5TH GRADE-8TH GRADE

Science and Technology

Content Standard E:

As a result of the activities in grades 5-8, all students should develop

- **Abilities of technological design**
- **Understandings about science and technology**

Content Summary

National Science Education Content Standards

K-4

Abilities to distinguish between natural objects and objects made by humans

Abilities of technological design

Understandings about science and technology

5-8

Abilities of technological design

Understandings about science and technology

9-12

Abilities of technological design

Understandings about science and technology

Minnesota Graduation Standards

Primary Level

Intermediate Level

Middle Level

Group Resources:
Manage resources as a team to produce a product or service

Writing:
Write for a variety of academic and technical purposes, situations and audiences

Technical Reading:
Comprehend technical information from documents or electronic media

High School Level

Technical Systems:
Apply knowledge, skills and tools of technological systems to extend human capabilities while preserving ecological functions

Technical Applications:
Apply mathematics to solve technical problems

New Product Development:
Research, develop and test a new product

Technical Reading:
Read and apply technical information from documents or electronic media

Technical Writing:
Write for a variety of technical purposes, situations, and audiences

Focus K-12

Grade	Early	Late
K-4	The focus of instruction early in this grade range is on providing opportunities for all students to investigate designed products and begin to develop the ability to design a solution to a problem.	The focus of instruction later in this grade range is on providing all students opportunities that continue to develop the abilities to design solutions to problems using situations and materials the students encounter in their daily lives.
5-8	The focus of instruction for all students early in this grade range is on establishing an awareness of the distinctions between science and technology and increasing students' abilities in design, using familiar science contexts.	The focus of instruction later in this grade range is on developing all students' understandings about similarities and differences between science and technology and using their abilities of technological design to solve problems in a variety of contexts.
9-12	The focus of instruction for all students at the high school level is on deepening students' understanding of the close relationship between science and technology and providing opportunities for them to apply science content and use their abilities of technological design to solve complex problems.	The focus of instruction for students pursuing further study is on providing opportunities for independent problem solving experiences which involve the full range of abilities and understandings of technological design.

Close-up 5-8

The focus of instruction for all students early in this grade range is on establishing an awareness of the distinctions between science and technology and increasing students' abilities in design, using familiar science contexts.

Through participation in inquiry and design activities, students begin to differentiate their understanding of technology and science. The work in science differs and complements the work in technology. Design activities appropriate for this age group should involve simple design tasks that meet needs or solve problems in students' homes, school, and immediate community. Teachers ensure that the design tasks are well defined, familiar to the students, and involve only one scientific concept for each task. In addition, students interview and conduct research about people who are engaged in science and technology related careers. Regardless of the design tasks or products studied, the emphasis should be placed on making use of science concepts and understanding new ones. Students and teachers observe established science safety procedures.

The focus of instruction later in this grade range is developing all students' understandings about similarities and differences between science and technology and using their abilities of technological design to solve problems in a variety of contexts.

Students improve their abilities in the design process through tasks which require them to develop new products and systems, or to evaluate designs, products, and systems. These tasks should allow students to explore a range of contexts including those familiar in homes and community such as commercial products and those from wider regional, national, or global contexts such as transportation and communication systems. Regardless of the areas of design studied, it is essential that students understand the underlying science concepts. Students can begin to differentiate between science and technology as well as understand their relationship, and to appreciate that technological problem-solving involves factors beyond the scientific concepts involved. Their understanding of how science and technology interact is increased. They learn through experience that there are constraints on technological design, that technological solutions result in both intended and unintended outcomes, and that perfectly designed solutions are not possible; there are always trade-offs, risks, and constraints. Students and teachers observe established science safety procedures.

On Location 5-8

The principle objective of this lesson is to perfect the design of various invented musical instruments. Embedded within this lesson are several aspects of the physical science standard related to sound. Design is not studied for its own sake, but becomes a vehicle for teaching important science concepts.

Students in Ms. T's class do activities to discover the nature of sound and how it is produced. Her students seem to understand how strings (or rubber bands) can make sound when plucked, but do not know how horns and tubas work. Ms. T records their questions and then asks her students to make "musical" instruments that produce sound in many ways. She provides some simple materials such as plastic tubes, water glasses, tuning forks, pop bottles, and funnels.

The teacher suggests that the students compare several objects to find which produce the highest and lowest pitch, the softest sound, the loudest ring, and the longest lasting sound. Along the way, her students find that sound can be made by plucking, banging, and blowing. Some discover for themselves that manipulating the tension (length) of a vibrating object changes its pitch.

Some of Ms. T's students already know how to make a "telephone" from juice cans and strings. Some of them try it. While Ms. T is careful not to give "cookbook directions," she asks clarifying questions and urges student groups to explore new directions.

Ms. T's students have discovered that sounds are made when things vibrate and that the speed at which things vibrate affects the kind of sound that is produced. They have observed that solids, liquids, and gases all can vibrate, and thus carry sound. Now they are ready to design an instrument that has certain characteristics. The teacher asks that students design instruments that can be heard at great distances, have the clearest tones, be the loudest, or play an actual tune.

Students write about their reasons for choosing their particular design, and as they play their instrument for the class, they explain the changes in design that occurred as they worked to accomplish their goal. Because Ms. T begins her unit with an exploration activity, her students are able to connect both observations and questions. Both can be tested by hands-on verification, a step that she always includes.

When the class becomes familiar with the properties of sounds as well as some of the things that can generate them, they are ready to make things that adhere to one or more specifications.

National Science Education Content Standards

5-8 Content Standard E

Abilities of Technological Design

- **Identify appropriate problems for technological design.** Students should develop their abilities by identifying a specified need, considering its various aspects, and talking to different potential users or beneficiaries. They should appreciate that for some needs, the cultural backgrounds and beliefs of different groups can affect the criteria for a suitable product.
- **Design a solution or product.** Students should make and compare different proposals in light of the criteria they have selected. They must consider constraints—such as cost, time, trade-offs, and materials needed—and communicate ideas with drawings and simple models.
- **Implement a proposed design.** Students should organize materials and other resources, plan their work, make good use of group collaboration where appropriate, choose suitable tools and techniques, and work with appropriate measurement methods to ensure adequate accuracy.
- **Evaluate completed technological designs or products.** Students should use criteria relevant to the original purpose or need, consider a variety of factors that might affect acceptability and suitability for intended users or beneficiaries, and develop measures of quality with respect to such criteria and factors. They should also suggest improvements and, for their own products, try proposed modifications.
- **Communicate the process of technological design.** Students should review and describe any completed piece of work and identify the stages of problem identification, solution design, implementation, and evaluation.

Understandings About Science and Technology

- Scientific inquiry and technological design have similarities and differences. Scientists propose explanations for questions about the natural world, and engineers propose solutions relating to human problems, needs, and aspirations. Technological solutions are temporary; technologies exist within nature and so they cannot contravene physical or biological principles; technological solutions have side effects; and technologies cost, carry risks, and provide benefits.
- Many different people in different cultures have made and continue to make contributions to science and technology.
- Science and technology are reciprocal. Science helps drive technology as it addresses questions that demand more sophisticated instruments and provides principles for better instrumentation and technique. Technology is essential to science because it provides instruments and techniques that enable observations of objects and phenomena that are otherwise unobservable due to factors such as quantity, distance, location, size, and speed. Technology also provides tools for investigations, inquiry, and analysis.
- Perfectly designed solutions do not exist. All technological solutions have trade-offs, such as safety, cost, efficiency, and appearance. Engineers often build in back-up systems to provide safety. Risk is part of living in a highly technological world. Reducing risk often results in new technology.
- Technological designs have constraints. Some constraints are unavoidable, for example, properties of materials, or effects of weather and friction; other constraints limit choices in the design, for example, environmental protection, human safety, and aesthetics.
- Technological solutions have intended benefits and unintended consequences. Some consequences can be predicted, others cannot.

Group Resources:

Manage resources as a team to produce a product or service.

What students should know:

1. Know background information about the product or service to be produced
2. Know basic principles of teamwork
3. Know basic material/processing options

What students should do:

1. Students work as a group to:
   a. identify and describe a product or service to be produced by creating a model, prototype or plan
   b. identify the resources of the team members involved
   c. list the other human and non-human resources required
   d. compare available resources with needs
   e. determine how to get needed resources or revise plan
   f. assign work roles to each member of the team
   g. create a flow chart or schedule describing how the task will be structured and specific work assigned to each member of the team
   h. create the product or service as a group
   i. evaluate effectiveness of the team's management of resources

In Addition:

Teacher will provide, or develop with students, the criteria for evaluating effective team management.

Writing:

Write for a variety of academic and technical purposes, situations and audiences.

What students should do:

1. Write a technical procedure or set of directions that includes:
   a. technical terminology and/or use of tools to perform an action
   b. original visual representations to support text, such as illustrations, diagrams, charts or technical drawings
   c. sequenced steps using a numbered, bulleted or outlined format
   d. precise wording and objective style
   e. a glossary of technical terms used in text
2. Write a narrative:
   a. describe events from direct experience or observation
   b. use relevant detail and figurative language to create an image of setting, characters and events
   c. include dialogue between characters
   d. show sequence of events or ideas leading to a logical ending
3. Write about an idea or an opinion:
   a. give a rationale which includes reasons to support or oppose the opinion
   b. use evidence (e.g., factual information, expert opinion) to support ideas
4. Finished products should have correct spelling and mechanics

In Addition:

1. Document the student writing process through observations and/or conferences.
2. Collect rough drafts along with final products.

Technical Reading:

Comprehend technical information from documents or electronic media.

What students should know:

1. Know relevant technical vocabulary, use of tools and safety procedures

What students should do:

1. Apply step-by-step directions using appropriate tools and safety procedures (e.g., set up a lab, assemble/construct a product)
2. Understand information from visual or graphic data (e.g., graphs, charts, tables, technical drawings, flow charts)

In Addition:

1. Performance package must be based on authentic sources such as owners' manuals, assembly procedures, instructions for age-appropriate models, computer manuals, multi-step procedures such as complete lab directions, complex recipes, clothing patterns and schedules.
2. Students must perform at least two different applications to meet the standard.