructing Explanations and Designing Solutions

- Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system. (MS-PS3-3)

ESS3.C: Human impact on Earth's systems

Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth Systems unless the activities and technologies involved are engineered otherwise. (MS-ESS3-4)

ESS3.A: Natural Resources

Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.(MS-ESS3-1)

Cause and Effect

- Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Connections to Engineering, Technology, and Applications of Science

Science Addresses Questions About the Natural and Material World

-Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.

Influence of Science, Engineering, and Technology on Society and the Natural World

- All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.

Lesson 10: Final Design!

Lesson Overview: The final evaluate lesson encompasses a performance based opportunity to tie concepts from all previous lessons together in a culminating activity. Student groups compile the information they have collected and present the results from their decision matrix based on their specific material into a Class Decision Matrix. A larger, class-wide discussion occurs that allows the class to weigh each material against the others. Students debate the information from their results, and the students justify the reasoning for their assigned weighting/ranking. Ideally, consensus can be achieved through class discussion to make a final decision on the best insulation material for the energy efficient community building scenario that also maximizes resource conservation. Depending on their weighting of criteria, students may do this through thermal efficiency, use of local/regional materials, and/or use of renewable materials. Ideally, students will consider and address all three factors in their final design decision.

Introduction to the Ongoing Unit Challenge: Groups will present the information on their insulation material that they have compiled throughout the unit to present to the rest of the class. During this presentation the rating and scores will be filled in on the Class Decision Matrix. Based on these results the students will consider the best design for wall insulation in the community building scenario, and provide a recommendation. Each individual student will write a letter to the town mayor to describe their final decision using evidence based reasoning to justify their recommendation.

Lesson Questions

- ➔ *Which wall insulation material will maximize conservation of natural resources and thermal energy?*
- ➔ *How confident are we in our decision making process?*

Constructing Explanations and Designing Solutions

- Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system. (MS-ESS3-1)

ETS1.A: Defining and Delimiting an Engineering Problem

The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions.(MS-PS3-3 secondary)

ETS1.B: Developing Possible Solutions

A solution needs to be tested, and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (MS-PS3-3 secondary)

Energy and Matter

- The transfer of energy can be tracked as energy flows through a designed or natural system.

Connections to Engineering, Technology, and Applications of Science

Science Addresses Questions About the Natural and Material World

-Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.