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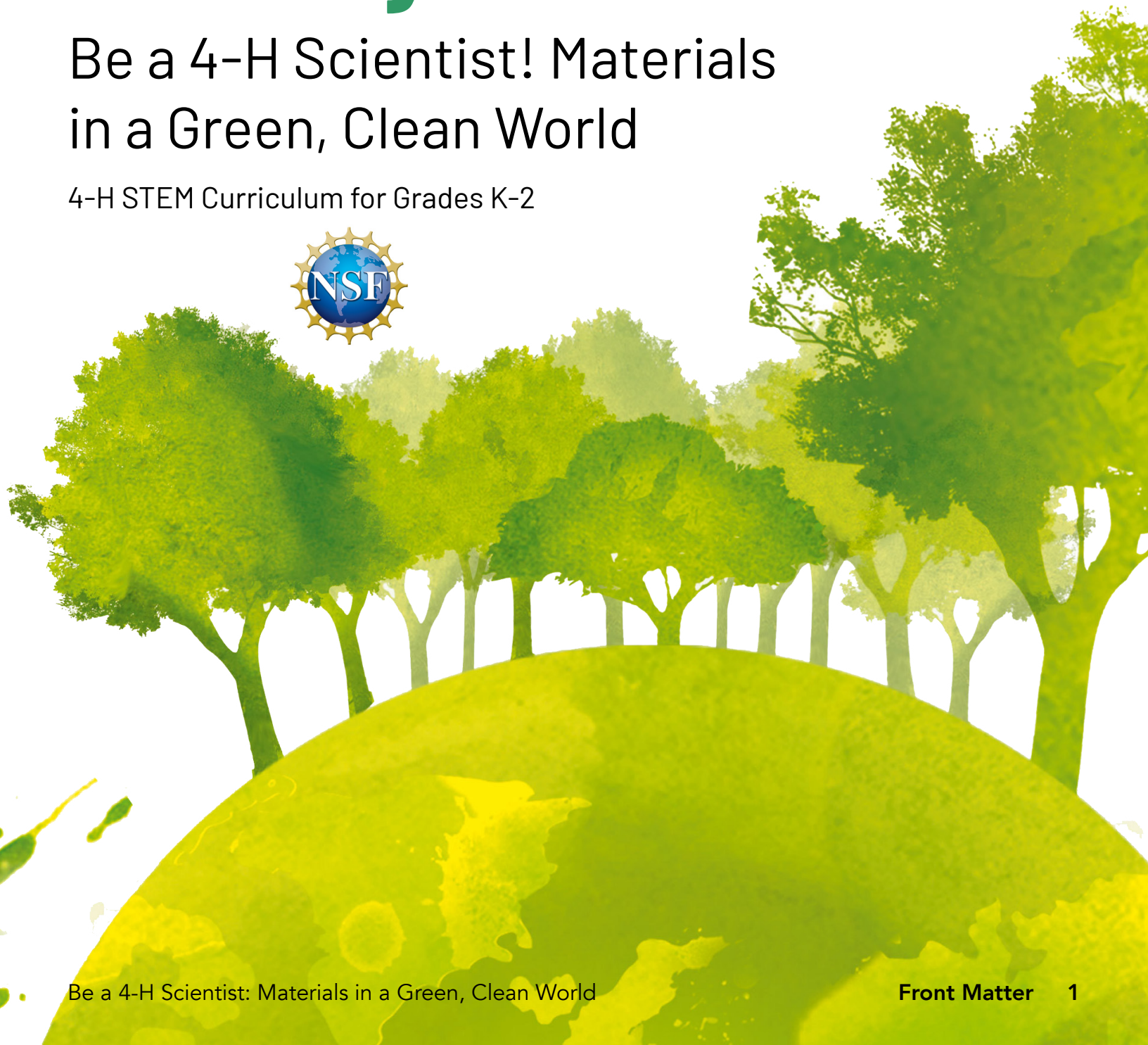
4-H Polymers

Be a 4-H Scientist! Materials in a Green, Clean World

4-H STEM Curriculum for Grades K-2



Front Matter

BY STEVEN WORKER AND JENNIFER HENDERSON

Be a 4-H Scientist! Materials in a Green, Clean World is an inquiry-based science curriculum focusing on the following concepts: materials; plastics; the three R's: Reduce, Re-use, Recycle; the work of scientists and engineers. The curriculum is designed to build foundational skills of science and engineering: observation, asking questions, sorting and classifying, and communicating. The curriculum contains six learning modules intended for delivery in out-of-school time facilitated by an educator (trained volunteers or program staff). Modules also include a "Science At Home" activity to be completed by parents/other adults and children at home.

CURRICULUM TARGETED AUDIENCE

Youth in grades K–2 (5 to 8 years of age)

DEVELOPMENT TEAM

A partnership between the University of Minnesota Center for Sustainable Polymers, University of Minnesota Extension, University of California Agriculture and Natural Resources, Cornell University Cooperative Extension, and edited by SciGirls. This work is supported by the National Science Foundation (NSF) under the Center for Sustainable Polymers CHE-1413862.

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LEARNING OBJECTIVES SUMMARY

In this set of six modules, children are introduced to the world of scientists and engineers. Using their senses, children become scientists themselves by making observations and asking questions about the world around them. As they work through the modules, children explore different materials and their properties. Experimentation illustrates how different materials may perform better in some

situations, depending on that material's properties. Special attention is paid to plastic, a material that is prevalent in our world. Children will learn the different types of plastics and their uses, as well as the positive and negative effects plastic (and its pollution) can have on humans, animals, and the environment. To help protect the environment and its resources, children learn about strategies to lessen waste and pollution (reduce, re-use, recycle) and the difference between renewable and non-renewable resources.

MODULE SUMMARIES

Module 1 What is a Scientist? Engaging Youth as Scientists and Engineers

Children are encouraged to use their senses and wonder about the world around them using mystery boxes and hydrogels. They learn that they are using the same skills scientists and engineers use everyday!

Module 2 The Many Properties of Materials

Every item and object we encounter is made of a material, and each material has a different set of properties. Using commonly found items, children categorize materials based on properties and then complete a series of challenges to select the appropriate materials to solve a problem.

Module 3 Plastics in Your World

Plastic and plastic products are abundant in our world. In this module, children learn about the different types of plastic and their uses. After familiarizing themselves with the many types of plastic items, children explore different methods of plastic disposal.

Module 4 Reduce, Re-use, Recycle

Using the techniques of real-life recycling facilities, children sort and separate different materials. They will review the different properties learned in Module 2 to sort these materials.

Module 5 Renewable vs. Non-renewable

The first part of this module reviews the different material properties discovered in Module 2. After learning about the difference between "renewable" and "non-renewable", children play a game in which they mine for resources. They will discover the difference when some materials replenish while others do not.

Module 6 Scientists and Engineers

Children learn about scientists and engineers through reading selected books aloud. Then they make their own stories featuring a scientist or engineer — and in one option, the children are the scientists in their story!

CONTENT SUMMARY: THE IMPACTS OF PLASTIC

The theme of these modules touches on the prevalence and impact of plastics in everyday life. Plastics are versatile materials that come in different shapes, sizes, and exhibit different material properties. Plastics can be strong and rigid (such as safety helmets and the exterior of automobiles) or soft and flexible (such as the those used in shoe cushioning or plastics bags). It's easy to find examples of plastics in everyday life, and we all encounter plastic items at multiple points each day. Plastics have many advantages as they can be lightweight alternatives that can save on fuel and energy.

Along with the many advantages of using plastics, plastics have disadvantages. Plastics that end up littered in the environment can take hundreds or thousands of years to degrade. It is estimated that 8 million metric tons of plastics end up in our oceans each year.■ One of the best ways to dispose of plastics is through a recycling program. Plastics that are recycled can be reprocessed into the same item or converted into a different item. However, not all plastic makes its way to the recycling bin. Only about 10% of all plastic is recycled — the rest is either incinerated, put into a landfill, or ends up as pollution in the environment.■

■ *"World's Oceans Clogged by Millions of Tons of Plastic Trash." Scientific American. February 2015*

■ *"A Whopping 91% of Plastic Isn't Recycled." National Geographic. July 19, 2017*

Scientists and engineers are working on new ways to create, use, and recycle plastics, so we can use plastics for their many advantages and lessen their effects on our environment. Some plastics are now designed to biodegrade without polluting the environment and others are created using renewable resources to lessen the dependence on traditional, oil-based plastics.

LIFE SKILLS AND POSITIVE YOUTH DEVELOPMENT

Positive youth development builds on young people's strengths and assets. Youth development involves an intentional process that promotes positive outcomes for young people by providing opportunities, choices, caring relationships, and the support necessary for youth to fully participate in families and communities. High-quality programming doesn't only provide valuable benefits in knowledge, skills, and interests, but also in the form of leadership development, life skills development, and civic development. Through participation in science and engineering education, youth should have opportunities to strengthen their competence, confidence, connection, character, caring/empathy, and contribution to community.

Practices to support positive youth development:

- Establishing a safe environment and building relationships. All youth need a caring, supportive relationship in their lives. Educators provide this by showing interest in, actively listening to, and fostering the assets of youth.
- Provide youth leadership opportunities. Creating opportunities for youth to develop skills and confidence for leadership and self-discipline is important for youth development.
- Provide community involvement experiences. Service forges bonds between youth and the community, and doing something valued by others raises feelings of self-worth and competence.

EXPERIENTIAL LEARNING CYCLE AND PROMOTING INQUIRY

The curriculum is designed around the teaching methods of inquiry and experiential learning. Experiential learning is a cyclical process where learners have opportunities to construct meaning through engaging experiences. The cycle includes multiple phases including a concrete hands-on experience; a reflection phase where youth share, process, and generalize from the experience; and application of learning in new and authentic situations to deepen their understanding.

In a learning environment that promotes inquiry-based learning, youth build understanding through active exploration and questioning. The key to inquiry is that youth seek answers to questions rather than being given answers. This requires those who lead activities to facilitate the learning process and not simply disseminate knowledge. When activities are being led in an inquiry manner, youth actively question, observe, and manipulate objects in the environment.

EXPERIENTIAL LEARNING IN THE CURRICULUM

The curriculum outlines each activity around the experiential learning cycle:

- **Opening questions and prompts**: Before providing the materials for the experience, you should facilitate a group discussion to get youth thinking about what they know about the main learning objectives of the module.
- **Experiencing**: Procedures and instructions for a hands-on activity.
- **Sharing, Processing, Generalizing**: Help guide youth as they question, share, and compare their observations. Sample broad and open questions are included. Often, some of the sharing and processing takes place during "experiencing", however, it is vitally important to schedule time for group reflection after the activity. If necessary, use more targeted questions as prompts to get to particular points.
- **Concept and Term Discovery**: During this sharing phase, it is important to ensure that the primary learning objectives and concepts have been introduced or discovered by the youth. The goal is to have the youth discover terms and concepts on their own.
- **Application**: The true test of learners' understanding is when they can apply new knowledge and skills to authentic situations. When engaging youth in inquiry-based learning, hands-on activities serve as vehicles for learning new concept knowledge and skills; however, it is the application of new knowledge or skills to independent, real-world situations that is the critical factor in the learning process. Thus, to complete the cycle of experiential learning it is important to intentionally provide youth specific opportunities for authentic applications. Each module includes examples for real-world application.

RECOMMENDED EDUCATOR PRACTICES

The educator is expected to be a facilitator of learning with the primary role being to help youth make meaning of their experiences. Educators are not expected to be the "sage on the stage" but rather the "guide on the side." Facilitating an open discussion is crucial in helping learners make meaning of their experience. Questions allow us to access information, analyze data, and draw sound conclusions. Good questions help stimulate thinking and creativity. To this end, broad and open questions are ideal in promoting discussion and interaction. They do not have a single right answer. In contrast, focused, narrow, and close-ended questions tend to be fact-based or yes/no answers and do not promote discussion. Furthermore, encouraging science talk has four purposes (elicitation, consolidation, data, and explanation) and may involve full group, small group, or partner discussions.

For more about encouraging productive science talk, see Sarah Michael and Cathy O'Connor's Talk Science, *Primer*, at:

https://inquiryproject.terc.edu/shared/pd/TalkScience_Primer.pdf

RECOMMENDATIONS FOR EVALUATION OF LEARNING

The curriculum emphasizes the use of embedded evaluation and formative strategies to assess learning which may occur in multiple places during the implementation of an activity. First, educators may assess youth understanding of the main concepts and their engagement with Next Generation Science Standards (NGSS) practices and concepts through the types of questions youth ask, moments of wonder or puzzlement, and being able to successfully complete the task. Second, when youth share their ideas and experiences, the educators can assess how well youth understood the primary learning objective through the activity. Additionally, during the sharing, processing, and generalizing phase, educators can ask more targeted or focused questions to assess youth understanding, particularly with regard to the concept and term discovery. Finally, the application phase provides another opportunity to assess youth learning. Educators may have youth share their application activity at subsequent sessions.

To conduct outcome assessment of the curriculum, educators may want to administer the Draw-a-Scientist Test (DAST) to assess youth perceptions of scientists before and then again after the curriculum. Research has shown that children develop a stereotypic image of scientist at an early age. Exciting, hands-on, and educational programs — such as this curriculum — should help youth deconstruct these images and help them start to see themselves as someone who can do, uses, and may contribute to science.

CONNECTION TO "SciGirls *SEVEN*"

These modules were designed to incorporate many of the practices and strategies used to engage girls in science education. *SciGirls* is an Emmy award-winning PBS Kids television show, website, and educational outreach program that engages girls in science, technology, engineering, and math (STEM) learning. Using research, *SciGirls* outlines seven best practices in their "*SciGirls Seven*". These strategies are used to target and engage girls in STEM learning but have also been proven to work with all learners, including underrepresented youth. In the individual modules, practices that correspond to one of the "*SciGirls Seven*" will be identified.

The "*SciGirls Seven*" proven strategies for engaging girls in STEM are:

1. Girls benefit from collaboration, especially when they can participate and communicate fairly.
2. Girls are motivated by projects they find personally relevant and meaningful.
3. Girls enjoy hands-on, open-ended projects and investigations.
4. Girls are motivated when they can approach projects in their own way, applying their creativity, unique talents, and preferred learning styles.
5. Girls' confidence and performance improves in response to specific positive feedback on things they can control — such as effort, strategies, and behaviors.
6. Girls gain confidence and trust their own reasoning when encouraged to think critically.
7. Girls benefit from relationships with role models and mentors.

CONNECTIONS TO NEXT GENERATION SCIENCE STANDARDS (NGSS)

This collection of activity modules incorporates many of the science and engineering practices identified in the Next Generation Science Standards (NGSS). Children in kindergarten–2nd grades will work on their skills in seven practices (in this collection, less focus is placed on using mathematical and computational thinking).

Science and Engineering Practices:

- Asking questions and defining problems
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematical and computational thinking
- Constructing explanations and designing solutions
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

Children explore many of different disciplinary core ideas defined by NGSS through these six modules. These core ideas span the physical sciences (PS), earth and space sciences (ESS), and engineering, technology, and the applications of science (ETS).

Disciplinary Core Ideas:

- Structure and Properties of Matter (PS1.A)
  - Matter can be described and classified by its observable properties
  - Different properties are suited to different purposes
- Human Impacts on Earth Systems (ESS3.C)
  - Humans affect the world around them, but can make choices to reduce their impacts on the land, water, air, and other living things
- Defining and Delimiting Engineering Problems (ETS1.A)
  - A situation that people want to change or create can be approached as a problem to be solved through engineering
  - Asking questions, making observations, and gathering information are helpful in thinking about problems
- Optimizing the Design Solution (ETS1.C)
  - There is always more than one possible solution to a problem, it is useful to compare and test designs

CONNECTIONS TO NEXT GENERATION SCIENCE STANDARDS (NGSS) *(CONTINUED)*

These modules also feature a number of crosscutting concepts. These concepts connect differing areas of content by providing related connections and tools.

Crosscutting Concepts:

- Patterns
  - Patterns in the natural and human designed world can be observed
  - Events have causes that generate observable patterns
- Cause and Effect
  - Events have causes that generate observable patterns
- Structure and Function
  - The shape and stability of structures of natural or designed objects are related to their function(s)
- Interdependence of Science, Engineering, and Technology
  - People encounter questions about the natural world every day
- Influence of Engineering, Technology, and Science, on Society and the Natural World
  - Human-made products are designed by applying some knowledge of the natural world and built using materials derived from the natural world
  - Developing and using technology has impacts on the natural world

Together, the practices, core ideas, and crosscutting concepts covered through these modules mirror a number of performance expectations for children in grades K–2, such as:

- Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment. (K-ESS3-3)
- Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties. (2-PS1-1)
- Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose. (2-PS1-2)
- Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through development of a new or improved object or tool. (K-2-ETS1-1)
- Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs. (K-2-ETS1-3)

The types of things scientists and engineers do:

Abilities

Build/Construct

Categorize/Order/Classify

Collaborate

Collect Data

Communicate/Demonstrate

Compare/Contrast

Design Solutions

Develop Solutions

Draw/Design

Evaluate

Hypothesize

Invent/Implement Solutions

Infer

Interpret/Analyze/Reason

Measure

Model/Graph/Use Numbers

Observe

Optimize

Organize/Order/Classify

Plan Investigations

Predict

Problem Solve

Question

Redesign

Research a Problem

State a Problem

Summarize

Test

Troubleshoot

Use Tools

Practices (NGSS)

Asking questions (science) and defining problems (engineering)

Developing and using models

Planning and carrying out investigations

Analyzing and interpreting data

Using math and computers

Constructing explanations (science) and designing solutions (engineering)

Engaging in argumentation

Obtaining, evaluating and communicating information

Glossary

- **5 Basic Senses:** Our senses include sense of touch, taste, hearing, smell, and sight.
- **Engineering:** using knowledge to invent, design, or improve a solution to a specific problem.
- **Engineers:** people who use knowledge to invent, design, or improve a solution to a specific problem. Engineers use science knowledge, math, creativity and their experience to design or re-design useful objects or useful ways of doing things (processes). Engineers must weigh design choices based on merits, constraints, and aesthetics to meet design specifications (considering both form and function) and be able to justify those choices.
- **Floatation:** rises to the surface of a liquid (or water).
- **Landfill:** a place used where garbage is disposed of; material put here is not recycled.
- **Litter:** any trash (e.g., paper, plastic or glass bottles, cans) that is left or disposed of in open (e.g., on land or in water) or public places.
- **Magnetic:** attracted to or repelled by a magnet
- **Material:** the substance which something is made from.
- **Non-renewable:** a material made from resources that are only available in limited quantities and take a long time to be replenished (i.e. millions of years)
- **Observation:** what you see, hear, touch, taste, or smell. Students use observations to identify properties of different objects.
- **Plastic:** a type of man-made material.
- **Property:** an attribute or quality of an item; how it looks, tastes, feels, sounds; qualities that can be observed or measured.
- **Recycle:** collecting old material and processing them to make a new material or object
- **Renewable:** a material made from naturally occurring resources that can be replenished, often within one person's lifetime
- **Re-use:** finding a way to use materials again (For simplicity in this curriculum, we also include the idea of "re-purpose" (use an item for a new purpose) under the term Re-use.)
- **Scientists:** people who asks questions about the world around them. Scientists explore the world through the process of inquiry where they describe, explain, and predict through observation, experimentation, modeling, and other scientific techniques. Science methods may rely on quantitative data (numbers), qualitative data (descriptions), or both.